SparkFun Autonomous Vehicle Competition 2017
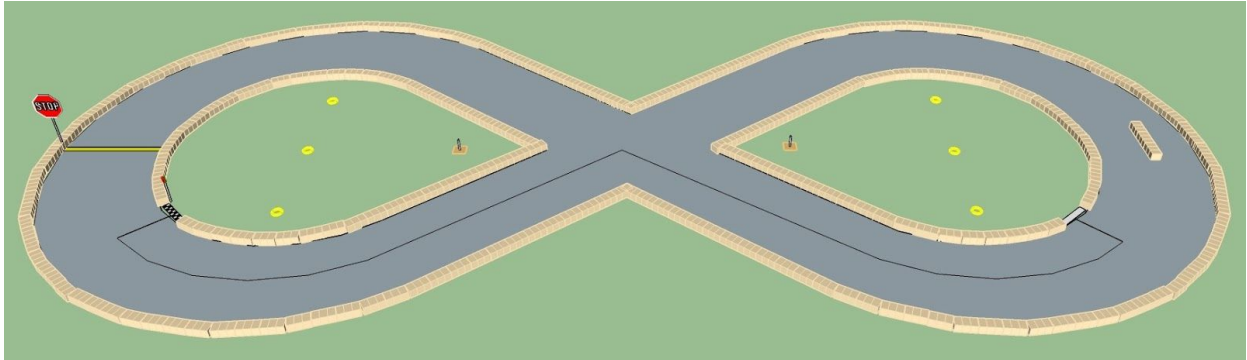
Logistics Class – Rules v1.0

1. Overview

Figure 1.1. Course Overview

1.1. While Google, Tesla and Uber are getting all the news coverage for driverless passenger vehicles, companies like Daimler have been building autonomous and semi-autonomous freight trucks for transporting cargo. The Logistics Class attempts to mimic the engineering hurdles faced in the in-warehouse transportation of goods, as well as in self-driving freight vehicles.

1.2. Task vs. Time: Each team will have 10 minutes to complete all tasks. Time will only be used to break a tie, in which case the shortest time wins. Performing compounded tasks fully autonomously will award the most points.

1.3. Intent: In an effort to capture the nature of autonomous in-warehouse and highway freight vehicles, the course will require robots to perform a number of tasks, including starting on a signal, stopping at an intersection, picking up objects for delivery, dropping off objects in a designated zone, stacking objects on a pole, and sorting the objects in a predetermined order. Robots can perform any or all of the tasks for points.

1.4. Autonomy: The intent of the challenge is to allow teams to primarily control their robot via remote control to complete the tasks. If certain tasks are completed without human intervention (i.e., fully autonomously), then a multiplier will be applied to earned points for those tasks.

1.5. Piecemeal: The Logistics Class challenge was created to be extremely difficult. We intend for teams to find ways to maximize their points and accomplish some tasks but not others. Teams can also choose to tackle some tasks autonomously and others via remote control in the same heat.

1.6.   One-at-a-Time: Only one robot will be allowed to compete at a time per heat.

1.7.   Disclaimer: These rules are subject to change up until the day of the first race. On race day(s), referee rulings will be final. Latest rules can be found on avc.sparkfun.com and forum.sparkfun.com.

2.   Robot Requirements

2.1.   Weight: The freight class autonomous/semi-autonomous vehicle must be less than 100 lbs. This is set to mitigate any dangers a heavy vehicle might pose to nearby spectators.

2.2.   Size: Width $\leq$ 4 ft.; Length $\leq$ 4 ft.; Height $\leq$ 3 ft.; (before start of each heat). The robot size is limited to provide a challenge for lifting, moving, carrying, etc. objects (and to fit through a predefined starting area).

2.3.   Remote Kill Switch to be demonstrated at check-in.

2.4.   No part of the robot may leave the ground (e.g., no detachable flying drones). As cool as this would be, we have audience safety to consider.

2.5.   Extra batteries are not required but strongly encouraged. Teams that miss a heat because the batteries are dead will not be allowed a makeup heat.

2.6.   Only one person from the team is allowed to operate the robot during a heat. This person is known as the "Operator" for the remainder of this document.

2.7.   If a person touches the robot during a heat, the heat will immediately end. Any points earned up to that point during the heat will be awarded.

3.   Course

3.1.   Layout Figure 3.1 shows the basic course overview with the sections, rings and mast labeled. The idea is that rings from the Twilight Zone need to be delivered to the Danger Zone, and rings from the Danger Zone need to be delivered to the Twilight Zone. Ideally, the rings should be sorted and stacked on the opposite zone's mast for maximum points.
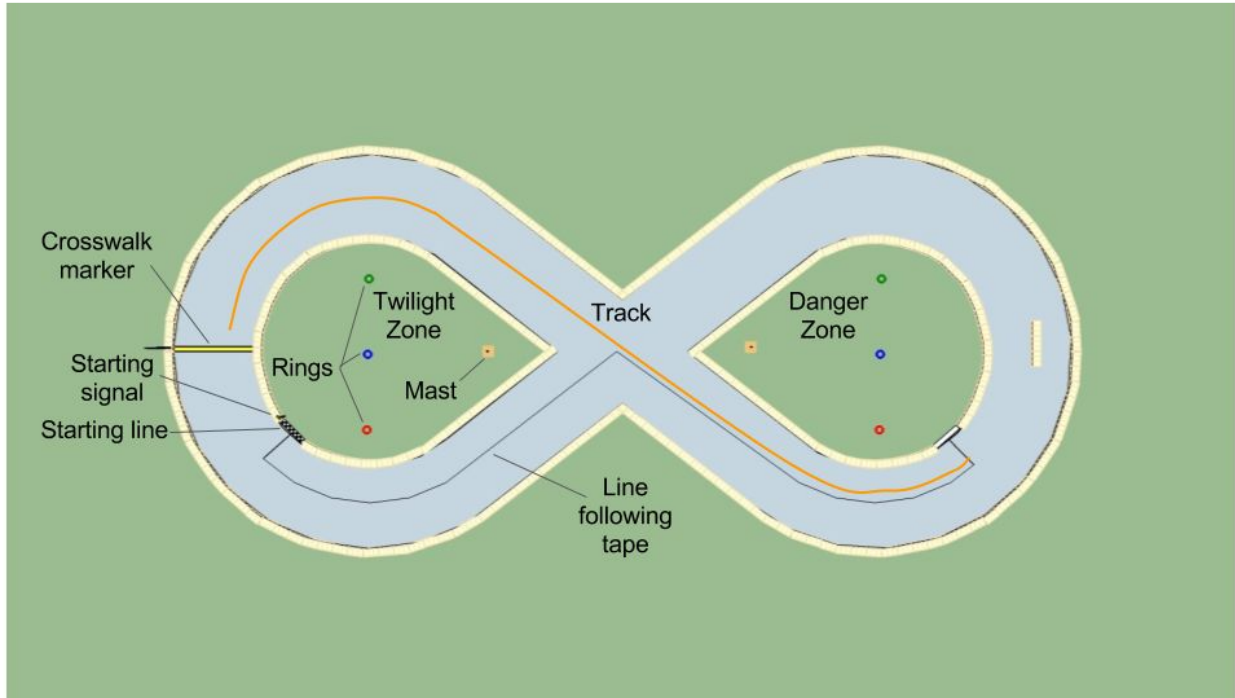
Figure 3.1. Course Layout

3.2. Track Description

3.2.1. Starting Line

3.2.1.1. Shown by the black-and-white checkered bar in front of the Twilight Zone.

3.2.1.2. Vehicles must start with their front behind the bar, facing into the Twilight Zone.

3.2.1.3. A starting signal will be placed facing the robot in the corner of Twilight Zone.

3.2.1.4. The starting signal will be a 2-foot circle with one side painted green 1 foot above the hay bales just to the left of the starting line.

3.2.1.5. At the start of the heat, the starting signal sign will flip to the green side.

3.2.2. Track

3.2.2.1. The track is a figure-eight layout with a major axis length of approximately 178 feet and a minor axis of approximately 78 feet.

3.2.2.2.   Track width is 16 feet.

3.2.2.3.   Track extents are defined by hay bales.

3.2.2.4.   Vehicles may take one of two routes between the zones.

3.2.2.5.   The easy route will be marked with a 2-inch vinyl tape from the starting line (Twilight Zone) to the entry point on the Danger Point. This will allow line-following robots a chance to obtain the autonomous bonus for the "Transport" task.

3.2.2.6.   The hard route will be unmarked (shown as an orange line in Figure 4.1), but will allow vehicles to stop at the crosswalk (yellow line) for the "Stop" task.

3.2.3.   Zones

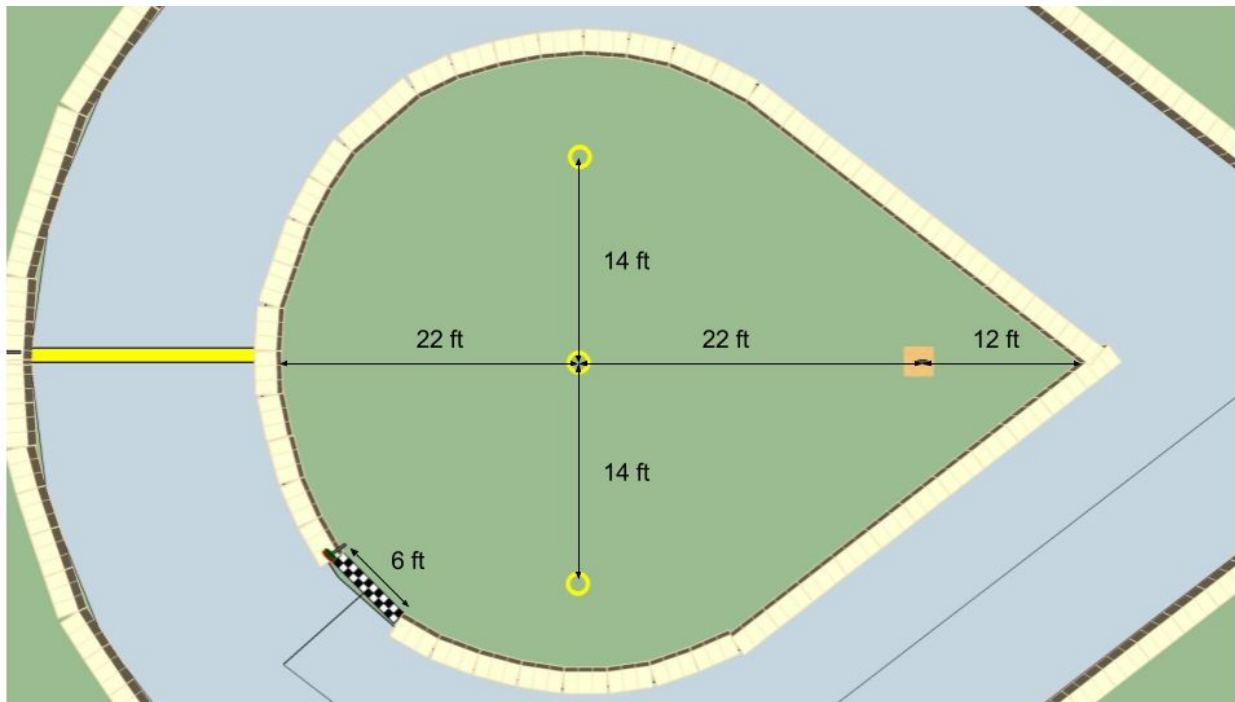14 ft

22 ft   22 ft   12 ft

14 ft

6 ft

Figure 3.2. Twilight Zone

3.2.3.1.   Two mirrored zones (Twilight & Danger) – They're not covered in mirrors; Twilight Zone (Figure 3.2) is a mirror image of the Danger Zone.

3.2.3.2.   Each will have a 6-foot-wide entrance (shown by checkered and white bars in the diagram). The real entrances will be marked with 2-inch green vinyl tape.

3.2.3.3.   Each will have a 2-foot mast for stacking rings placed 12 feet away from the inner "point" in the teardrop shape of the zone.

3.2.3.4.   Each will have three pickup locations (yellow rings in Figure 3.2) where one of the colored (red, green, blue) rings will reside.

3.2.3.4.1.   One ring will be placed entirely in each pickup area.

3.2.3.4.2.   The three pickup areas will have the three rings originating in that zone in any particular order. The ring locations are shown in yellow in Figure 3.2.

3.2.3.4.3.   Each pickup area will be 2 feet in diameter.

3.2.3.4.4.   The middle pickup area will be 22 feet from the mast.

3.2.3.4.5.   Two pickup areas will be on either side of a centered pickup area, equally spaced 14 feet away from the centered area.

3.3.   Rings

Top Down

RFID Tag

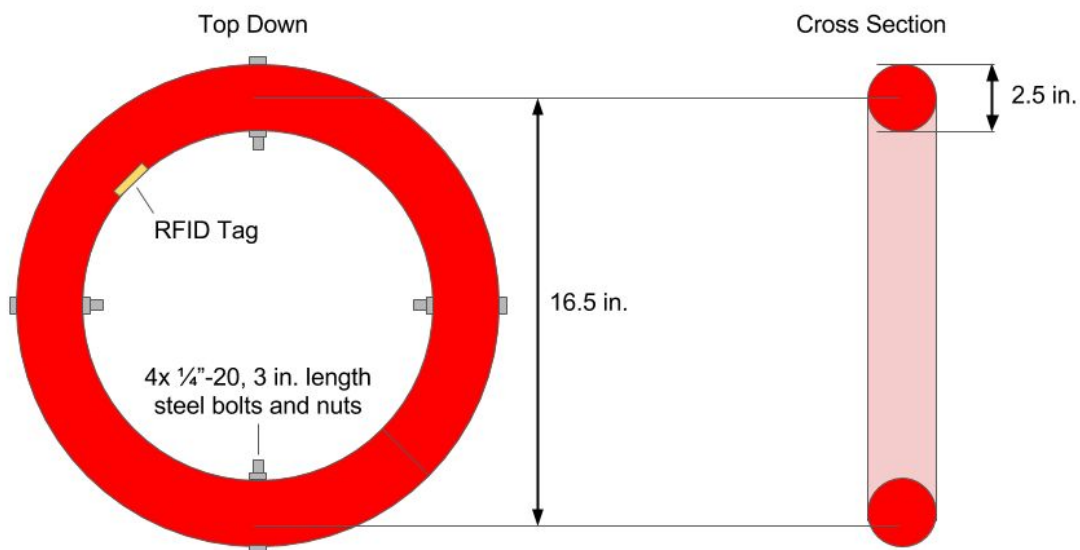4x ¼"-20, 3 in. length steel bolts and nuts

16.5 in.

Cross Section

2.5 in.

Figure 3.3. Ring

3.3.1.　Each ring will be a 52-inch pool noodle bent and connected to itself to form a torus with a diameter of about 16.5 inches.

3.3.2.　Each ring will be one of three colors: red, green, blue.

3.3.3.　Each zone will have one ring of each color.

3.3.4.　Four ¼"-20 bolts will be inserted radially into each ring. This will allow a ferrous surface for picking up the rings using magnets.

3.3.5.　Each ring will be given an RFID tag (https://www.sparkfun.com/products/14151) with a unique identifier string (https://learn.sparkfun.com/tutorials/simultaneous-rfid-tag-reader-hookup-guide/example-4---read-user-data) that gives the destination and stacking order of that ring. These strings are as follows:

　　3.3.5.1.　"DZ1" – Red ring that starts in the Twilight Zone and should be delivered to the bottom position on the mast in the Danger Zone.

　　3.3.5.2.　"DZ2" – Green ring that starts in the Twilight Zone and should be delivered to the middle position on the mast in the Danger Zone.

　　3.3.5.3.　"DZ3" – Blue ring that starts in the Twilight Zone and should be delivered to the top position on the mast in the Danger Zone.

　　3.3.5.4.　"TZ1" – Red ring that starts in the Danger Zone and should be delivered to the bottom position on the mast in the Twilight Zone.

　　3.3.5.5.　"TZ2" – Green ring that starts in the Danger Zone and should be delivered to the middle position on the mast in the Twilight Zone.

　　3.3.5.6.　"TZ3" – Blue ring that starts in the Danger Zone and should be delivered to the top position on the mast in the Twilight Zone.
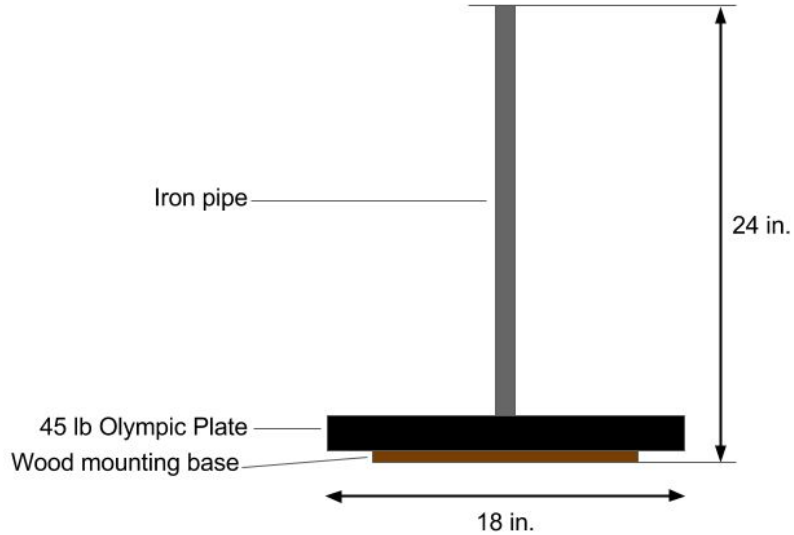
3.4.　Masts

Figure 3.4. Mast

3.4.1. Masts for stacking rings will be made out of 1-inch-diameter iron pipe attached to a wood plank and a 45lb barbell plate for weight.

3.4.2. The pipe will be 24 inches tall from the ground.

4. **Tasks**

4.1. *Start:* The robot should cross from the Track to completely inside the Twilight Zone.

4.1.1. A green signal will indicate the start of the heat.

4.1.2. A ZigBee (XBee) string "GO" will be broadcast on channel 0x12 and PAN ID 0xFA57 to indicate the start of the heat.

4.1.3. This task may only be completed once.

4.2. *Stop:* The robot should come to a complete stop in front of the crosswalk.

4.2.1. 2-inch yellow vinyl tape will mark the crosswalk.

4.2.2. The robot must stop in front of the yellow vinyl tape without going over the tape with any part of the robot. The front of the robot must be within 10 feet of the tape.

4.2.3. This task may be completed twice: once for each direction (to Danger Zone and to Twilight Zone).

4.3. *Pickup:* The robot must transport one or more rings outside their starting zone.

4.3.1. The ring must be completely outside its starting zone to count for points.

4.3.2. The number of rings that make it outside their starting zone will determine the number of points awarded.

4.4. *Transport:* The robot must move one or more rings into their destination zone(s).

4.4.1. A ring must be completely inside its destination zone to count for points. Rings can still be attached to the robot to count.

4.4.2. The robot may deliver a ring to its destination in any way, so long as it does not violate the Robot rules (section 2).

4.5. *Stack:* The robot must place each ring onto a mast.

4.5.1. The ring must completely encircle the mast.

4.5.2. Rings may be placed on any mast to receive points.

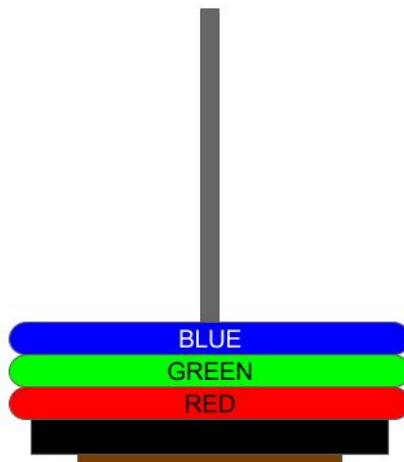4.6. *Sort:* The robot must stack the rings in the correct order on the mast.

Figure 4.1. Stacking Order

4.6.1. The ring colors should be red, green, blue from bottom to top (Figure 4.1)

4.6.2. Getting points for sorting rings automatically means points were awarded for stacking.

4.6.3. Points are awarded based on number of rings in the correct positions. For example, stacking three rings in the order blue, green, red (bottom to top) would award points for one ring in the correct position.

4.6.4. Stacking more than three rings on a mast (even if in the correct order) will not award any more points for sorting.

5. Autonomy

5.1. Contestants may use remote control at any time during the heat to direct and control their vehicle.

5.2. The Operator must inform a judge that they intend to attempt a task autonomously before enabling autonomous mode on their robot.

5.3. To receive the autonomous bonus multiplier for the task, the Operator may not touch the vehicle's controls while the vehicle performs that task.

For example, you may pick up two rings in the Twilight Zone and then switch to autonomous mode before exiting the Twilight Zone (after informing a judge that you are attempting the "Transport" task autonomously). The robot navigates to the Danger Zone on its own. Upon fully entering the Danger Zone, you would be awarded points for transporting two rings times the autonomous multiplier. Note that you would also receive points for picking up the two rings, but no autonomous multiplier would be applied for that task.

5.4. If a robot does not complete a task autonomously (i.e., the Operator takes control of a robot midway through a task), then no multiplier is awarded (but base points for that task may still be awarded). All parts of a task must be completed autonomously in order to receive the multiplier bonus.

For example, moving two rings out of their originating zone autonomously but moving the third ring with remote control will award base points for "pickup" for three rings but no autonomous multiplier.

6. Scoring

6.1. Points will be awarded to individual tasks completed by the robot.

6.1.1. *Start:* 10 points for moving into the Twilight Zone. 3x multiplier for autonomous (Max: 10 pts; Autonomous max: 30 pts).

6.1.2. *Stop:* 5 points for stopping no more than 10 ft before the crosswalk. Can be awarded up to two times for each heat. 3x multiplier for autonomous (Max: 10 pts; Autonomous max: 30 pts).

  6.1.2.1. The "Stop" task will start when a robot in on the track and is within 20 feet from the yellow crosswalk tape.

6.1.3. *Pickup:* 5 points for each ring (up to six rings) moved entirely out of its originating zone. 5x multiplier for autonomous (Max: 30 pts; Autonomous max: 150 pts).

  6.1.3.1. The "Pickup" task will start when a robot is within 10 feet of a ring.

6.1.4. *Transport:* 5 points for each ring (up to six rings) entirely within the opposite zone at the end of the heat. 3x multiplier for autonomous (Max: 30 pts; Autonomous max: 90 pts).

  6.1.4.1. The "Transport" task will start as soon as a ring crosses onto the track.

6.1.5. *Stack:* 5 points for each ring (up to six rings) placed on and encircling a drop-off mast at the end of the heat. 5x multiplier for autonomous (Max: 30 pts; Autonomous max: 150 pts).

  6.1.5.1. The robot may not be touching a ring at the end of the heat for it to count for points.

  6.1.5.2. Note that more than three rings may be placed on a mast for points in this category.

  6.1.5.3. The "Stack" task will start when a robot is within 10 feet of a drop-off mast.

6.1.6. *Sort:* 5 points for each ring (up to six rings) placed on a drop-off mast in its correct position. For the mast in each zone, the correct positions (bottom to top) are red, green, blue. 5x multiplier for autonomous (Max: 30 pts; Autonomous max: 150 pts).

  6.1.6.1. The robot may not be touching a ring at the end of the heat for it to count for points.

  6.1.6.2. The "Sort" task will start when a robot is within 10 feet of a drop-off mast.