State Fair Robotics Challenge 2018

Youth teams will design, build and program a robot to face a themed challenge. At the Colorado State Fair, they will test their design and programming to meet the challenge.

Autonomous Cars

Autonomous cars, ones that can sense their environment and navigate it without human input, are being developed and tested with increasing frequency around the world. Vehicles are using sensors and programming to do things as simple as notifying a car if something is in their blind spot, or helping a driver parallel park. More advanced vehicles are more highly automated and require little to no driver intervention to operate.

Autonomous vehicles promise to reduce traffic accidents, most of which are caused by driver error. Widespread use will also increase capacity of roadways and lower road congestion. They can also provide increased mobility to people with disabilities, the elderly, and those who can't afford personal vehicles.

Numerous practical, financial, ethical and legal considerations are being examined as these technologies are developed. For these vehicles to be viable, vehicle programmers need to write complicated code, integrate numerous sensors and systems, and determine appropriate behavior in a number of situations. Autonomous cars need to be able to react to road markings, signs, and hazards, among other things. Much of the work in this area is being done with pattern recognition and machine learning.

This year's State Fair Robotics Challenge explores building and programming a robot with some of these considerations in mind. Teams will build robots that can navigate a roadway, avoid obstacles, and parallel park.

Challenge Information

This is an autonomous programming challenge designed for LEGO Mindstorms EV3 robots. NXT robots can also compete. All tasks must be accomplished with programming. Teams are not allowed to control their robot through any non-autonomous methods. In addition, teams MUST use sensors to stop their robot at the stop lines, avoid the walking pedestrian, and parallel park. If a team chooses to try for the "avoid puddle" points, they should also use a sensor to accomplish this task. Each scoring task can only be completed once for points (and they will generally be completed in the listed order). The maximum number of points possible is 260.

Teams are not required to complete all of the tasks. Point totals for each task are listed on the scoresheet. Descriptions of each task are listed below. Teams will have up to 3 minutes to complete as many tasks as possible and park in the finish box. Once team's robots are entirely in the green "finish" box and their robot stop completely, they can call for an end to the time. The completion time will be noted and will be used as a tie-breaker (teams with a faster time will win any ties). Deductions will be made for hitting the walls and items on the board (cars, signs, parking meters, cyclists, cones, pedestrians). See deduction values on the scoresheet. Each time an object is hit will count as one

deduction (so if the same car is hit more than once, it will earn a deduction for every time it is hit). The one exception to the deductions is as follows: teams may use a touch sensor to complete the parallel parking task. This sensor/sensor attachment is allowed to tap the parked cars with no deductions. However, no other part of the robot (aside from this sensor attachment) may hit the parked car, or that will count as a deduction.

Robots and all attachments/sensors MUST fit completely in the start box to compete. The box will be approximately 9 inches wide by 10.5 inches long and is marked on the challenge mat.

Note: the pedestrian is connected to fishing line and a Lego sensor. It starts already in the crosswalk (at the position marked in light blue on the mat). As soon as a robot stops at the stop line, the pedestrian program will start (either via a touch sensor pushed by scoring personnel, or via an ultrasonic sensor). The program has the pedestrian wait a set number of seconds, then slowly "walk" across the crosswalk. Teams should program their robot to not hit the pedestrian, or drive through the fishing line. The pedestrian walks away from the stop sign (towards the wall/outside of the mat).

Scoring Tasks (see scoresheet for point values and annotated mat on page 8 for visuals)

1. **Start entirely in start box** – Robot and all attachments must fit completely in the green box marked "start". All robots start all runs from this area.
2. **Navigate 1st section of road in lane** (reach 1st stop sign) – Robot must get from the start box to the first stop sign. Point will be earned when the robot's front wheels pass the stop line.
3. **Stop at stop sign** (using sensor) – Robot uses a sensor (color, ultrasonic, infrared, etc.) to stop at the first stop sign (there is a red stop sign, as well as a white stop line on the pavement to mark each stop). The robots wheels should stop completely for at least 1 second.
4. **Signal turn** (lights, screen or manually) – Robots signal their right turn at the stop sign using the built in brick lights, screen display, or a manually developed signaling mechanism.
5. **Make first right turn** – Robot successfully moves from straight first lane, into the perpendicular lane. Robots wheels should reach even with the rear of the car in the adjacent lane for this task to count as complete.
6. **Avoid puddle** (using sensor) – Robot uses a sensor to completely avoid the blue puddle on the roadway. To accomplish this task, the main portion of the car (not counting sensor attachments) should not pass over the puddle. If any part of the car, aside from sensor attachments passes over the puddle, points would not be earned.
7. **Navigate second section of road** (reach 2nd stop sign) – Robot successfully navigates from the first stop sign to the second stop sign. Points will be earned when the robot's front wheels pass the stop line.
8. **Stop at stop sign** (using sensor) – Robot uses a sensor (color, ultrasonic, infrared, etc.) to stop at the second stop sign (there is a red stop sign, as well as a white stop line on the pavement to mark each stop). The robots wheels should stop completely for at least 1 second.
9. **Signal turn** (lights, screen or manually) - Robots signal their right turn at the stop sign using the built in brick lights, screen display, or a manually developed signaling mechanism.
10. **Wait for pedestrian to clear crosswalk before advancing** (using sensor) – Robot uses a sensor to wait at stop sign until the crosswalk in front of their lane is completely clear of the pedestrian, then advances. The pedestrian starts in a fixed position in the crosswalk (marked in light blue on the mat). Robots should not proceed into the opposing lane to drive around the pedestrian, as

they will not earn these points, and may get caught up in the pedestrian walking mechanism (fishing line connected to a medium motor). Robots only gain these points if they successfully wait, and then proceed through the crosswalk.

11. **Make 2nd right turn** – Robot successfully moves from stop sign/crosswalk, into the perpendicular lane. Robots wheels should reach even with the start of the parking lane for this task to count as complete.
12. **Navigate third section of road** (reach parking space) – Robot successfully navigates from the second stop sign to the "Finish" parking space. Points will be earned when the robot's front wheels reach parallel to the front of the parking space.
13. **Successfully parallel park** (using sensor end completely in green finish box) – Robot use a sensor or multiple sensors to successfully parallel park. To get these points the robot needs to follow parallel parking procedures of backing into the space. Touch sensors may be employed in this task, and they can "tap" the other parked vehicles, without deduction. Color and ultrasonic sensors can also be used, but they shouldn't come into contact with the other vehicles. The car must end up completely in the green "Finish" parking space and stop completely to earn these points. If any parts of the robot extend beyond the green box, points will not be earned.

Deductions

Any time the robot does any of the following, they will get a point deduction. Each additional time an object is hit counts as another deduction.

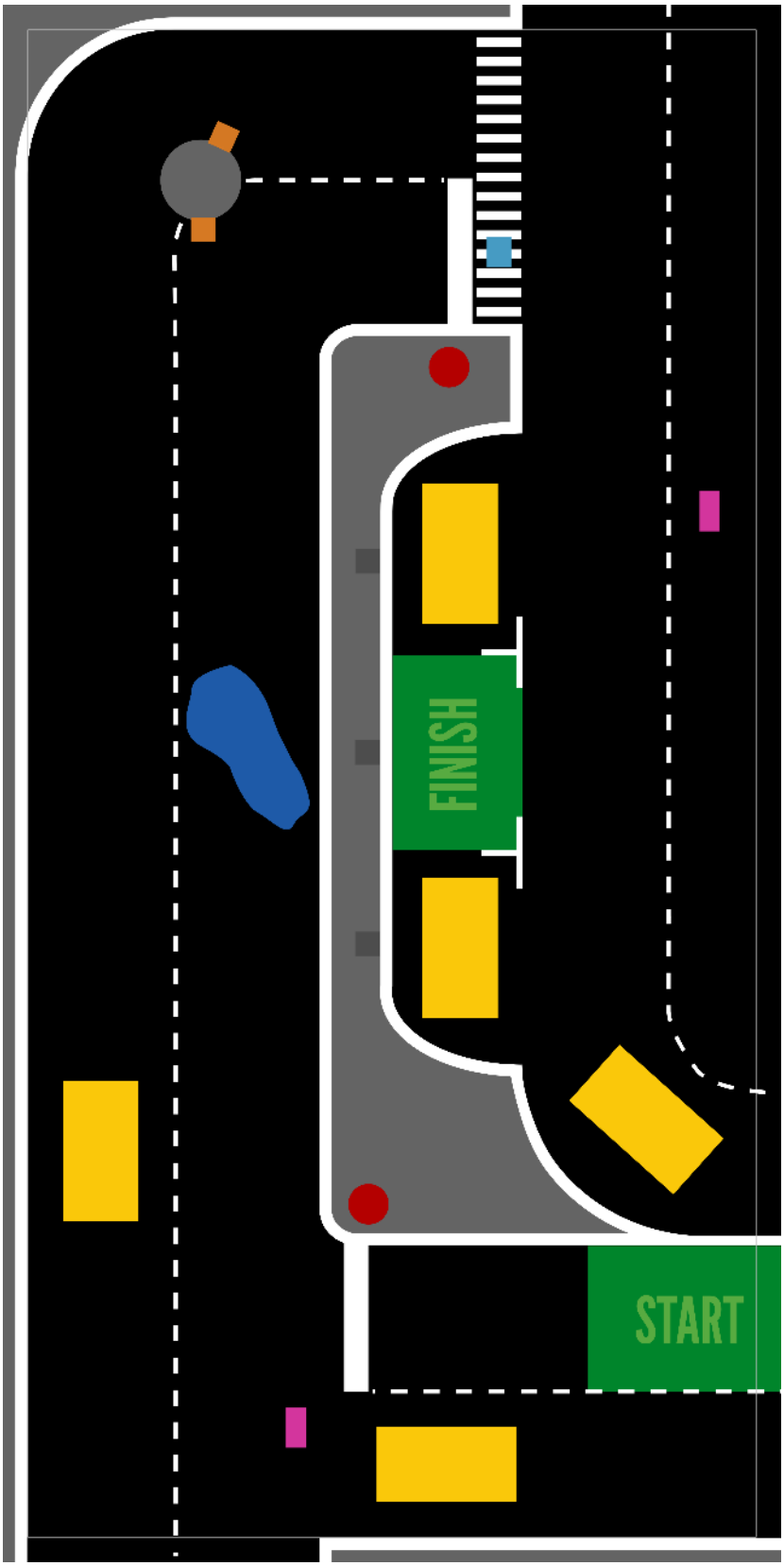
- Hit Wall
- Hit Sign
- Hit Car (see exception in regards to parallel parking in task 13 above)
- Hit Pedestrian
- Hit Cyclist
- Hit Parking Meter
- Hit Cone

Materials

Mat

This task uses a printed vinyl mat as the board. At the state challenge, this mat is placed inside a walled insert. The printed mat is 8 feet by 4 feet. The faint grey line near the edge is where the mat will be cut to fit into the state fair mat holder board (the working area at the state fair should be 45 inches wide, 93 inches long). Local contests may choose to use the mat at full size. If you'd like to commercially print your own copy of the mat, or view a larger version, access the pdf here: https://drive.google.com/open?id=16o299lPlYKziyDLZhH30l5rWryX-rzku. Cost to print will be around $80. A limited number of mats may be available for counties to borrow for practice purposes.

A number of 3 dimensional items will be placed on the mat in spaces indicated with shapes and colors on the mat itself. No items will be physically attached to the mat, with the exception of the "parked" cars, which will have Velcro or a magnet attaching them to the mat. All other obstacles will move when hit. See item descriptions to see where they will go on the mat.



Mat file with obstacle spaces, start, and finish marked.

Robot Platform

This challenge is designed for LEGO Mindstorms EV3 or NXT robots. Teams should not supplement the standard kits with any additional parts for this challenge. The only exception will be that teams may choose to use a second LEGO color sensor for the challenge. Teams can borrow this sensor from another kit or purchase one from LEGO (https://shop.lego.com/en-US/EV3-Color-Sensor-45506).

Obstacles

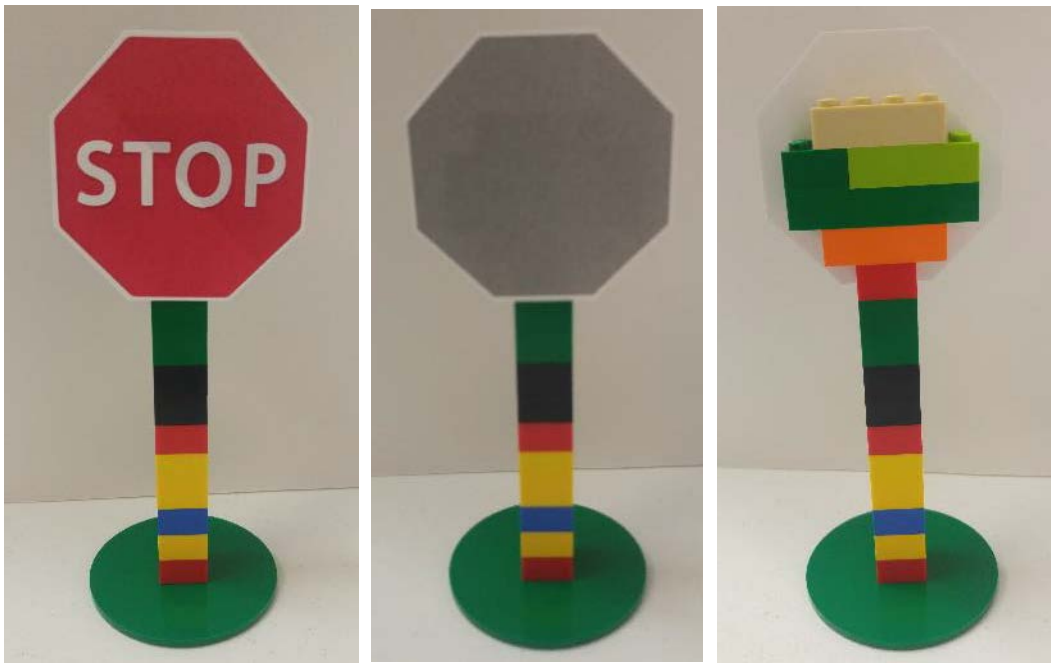
All of the obstacles for the challenge can be made with everyday items and Lego parts. See the end of this document for a complete Lego part list if you'd like to order parts direct from LEGO or through BrickLink. All artwork for signs, cars, and people can be downloaded, printed on cardstock, and attached to stands using tape. Download that artwork here. Be sure to print art at 100% size (not "shrink to fit").

The various obstacles that appear on the board (left to right): pedestrian, cone, parking meter, car, stop sign, cyclist.

5 Cars (yellow) - 5 rectangular boxes of tissue (Kleenex or Puffs). Approximate size: 4.75 in. wide, 3.5 in. high, 8.75 in. long. Placed on yellow rectangles on the mat. Cardstock images of cars of various colors are taped to the outside of the boxes.

Tissue box before images attached (left), finished grey "car" with art attached (right).

2 Stop Signs (red) – 2 stop signs, made of LEGO pieces and cardstock printouts. Placed on red circles on the mat. Each sign uses a round base plate and various other pieces. Finished signs are approximately 6.5 in. tall. Sign base is approximately 2.5 in. wide.

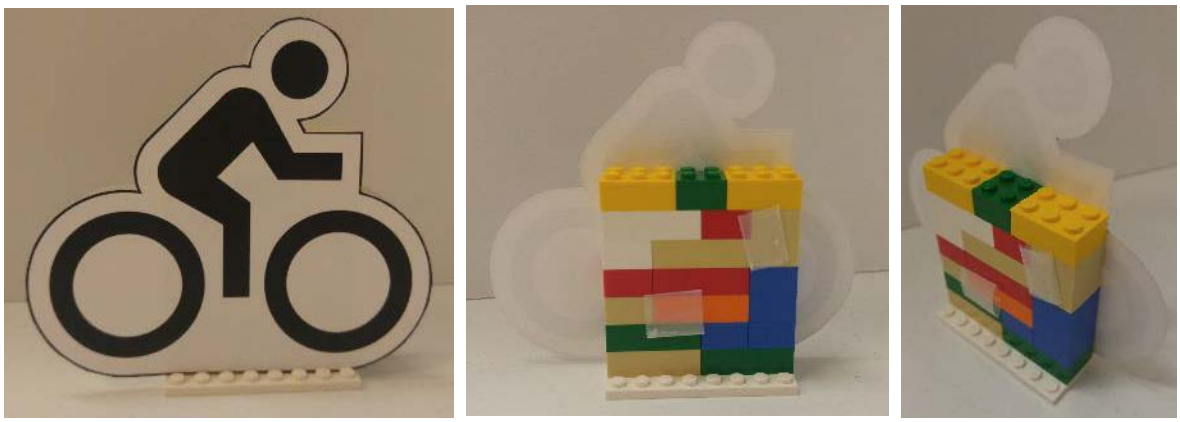


Finished stop sign front (left), back (center) and inside view (right).

3 Parking Meters (dark grey) – 3 parking meters, made of LEGO pieces and cardstock printouts. Placed on dark grey squares next to the parked cars. Approximately 3.75 in. tall. Base is 4x4 LEGO plate, approximately 1.25 x 1.25 in.

Finished parking meter front/rear (left), side (center) and inside view (right).

2 Cyclists (pink/magenta) – 2 cyclists, made of LEGO pieces and cardstock printouts. Placed on magenta/pink rectangles on the mat. A little over 4.5 in. tall at the cyclist's head. 5 in. wide at widest point. Mounted on an 8x4 LEGO plate.

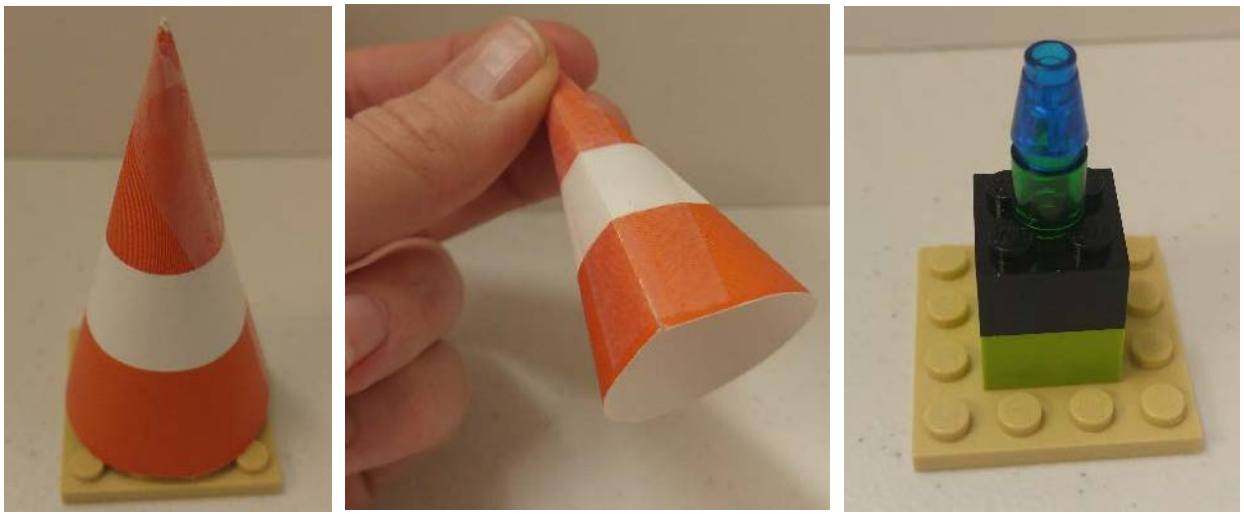


Finished cyclist front (left), interior (center) and interior detail (right).

1 Pedestrian (light blue) – 1 pedestrian, made of LEGO pieces and cardstock printouts. Placed in the crosswalk on the light blue rectangle. The pedestrian has a piece of fishing line connected to it at the base. The line is connected to a medium LEGO motor that will pull the pedestrian through the cross walk towards the wall (away from the stop sign). See a sample video of this action here: https://drive.google.com/file/d/1sEdsv99bNApI7Zp_kYJZZ9Kl7yVdEZYl/view?usp=sharing (note: this is not the finished mechanism, it's just meant to give you an idea how this might work). Pedestrian is a little over 4.75 in. tall and 3.25 in. wide at widest point. Mounted on a 6x4 LEGO plate.

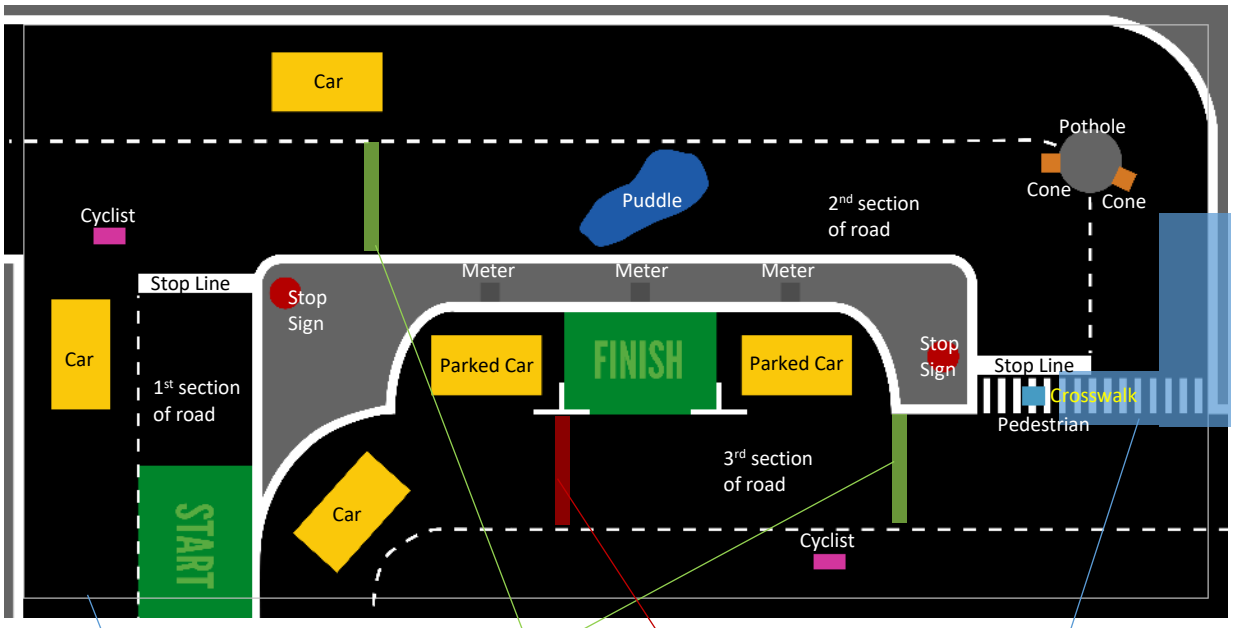
Finished pedestrian front (left), interior (center) and side with fishing line (right).

2 Cones (orange) – 2 cones, made of LEGO pieces and cardstock printouts. Placed on the orange squares around the grey "pothole" on the mat. Approximately 2.75 in. tall. Paper cone placed over LEGO pieces, mounted on 4x4 LEGO plate.



Finished cone (left), taped paper cone detail (center), and interior (right).

Annotated Mat



Light grey line – This is the line where we'll cut the mat for the state challenge so it fits inside the challenge boards.

Green lines – These mark where a turn will be counted as complete (front wheels must reach these lines for task 5 and 11)

Red line – This marks where vehicle must reach to count 3rd section of road complete (front wheels must reach this line for task 12)

Light blue highlight – Robots should plan to avoid this area as the fishing line from the pedestrian, and the apparatus that moves it may extend into this area.

Have questions about the challenge or need clarification on anything? Contact Amy Henschen, SLV Area 4-H Agent, at amy.henschen@colostate.edu or 719-852-7381

Challenge Lego Part List

Many of the obstacles can be made with various combinations of LEGO pieces, as demonstrated with the examples above. The pieces (and colors) below will be used for the State Fair Challenge. If you'd like to order the parts from Bricklink (https://www.bricklink.com), you can upload the Lego Digital Designer file to get the complete part list. Ordering all the parts on Bricklink should run around $10 (not including shipping). You can also try to order individual parts from LEGO pick-a-brick (https://shop.lego.com/en-US/Pick-a-Brick).

Download Lego Digital Designer free building software here: http://ldd.lego.com/en-us/

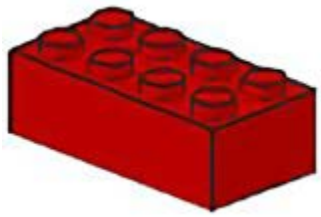
Download the Lego Digital Designer file for the challenge obstacle pieces (which you can use for building instructions or to order pieces) here:
https://drive.google.com/open?id=1bu6ozogwYHaEIlBxivsp4hg8cCfhaoQ6

Tile, Modified 1 x 2 with Handle (quantity 1)
2432
Black

Brick 2 x 4 (quantity 37)
3001
Black

Brick 2 x 6 (quantity 4)
2456
Red

Brick 2 x 2 (quantity 4)
3003
Orange



Brick 2 x 4 (quantity 4)
3001
Red

Brick 2 x 2 (quantity 28)
3003
Dark Bluish Gray

Plate 4 x 4 (quantity 2)
3031
Orange

Plate 4 x 4 (quantity 3)
3031
Dark Bluish Gray

Plate 4 x 6 (quantity 1)
3032
Black

Plate 4 x 8 (quantity 2)
3035
Black

Brick, Round 1 x 1 Open Stud (quantity 2)
3062b
White

Brick, Round 2 x 2 with Axle Hole (quantity 15)
3941
Dark Bluish Gray

Cone 1 x 1 without Top Groove (quantity 2)
4589
White

Tile, Round 8 x 8 (quantity 2)
6177
Green

State Fair Robotics Challenge 2018 Score Sheet

COLORADO STATE UNIVERSITY EXTENSION

Team Members: _____ Run #: ___

County: _____ ☐ Junior ☐ Senior

Item	Value	Complete?	Points Earned
1. Start entirely in start box	**10**		
2. Navigate 1st section of road (reach 1st stop sign)	**20**		
3. Stop at 1st stop sign (using sensor)	**20**		
4. Signal 2nd turn (lights, screen or manually)	**10**		
5. Make first right turn after stop	**20**		
6. Avoid puddle (using sensor)	**20**		
7. Navigate 2nd section of road (1st stop sign to 2nd stop sign)	**30**		
8. Stop at 2nd stop sign (using sensor)	**20**		
9. Signal 2nd turn (lights, screen or manually)	**10**		
10. Wait for pedestrian to clear crosswalk before advancing (using sensor)	**20**		
11. Make second right turn after stop	**20**		
12. Navigate 3rd section of road (2nd stop sign to parking space)	**20**		
13. Successfully parallel park (using sensor, park & stop completely in green finish box)	**40**		
		Total Task Points	

Deductions *(point deductions multiplied by number of times each item is hit)*					
Hit Wall *(minus 5)*	Hit Car *(minus 10)*	Hit Pedestrian *(minus 25)*	Hit Cyclist *(minus 15)*	Hit Cone *(minus 5)*	Hit Sign/Meter *(minus 10)*
x 5 =	x 10 =	x 25 =	x 15 =	x 5 =	x 10 =

Task Points: _____ *(max 260)* **Total Deductions: _____**

Deductions: - _____ **Completion Time: _____**

Total Score: _____