2023 4-H LEGO Robotics Challenge

Enjoying our Waterways

Image courtesy of NASA

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2023 Enjoying our Waterways

The goal of the 4-H LEGO Robotics Challenge is to provide a simple LEGO Robotic game for entry level participants. This is done through a mission-based activity where youth design, build and program LEGO MINDSTORM robots to solve defined tasks. The activity is performed on a 4' x 4' game mat, using pre-defined mission pieces. Each mission has points assigned, based on achieving a set goal. Although the missions are predefined, the solutions for achieving those missions are very open-ended, and depend on the creativity and skill of the participants. This document defines the rules and operating procedures for the 2023 game. If you have any questions contact Willie Lantz at the Garrett County Extension office at 301-334-6960 or wlantz@umd.edu.

1 Teams and Coaches

Updated information on the Maryland 4-H Robotics Challenges can be found on the Maryland 4-H STEM website at https://bit.ly/MD4-HSTEM. If you are not a 4-H volunteer and want to get involved in the Maryland 4-H Robotics Challenges, contact your local 4-H office or the Maryland 4-H State Office at 301-314-9070 for information. This process requires registering as a volunteer in 4-H Online. Coaches who are registered will receive updates on the game and contests. To coach a Maryland 4-H Robotics team, you must be a certified 4-H volunteer, and your team must always have two certified 4-H volunteers leading the team and its meetings. More information about how youth and adults can register for Maryland 4-H can be found on the Maryland 4-H website.

4-H robotics teams consist of 3 to 8 youth members apiece, as decided upon by club members and mentors. Youth participating can be 4-H "Program Age" 8-18 years old (Program Age defined as the age of youth on January 1, 2023), though local clubs have the responsibility to determine how team members will be distributed (if multiple teams are participating locally). The age division (Junior, Intermediate, or Senior) that teams participate in at contests is determined by the Program Age of the oldest member of the team. Each team can register multiple coaches, and coaches can lead multiple teams, but **youth can only compete on one robotics team per year**.

The Maryland State 4-H Robotics contests usually take place on the last Sunday in August every year, at the Maryland State Fair in Timonium, MD. Registration for these and the other state fair contests go live in the summer. The local 4-H educators will provide instructions to volunteers and families on how participants can register for events at that time.

2 The Game

Team members will construct a robot, using ONLY LEGO parts. The robot will be controlled by a LEGO Mindstorms or Spike Brick. The robot will autonomously perform specific tasks. The team will have 2 minutes and 30 seconds to perform as many tasks as possible.

2.1 Competition kit

The competition kit comprises the playing field "mat" and the Mission Models. The mission models are constructed from a LEGO Spike Prime accessory kit of parts. Competition kits can be shared among multiple teams.

This is the Lego Spike Prime Accessory kit, used to build the mission models for the 4-H Lego game.

2.2 Field Mat

The field mat is a 48” x 48” vinyl banner which is mounted inside a wooden “playing field” for stability. The mat defines the various mission regions of the game, and provides registration marks for positioning mission pieces.

This picture shows the starting position for all mission pieces.

2.3 Playing Field

The field will be constructed of a ½” thick sheet of plywood (48” X 48”) with 2” X 4” (studs) on edge to create a playing area of 45” X 45” (inside the 2x4 frame). The mat (48” X 48”) will be installed between the 2” x 4” edge and the plywood. The playing field can be laid on a table or supported by two sawhorses 28” to 32” tall.

3 The Robot

3.1 Allowed Materials

Robots must be constructed using a single MINDSTORMS Brick (RCX, NXT, EV3 or a Spike Prime) and any additional official LEGO parts. Non-LEGO parts will not be allowed. The robot must be programmed with LEGO Mindstorms software to perform the tasks **autonomously.**

A maximum of the following motors and sensors may be attached to the robot at any time. This does not include “extra” robot manipulators brought to the table but not currently attached to the robot:

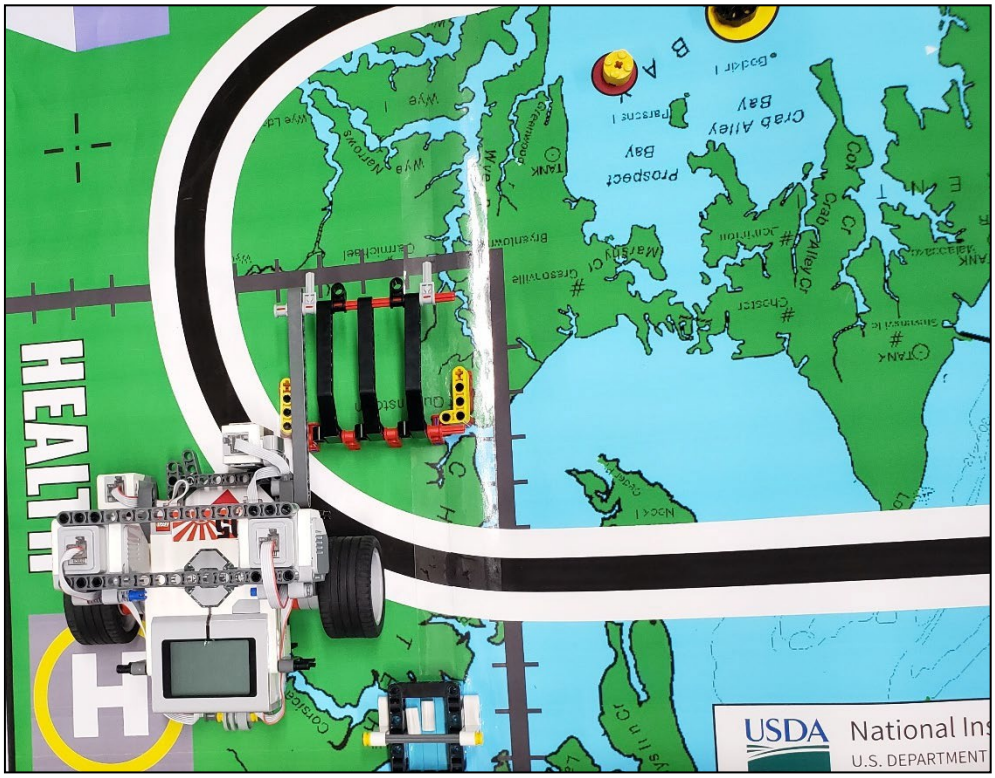
a. 2 x touch sensors
b. 2 x light sensors
c. 1 x ultrasonic sensor
d. 1 x lamp
e. 1 x gyro sensor
f. 3 x motors

The following may not be used:

a. Paint, tape, glue, and oil
b. Non – LEGO stickers
c. Remote controls of any type

3.2 Robot Size

The robot and any attachments must start completely inside of the Base area of the board which measures 12" X 12" and must not be taller than 12". After the robot leaves the Base area it may expand to any dimension. For the 2023 LEGO Robotics Challenge, the Base Area is located in the North East Corner of the mat (Health H corner). The actual base area includes the THICK perimeter line, but not the thin lines that extend beyond the THICK line.



3.3 Robot Operations

3.3.1 Robot in Base

While in Base, members my change programs or change parts on the robot. The robot will be considered in Base if any part of the robot is within the Base Area perimeter (see section 3.2)

3.3.2 Handling the Robot

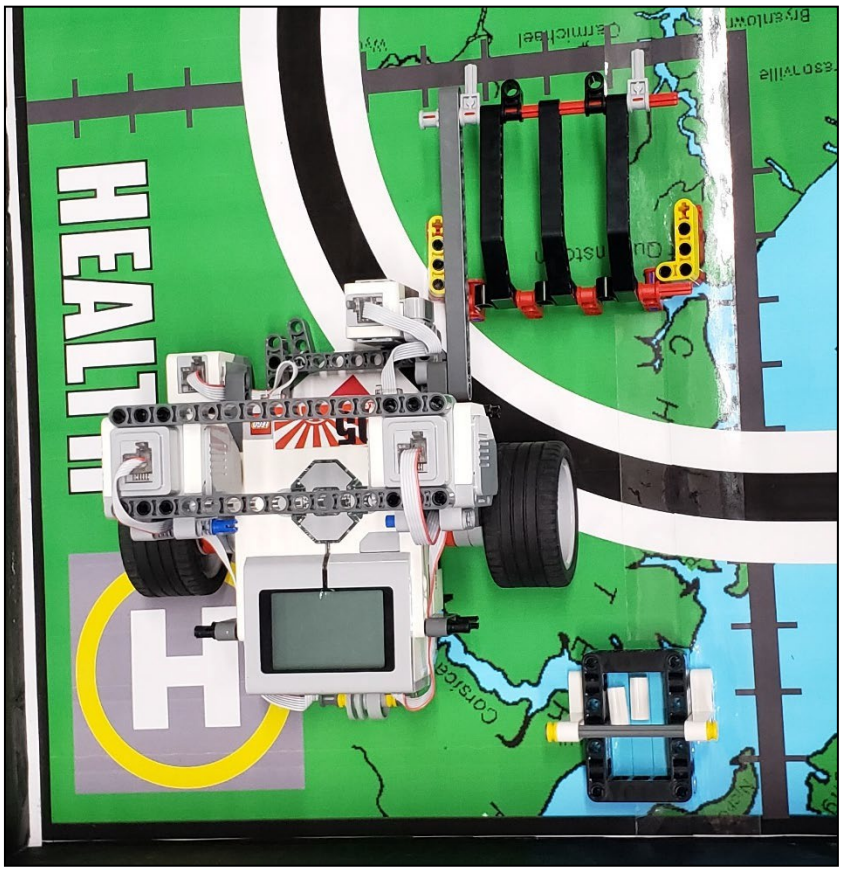
The robot may only be handled by the team members while the robot is in the Base Area. Once the robot completely leaves the Base area, or it makes contact with a Mission Model, then the mission is considered to be “under way.” The member cannot touch, or in any way influence the movement of, the robot or Mission Model until it comes back to Base (any part of the robot breaks the plane of the base) without a penalty. See section 6 for more about Robot Touch Penalties.

Any Mission Objects that are to be brought back to Base must cross into the Base before a member touches the robot. Any mission that was in progress will be terminated if a member touches or in any way interferes with the robot while the Mission Object is still outside of Base**. If scoring pieces are in the control of the robot and have not crossed into base, the points will not count, and the pieces cannot be used for further missions.**

Teams may re-run the mission, but Mission Models will remain where they are when the robot was touched. The robot may leave Base and return as many times as time allows.

3.3.3 Mission Objects in Base

Several Mission Objects start the challenge within the Base Area. These may be loaded onto the robot or its attachments by hand. Only the robot may move them out of, or back into base. Once they have left the base with the robot, they may not be manipulated by hand until they return back to base.



The mission models that start in Base include the baby oysters and the team made dock.

4 Game Rules

4.1 Mission Models

Mission Objects are constructed from a standard LEGO Education Spike Prime Accessory Kit. Instructions for construction of mission models will be provided on the State 4-H Robotics Challenge web site at https://bit.ly/MD4-HSTEM. Build instructions are provided in the form of assembly videos. As these videos may be updated to provide last minute changes, **the Models shown in the videos supersede images shown in this document**. Teams should make every effort to construct mission models according to the videos. A YouTube Video playlist can also be found here:

https://www.youtube.com/watch?v=qYGQICcYz6U&list=PLKxIFjlI_T1wFa6pLJPKgLiVoUVw8IZc1

UPDATE: For the 2023 4-H Lego game, only four mission models are dura-locked (or velcro-ed) to the Lego mat, to maintain their placement on the field during robot rounds. These mission models (explained more in Section 5) are the X, Y, Z rectangle, the dam, the trash bin, and the pier.

4.2 Robot Rounds

Each robot will play three rounds with the average of the three rounds contributing to their final contest score. Each robot round lasts for 2 minutes 30 seconds. The round will be started at the referee's call and the robot will be turned off by the referee at the end of the round if still in motion. Teams will be given a minimum of 10 minutes between rounds.

4.3 Robot Operators

Two members will be allowed at the table during the robot rounds. **Additional team members must stand in the designated area and may tag in and out during the round.**

4.4 Scoring of Mission Objects

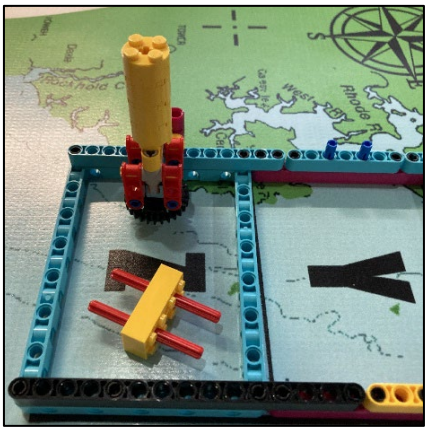
All scoring of robot missions is Based on the location of items at the end of the match. If an item is placed in scoring position and then moved by the robot, the item will receive the point for the final resting spot at the end of the match.

5 Missions

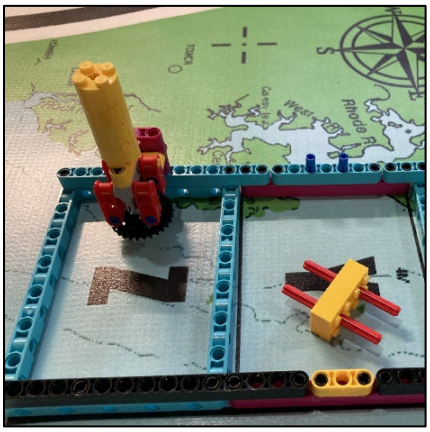
"Missions" are the definition of what the robot must do to gain points. Missions may be performed individually, or grouped together within a single program. Mission may have several different point values depending on the degree to which the mission is completed. Missions are defined in the following sections.

5.1 Placing the canoe in the marked area (Buoy marks the "safe area")

The robot must deliver the canoe to the area (X, Y or Z) indicated by the Buoy. If the team is going to attempt to use a sensor to detect the correct area, they must let the referee know before the match starts. The "Placing the Canoe" mission must be the first mission the team attempts in order to get the bonus score for placing the canoe in the designated area. Once the team is ready, they will signal the referee who will roll the dice and place the lighthouse in the corresponding area. **Once the referee rolls the dice, the team cannot touch their robot until the referee starts the match. When the referee says "go" the team may then ONLY push the start button.** If the robot successfully places the canoe completely in the designated square during their first mission, the team will earn 40 points. If the team places the canoe completely in any of the other squares, or at any time other than the first mission attempted, the team will receive 20 points. To earn the full credit for the mission (40 points), the canoe must be completely inside the area enclosed by the LEGO beams. Any canoe that is only partially in an area will only receive half credit for the highest scoring achievement.



A



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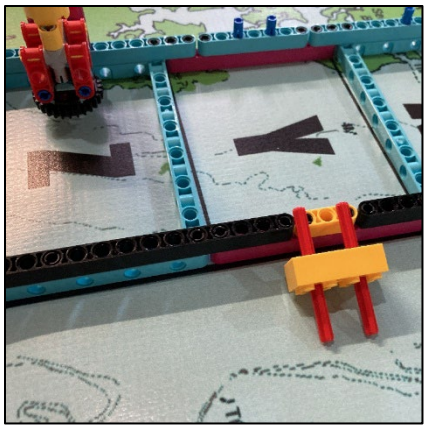


C

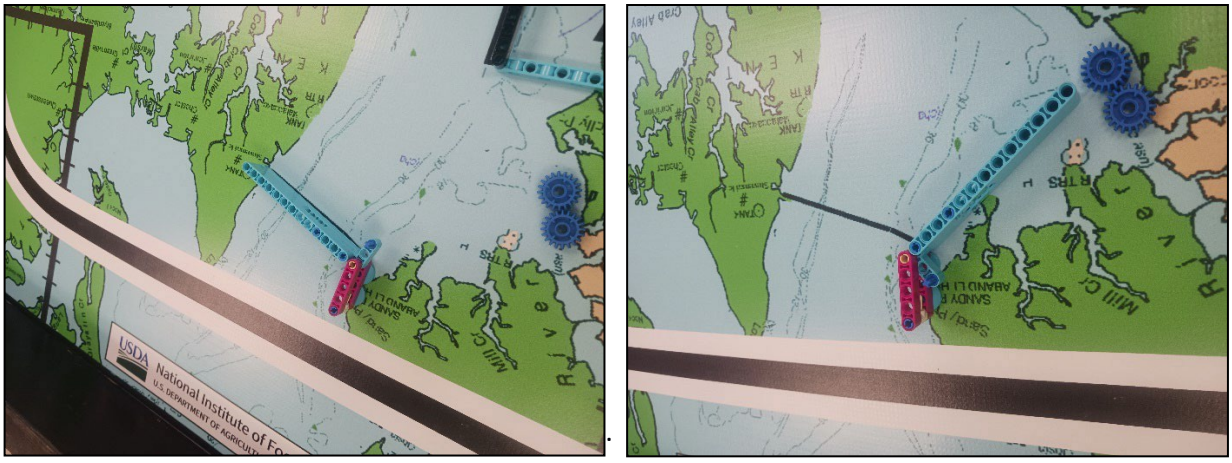
Picture A shows the canoe placed completely in the designated area. 40 Points.

Picture B shows the canoe completely in a non-designated area. 20 Points.

Picture C shows the canoe near a non-designated area. If the canoe oars had extended over to the inside of the contained area, it would be worth half points (10) since it's a non-designated area, but since the oars end above the LEGO beam, they are not inside the area at all, so they score zero points.

5.2 Opening the Dam

The robot needs to rotate the dam till it hits the stop for 10 points. **Note:** the Dam base will be dura-locked to the mat.



The picture above on the left shows the dam at its starting location. The picture on the right shows the dam in the open position.

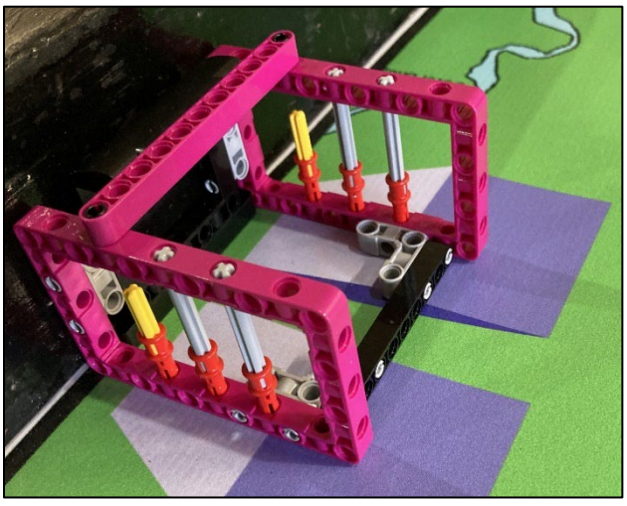
5.3 Collect Invasive Species

The robot will collect the invasive species from the yellow circles and take to base. Each invasive species in base is worth 5 points.

Invasive Species (red LEGOs) on yellow circles

5.4 Collect Trash and Place in Trash Bin

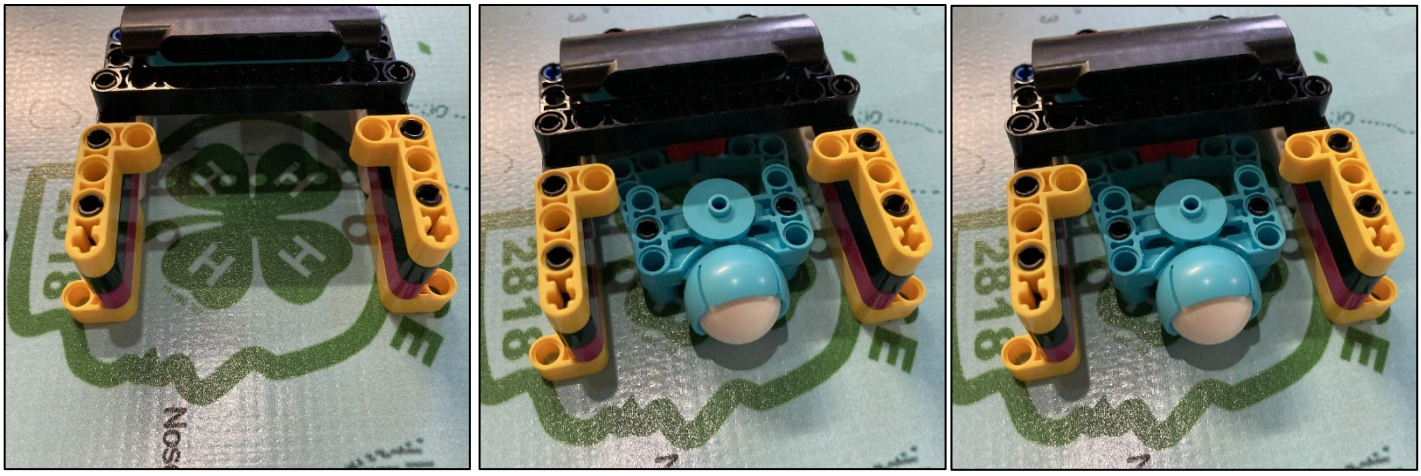
The robot will collect trash (white pieces) from the brown circles and place them in the trash bin.



The picture on the left shows the trash (white LEGOs) in the starting position on the brown circles. The picture on the right shows the trash in the trash bin. Trash completely in the bin, behind the black beam will count 10 points each.

5.5 Harvest Blue Crab

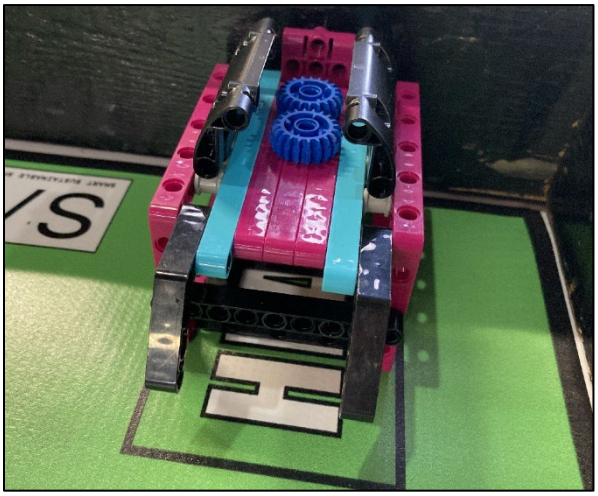
The robot must remove the crab from the cage and return to base. The cage must remain on the board touching some part of GEARS island. 20 points for crab in base if the cage is touching the island.



The left picture shows the position of the crab cage at the start of the match. The cage is centered on the 4-H clover. This position is fixed. To earn the points, the cage must remain on the field touching some part of "GEARS Head Island" as defined as the thick green line forming the outline of the head. Team can place crab in any orientation inside cage prior to starting match. It must be fully inside the cage perimeter. Once the match starts the crab can no-longer be moved by hand.

5.6 Place the Small Crabs in the Water

The robot must remove the crabs from the pier and return them to the water. 10 points for each crab on blue water.



The picture above shows the crabs on the pier in the starting position (HEAD).

5.7 Build a Fishing Dock

Teams will build a "dock" which will start in base and the robot will deliver it to Horn Point. The dock must be touching the yellow star. The dock must be a minimum of 6 LEGO spaces long, 4 LEGO spaces wide and 1 LEGO spaces thick and maximum of 10 LEGO spaces long, 6 LEGO spaces wide and 3 LEGO spaces thick. The team must show their dock to the referee before the start of the match to verify the size. Placing the dock will be worth 20 points.

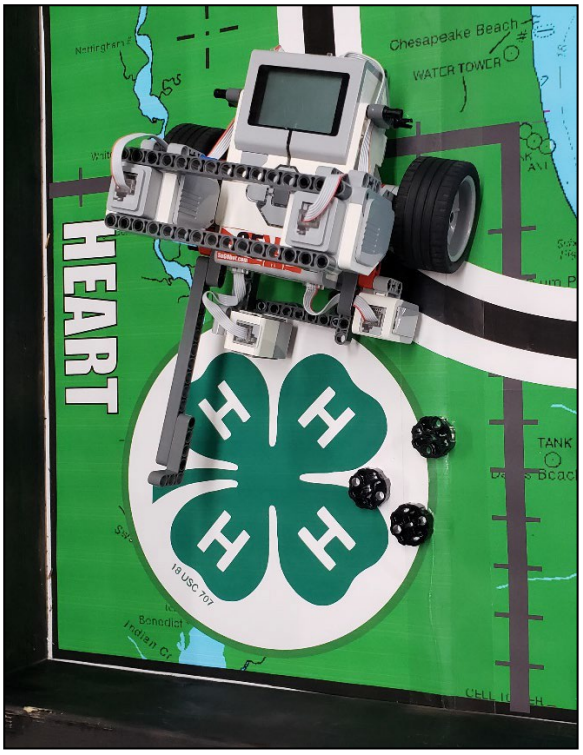
The picture above shows an example dock touching the yellow star at Horn Point.

5.8 Place the Oyster Spat in the ABC Area

The robot should deliver the Oyster Spat (start in base) to the ABC Area (Lego pieces must be completely inside the ABC area. 2 point each in base and 4 points each in the ABC area.

5.9 Park in Heart Area

If the robot is parked fully in the Heart area at the restaurant at the end of the match the robot will receive 10 points.



6 Touch Penalties

During the robot round, if the robot is touched while the robot is completely outside of the Base area it must be brought back to Base immediately and the team will be assessed a touch penalty. To assess the touch penalty, the referee will take one of the oyster spat for each touch penalty.

7 Team Notebook

Each team should document the building of their robot in a journal. Each day that the team meets: record plans for the day, pictures and diagrams of robot building process, and ending reflections. The notebook will be shared with the judges during the technical presentation.

8 Technical Presentation

Each team will be assigned a 10-minute time period prior to the robot rounds to present to a panel of judges their robot's design. The presentation should include information on the team's design features, game strategies and programming. A game table with mission models will be provided. The team may utilize the game table to demonstrate the robot completing missions. A panel of 2-4 judges will rate the team's technical presentation based on the Technical Rubric (Appendix A). The team will be assigned a numerical score between 0 and 100.

9 Service Project

Through the service project, the team should conduct a service project related to protecting waterways. The team should share their project with a community organization or in an appropriate manner to help educate the public about waterway protection. If a robotic program has multiple teams doing the same or a similar community service projects, be clear in explaining the roles of the team members in conducting the project.

9.2 Project Display

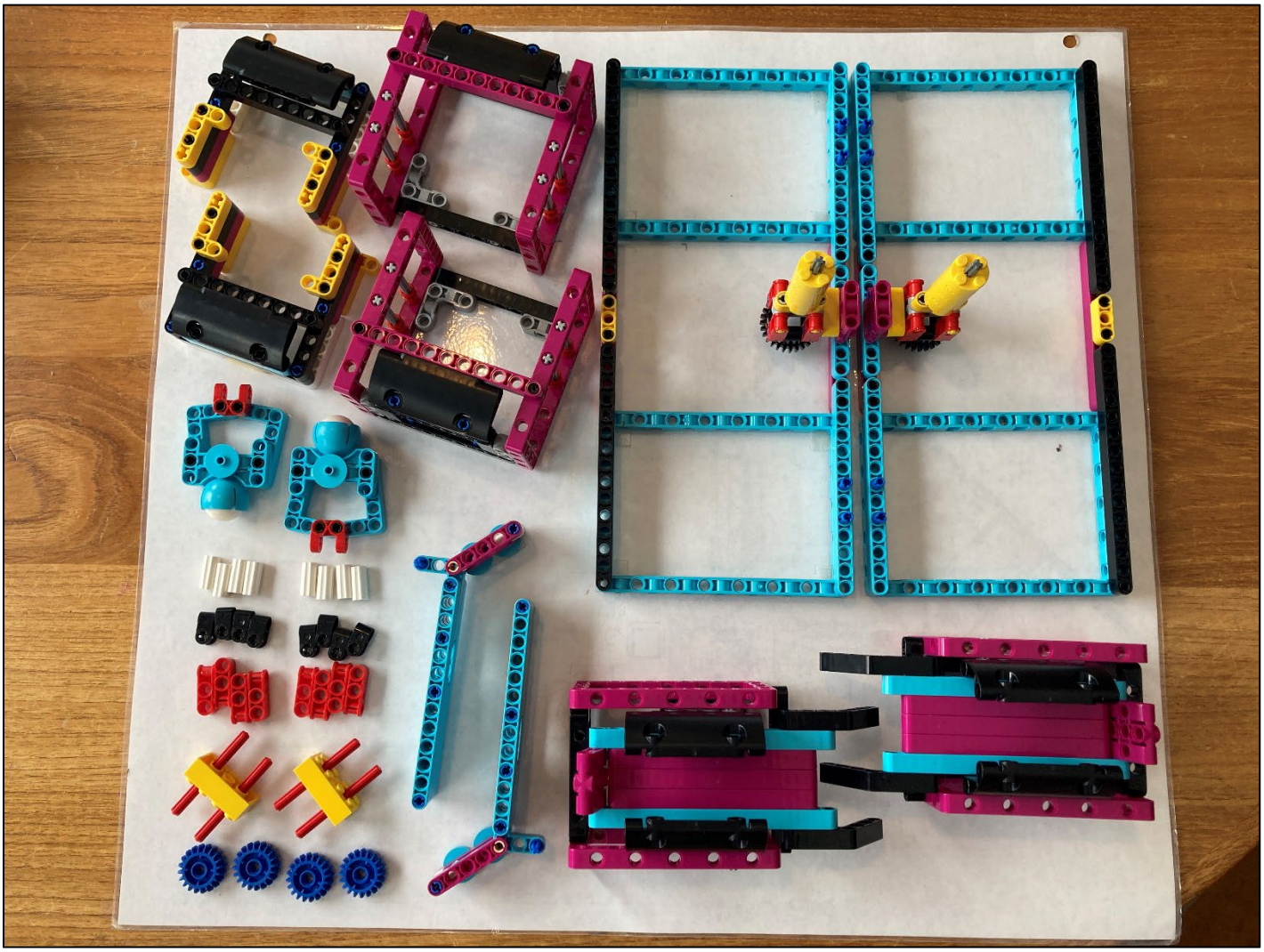
The teams should create a tabletop display that will explain their service project. The board should be displayed during the competition on the team's pit table and can be used during their presentation.

9.3 Project Presentation

Teams should be ready to present a 3-5 minute presentation about their project to a panel of judges. The judges will then have 5 minutes to ask questions to the team.

10 Mission Point Scoring summary

Mission	Description	Point Value
5.1 Canoe	If the canoe is placed in the designated area on the first mission (Half credit for canoe not completely in the designated area.) **OR** If the oyster canoe is placed in a non-designated area during the first mission, or any area during any mission run after the first mission. (Half credit for canoe not completely in the designated area.)	**40 points (FULL)** **20 points (HALF)** **OR** **20 points (FULL)** **10 points (HALF)**
5.2 Open Dam	The dam is completely open	**10 points**
5.3 Collect Invasive Species	Invasive species in base	**5 points per invasive species** **20 points**
5.4 Collect Trash	Trash collected and placed in the trash bin	**10 points each** **40 points**
5.5 Harvesting Crab	Collect Crab from Cage – Cage must remain on board touching “Gears Head Island”.	**20 points**
5.6 Return Small Crabs to Water	Small Crabs must be touching water	**10 points each** **20 points**
5.7 Build Fishing Dock	Dock at Horn Point touching the yellow star.	**20 points**
5.8 Oyster Spat to ABC area	Spat completely inside of ABC area.	**2 points each in Base** **4 points each in ABC area** **20 points**
5.9 Park in Heart	Robot completely inside of the Heart area	**10 points**
		Total Possible: 200 points



This photo shows two complete field setups. Each component is shown from two different directions.

See the mission-piece build guide videos for details on building each component:

https://extension.umd.edu/programs/4-h-youth-development/program-areas/stem

Appendix A - Maryland 4-H Lego Robotic Challenge – Robot Technical Presentation Rubric

Robot Design	Evidence of structural integrity, constructed in a manner to allow for multiple tasks appropriate for the game, efficient use of parts.				
	Beginning (1-point each)	Developing (2 points each)	Accomplished (3 points each)	Exemplary (4 points each)	Score
	O Quite fragile & breaks a lot O Repairs and adding attachments take considerable time O Little use of manipulators O No sensors used for positioning O Very basic robot design	O Frequent faults or repairs O Parts of the robot do not fit well together O Simple manipulators O Limited or no use of sensors O Basic robot design with good balance	O Limited faults or repairs O Parts of the robot fit and function well together O Manipulators are designed and function well O Use of sensors for basic positioning O Robot design is sound and functions well with game	O No faults or repairs needed O Robot is streamlined and functions as a unit O Manipulators are well designed and perform tasks efficiently O Use of sensors for accurate positioning O Robot design is well thought out and performs task every time	
Strategy & innovation	Ability to develop and explain improvement to robot design that happened throughout the season including methods for making decisions and testing. Ability to clearly define and describe team goals and strategies for accomplishing goals. Creation of new, unique or unexpected features that are beneficial in performing the specific tasks.				
	Beginning (1 point each)	Developing (2 points each)	Accomplished (3 points each)	Exemplary (4 points each)	Score
	O Organization AND explanation of the team needs improvement O No clear goals O No clear strategy for accomplishing the mission O Robot has typical features and operates as expected	O Either team organization OR explanation needs improvement O Goals setting is ambiguous O Strategy is unclear O Robot has minimal features that are innovative	O Organization of the team is systematic and well explained O Team has good goals O Team has a clear strategy to accomplish tasks O Robot has features that are innovative that allow it to accomplish goals and strategies	O Organization is systematic, well explained and well documented O Team has document goals O Team has clear strategy to accomplish most/all game missions O Robot has many innovative features which allows the team to accomplish most/all game missions with accuracy	
Programing	Programs are appropriate for the intended purpose and would achieve consistent results, assuming no mechanical faults. Programs are modular, streamlined and understandable with documentation. Ability of the robot to move or act as intended using mechanical and/or sensor feedback (with minimal reliance on driver intervention and/or program timing).				
	Beginning (1 point each)	Developing (2 points each)	Accomplished (3 points each)	Exemplary (4 points each)	Score
	O Program is very basic relying on no feedback from the field O Program is not documented O Program is difficult to understand O Excessive driver interaction needed to aim/set robot before each mission O Robot completes missions infrequently or only after multiple attempts.	O Program is basic relying on little feedback from the field for positioning. O Program documentation is not complete O Program contains inefficient code O Driver must spend time to aim/set the robot before each mission. O Robot completes missions inconsistently or only after a few attempts.	O Program uses field or sensors to determine robot position on the field. O Program is documented and easy to understand O Program uses appropriate code complexity for tasks completed O Driver spends little time aiming/setting the robot before each round. O Robot completes missions consistently most of the time.	O Program uses complex code and sensors to determine position on the field. O Program is well documented and is easy for anyone to understand O Program uses streamlined code. O Robot position at the beginning of the match is not relying on driver aiming O Robot completes missions nearly every time and regardless of field conditions.	
			Over for Comments	Total Score	