2020

4-H LEGO Robotics Challenge:
Agricultural Innovations

In

Rural and Urban Communities

Document Rev 1.0  2/2/2020   Original

Document Rev 1.1  4/22/2020   Added SPIKE to allowable Bricks and opened up software.
                                 Fixed water Valve Image and High Tunnel section number.
2020 4-H LEGO Robotics Challenge

Agricultural Innovations in Rural and Urban Communities

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 easily 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 2020 game. If you have any questions contact Willie Lantz at the Garrett County Extension office at 301-334-6960 or wlantz@umd.edu.

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1 Teams and Coaches

Teams will consist of 3 to 8 members. The age range of team members may be defined by the local event organizers. Coaches of teams need to be official UME volunteers. If you are not a UME volunteer, contact your local extension office or the Maryland State Office at 301-314-9070 for information on becoming an official volunteer. Coaches also need to register through Maryland 4-H Online. A link is provide on the Maryland 4-H Robotics Page at http://extension.umd.edu/4-h/4-h-program-areas/robotics-0. Coaches who are registered will receive updates on the game and competitions. Each team can register multiple coaches. Please do not register youth team members. There will be a later registration date for the Maryland State 4-H Robotic Challenge.

2 The Game

Team members will construct a robot, using ONLY LEGO parts. The robot will be controlled by a programmable LEGO Brick, and must perform specific tasks autonomously once it leaves base. The team will have 2 minutes and 30 seconds to perform as many tasks as possible. Tasks can be performed in any order and combination.

2.1 Competition kit

The competition kit comprises the playing field “mat” and the Mission Models. The mission models are constructed from a standard LEGO EV3 accessory kit of parts. Competition kits can be shared among multiple teams.

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.

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 LEGO Programmable Brick (RCX, NXT, EV3 or SPIKE Prime) and any additional official LEGO parts. Non-LEGO parts will not be allowed. The robot may be programmed with any LEGO compatible 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/color 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 2020 LEGO Robotics Challenge, the Base Area is located in the South Corner of the mat. The actual base area includes the THICK perimeter line, but not the thin lines that extend beyond the THICK line.

3.3 Robot Operation
3.3.1 Robot in Base
While in Base, members may 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.
4 Game Rules

4.1 Mission Models
Mission Objects are constructed from a standard LEGO Education MINDSTORMS EV3 Expansion kit (6082064). Instructions for construction of mission models will be provided on the State 4-H Robotics Challenge web site at https://extension.umd.edu/4-h/4-h-program-areas/robotics-0. 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://bit.ly/2UiTsQj

The field(s) at the competition may not be altered by teams. Leeway may be given if discussed with the referee.

4.2 Robot Rounds
Each robot will play three rounds with the highest score of the three rounds counting toward the final award. Each robot round will last for 2 minutes 30 seconds. The round will be started at the referees call and the robot will be turned off by the referee at the end of the round. 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  Aquaculture - Stock the Pond

The robot must deliver the fish from base to the 4-H Clover. All parts of the fish must be inside the outside edge of the red part of the circle. The team will receive 20 points for delivering the fish.

Fish completely inside the red circle – 20 points

Fish not completely inside the red circle – no points

5.2  Automation - Feed the Cows

The robot must deliver the hay bales to the dairy farm. The bales must be breaking the plane of the small black circle. The team will receive 5 points per bale that is delivered for a total of 20 points.

The 4 bales start in the orange boxes as shown in the photo on the left. The bales must be breaking the plane of the small black circle of cows for the team to receive points.
5.3 **Automation - Milk the Cows**
The robot must collect the milk from cow section and deliver it to base. The milk in base the milk is worth 25 pts.

![The milk starts in the cow section.](image1)

![Milk in base for 25 points](image2)

5.4 **Urban Farming - Build a Rooftop Garden**
The robot must transfer the garden from base to the urban center and place it on top of the building to receive 35 pts.

![The garden must be on top of the building and be completely supported by the building](image3)

5.5 **Automation - Water Valve**
The robot must turn the water valve at least 90 degrees in either direction to be activated. The valve indicator will start pointing straight up. The team will receive 40 points for completing this mission.

![The valve indicator starts straight up as shown in the photo on the left and must be moved at least 90 degrees in either direction to score.](image4)
5.6 Automation - Robotic Weeding

The robot must knock over the weed, (the tallest plant) without knocking over any of the other plants to receive 30 points. The team will not receive any points for this mission if any of the other plants are knocked over.

5.7 Precision Agriculture - Remote Sensing

The robot must locate the field with deficient nutrients and apply fertilizer. The deficient nutrient field has a black insert. There are 6 pieces of fertilizer. If a team plans to place the fertilizer, they must notify the referee and run this as their first mission. Once the teams have started their program and are ready to run the mission, the referee will randomize the field with the black insert by rolling a dice. After the field is randomized, the team cannot push any buttons on their robot except the start button when the game begins.

The team will receive 15 points for each fertilizer placed in the nutrient deficient field during their first mission. Teams will receive 7 points for each fertilizer placed in any field during the remainder of the game. Each fertilizer in base at the end of the game is worth 5 points.
5.8 **Automation - Egg Collection**

The robot must collect the eggs from the four green circles in the middle of the field and deliver them to base. If the eggs are moved off the circles and are not in base, the team will lose 2 points per egg. Each egg in base is worth 5 points.

6 fertilizers placed in any field after the first mission, are worth 45 points.

5.9 **Urban Farming - High Tunnel**

The robot must relocate the high tunnel from the Head zone to the urban center for 20 points. As long as any part of the high tunnel crosses the black line in the urban center area the team will receive points.

The eggs start on the green circles as shown above and must be placed in base to score.

The high tunnel starts in the Head zone. The team will receive points any part of the high tunnel crosses the black line as shown in the photo on the right.
6 Touch Penalties

If the robot is touched 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 pieces of fertilizer away for each touch penalty. The referee will start by taking away pieces of fertilizer from base. The referee will then take away pieces of fertilizer from the field.

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 teams 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 research agricultural innovations in communities similar to the community the team lives in. The team should share with community organizations and leaders about the agricultural innovations they learned about. 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.

9.1 Project Display

The teams should create a table top 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.

9.2 Project Presentation

The team will present a 3-5 minute presentation about their project to a panel of judges. The judges have 5 minutes to ask questions.
### 10 Mission Point Scoring summary

<table>
<thead>
<tr>
<th>Mission</th>
<th>Description</th>
<th>Point Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.1 Stock the Pond</td>
<td>The fish must be completely inside the red circle of the 4-H emblem.</td>
<td>20 points</td>
</tr>
<tr>
<td>5.2 Feed the Cows</td>
<td>The four hay bales must break the plane of the inside black circle</td>
<td>5 points per bale of hay</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Maximum 20 points</td>
</tr>
<tr>
<td>5.3 Milk the Cows</td>
<td>The milk is delivered to base</td>
<td>25 points</td>
</tr>
<tr>
<td>5.4 Roof Top Garden</td>
<td>The garden is placed on top of the building in the Urban Center.</td>
<td>35 points</td>
</tr>
<tr>
<td>5.5 Water Valve</td>
<td>The water valve must be turned at least 90 degrees from starting point (straight up)</td>
<td>40 points</td>
</tr>
<tr>
<td>5.6 Robotic Weeding</td>
<td>The tallest weed is knocked over and the other plants in the garden remain standing.</td>
<td>30 points</td>
</tr>
<tr>
<td>5.7 Precision Agriculture</td>
<td>Fertilizer in nutrient deficient area during the first mission</td>
<td>15 points each</td>
</tr>
<tr>
<td></td>
<td>Fertilizer in any field outside of the nutrient deficient area during the first mission.</td>
<td>7 point each</td>
</tr>
<tr>
<td></td>
<td>Fertilizer in base</td>
<td>5 points each</td>
</tr>
<tr>
<td></td>
<td>Maximum 90 points</td>
<td></td>
</tr>
<tr>
<td>5.8 Egg Collection</td>
<td>Eggs collected and delivered to base are 5 points each. Any egg left on the field outside the starting location earns a 2 point penalty.</td>
<td>5 points each</td>
</tr>
<tr>
<td></td>
<td>Maximum 20 points</td>
<td></td>
</tr>
<tr>
<td>5.9 High Tunnel</td>
<td>High tunnel in the Urban Center</td>
<td>20 points</td>
</tr>
<tr>
<td></td>
<td>Total Possible: 300 points</td>
<td></td>
</tr>
</tbody>
</table>

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

### Robot Design
- **Beginning (1 point each)**
  - Quite fragile & breaks a lot
  - Repairs and adding attachments take considerable time
  - Little use of manipulators
  - No sensors used for positioning
  - Very basic robot design

- **Developing (2 points each)**
  - Frequent faults or repairs
  - Parts of the robot do not fit well together
  - Simple manipulators
  - Limited or no use of sensors
  - Basic robot design with good balance

- **Accomplished (3 points each)**
  - Limited faults or repairs
  - Parts of the robot fit and function well together
  - Manipulators are designed and function well
  - Use of sensors for basic positioning
  - Robot design is sound and functions well with game

- **Exemplary (4 points each)**
  - No faults or repairs needed
  - Robot is streamlined and functions as a unit
  - Manipulators are well designed and perform tasks efficiently
  - Use of sensors for accurate positioning
  - Robot design is well thought out and performs tasks every time

### Strategy & Innovation
- **Beginning (1 point each)**
  - Organization AND explanation of the team needs improvement
  - No clear goals
  - No clear strategy for accomplishing the mission
  - Robot has typical features and operates as expected

- **Developing (2 points each)**
  - Either team organization OR explanation needs improvement
  - Goals setting is ambiguous
  - Strategy is unclear
  - Robot has minimal features that are innovative

- **Accomplished (3 points each)**
  - Organization of the team is systematic and well explained
  - Team has good goals
  - Team has a clear strategy to accomplish tasks
  - Robot has features that are innovative that allow it to accomplish goals and strategies

- **Exemplary (4 points each)**
  - Organization is systematic, well explained and well documented
  - Team has document goals
  - Team has clear strategy to accomplish most/all game missions
  - Robot has many innovative features which allows the team to accomplish most/all game missions with accuracy

### Programming
- **Beginning (1 point each)**
  - Program is very basic relying on no feedback from the field
  - Program is not documented
  - Program is difficult to understand
  - Excessive driver interaction needed to aim/set robot before each mission
  - Robot completes missions infrequently or only after multiple attempts.

- **Developing (2 points each)**
  - Program is basic relying on little feedback from the field for positioning.
  - Program documentation is not complete
  - Program contains inefficient code
  - Driver must spend time to aim/set the robot before each mission.
  - Robot completes missions inconsistently or only after a few attempts.

- **Accomplished (3 points each)**
  - Program uses field or sensors to determine robot position on the field.
  - Program is documented and easy to understand
  - Program uses appropriate code complexity for tasks completed
  - Driver spends little time aiming/setting the robot before each round.
  - Robot completes missions consistently most of the time.

- **Exemplary (4 points each)**
  - Program uses complex code and sensors to determine position on the field.
  - Program is well documented and is easy for anyone to understand
  - Program uses streamlined code.
  - Robot position at the beginning of the match is not relying on driver aiming
  - Robot completes missions nearly every time and regardless of field conditions.

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<table>
<thead>
<tr>
<th>Score</th>
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