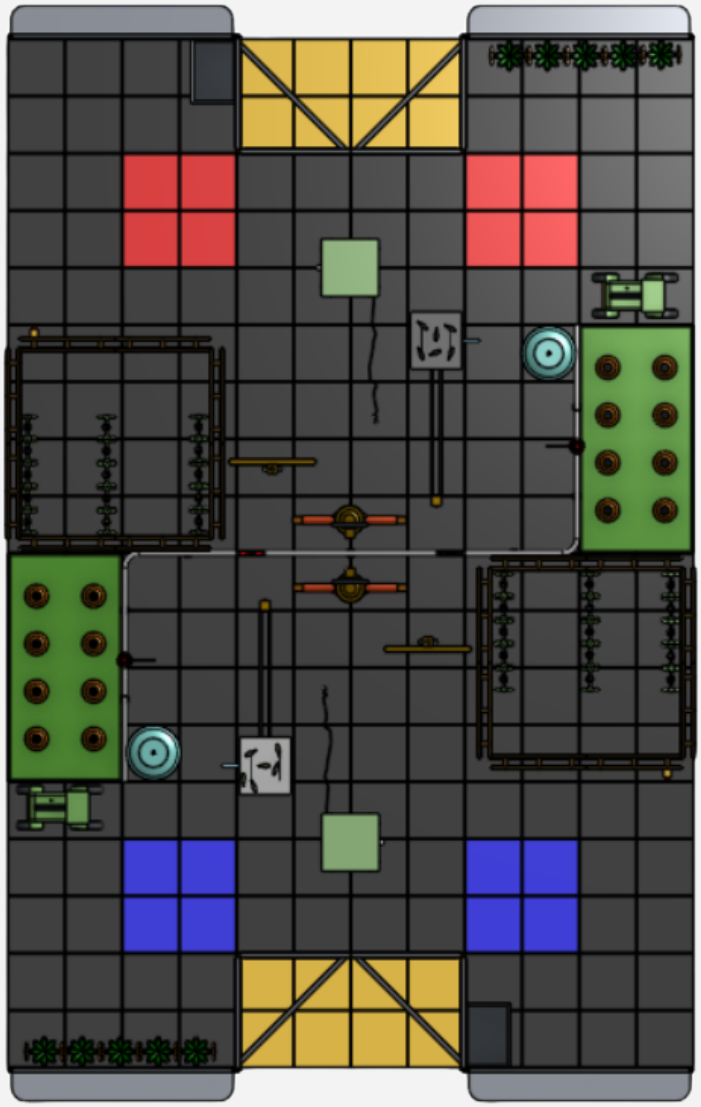
ROBOT DRONE LEAGUE

SCARECROW

PRESENTED BY STREAMWORKS

2023 Official Challenge Manual

2023 SCARECROW - Official Field



Three Laws of Robotics

1. *A robot may not injure a human being or, through inaction, allow a human being to come to harm.*

2. *A robot must obey the orders given it by human beings except where such orders would conflict with the First Law.*

3. *A robot must protect its own existence as long as such protection does not conflict with the First or Second Laws.*

~Isaac Asimov

And one more….

4. *A robot may not intentionally injure another robot unless the action or inaction conflicts with the First, Second, or Third Laws. ~ Scooter Willis (Creator of RDL)*

"The industrial revolution in the 19th century and the digital revolution in the 20th century forever changed our world, adding speed and efficiency to almost every aspect of our lives. The 21st century is ushering in a third revolution, one that uses biology to meet local and global challenges. The RDL SCARECROW Challenge integrates these three revolutions, asking students to solve emerging agricultural problems in novel ways."

- **Dr. Natalie Kuldell,**
  Executive Director- *BioBuilder*

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Revisions Date	Page	Notes
October 7, 2023.	**Pgs. 10, 11, 13, 14, 20, Index.**	**Added "last 2-minute period" info, updated beacon specifications, corn height differentiation, edits to power line task, and added example sheets for solar panel optimization, fungi identification, and beetle identification.**
December 14th, 2023	**Pg. 28**	**Added specific information for championship match and queue procedures to be used at competition**

Table of Contents

Introduction

Creativity and innovation are key elements to advancing the fields of science, technology, engineering, and mathematics (STEM) into the future. Robot Drone League (RDL) has been designed to provide students with open-ended challenges that allow for creation and innovation by engaging in hands-on design, engineering, and programming of interactive robots and drones. Students are presented with the opportunity to develop real-world connections to classroom learning. Working with robots in a collaborative game format can be a very powerful tool to engage students and enhance math and science skills through hands-on, student-centered learning. Through participation in RDL, students can develop the essential life skills of teamwork and collaboration, as well as critical thinking, project management, and communication required to become the next generation of innovators and problem-solvers in our global society. The 2023 RDL "SCARECROW" Challenge, presented by STREAMWORKS, is designed to inspire students to develop a lifelong passion for learning and pursuing educational and career opportunities in STEM fields by implementing real-world STEM-related problems that require innovative and critical thinking to find solutions.

For additional information, please contact:

Dennis Courtney

Executive Director of STREAMWORKS

dcourtney@streamworkeducation.org

Please visit www.robotdroneleague.com

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ROBOT DRONE LEAGUE

Challenge Overview

RDL 2023 Challenge: SCARECROW

In this scenario, agricultural crops across the globe are being ravaged by fungi and insects. These new diseases are infesting crop lands and agricultural food resources, devastating a vital global crop: corn. It's clear that governments, farmers, and scientists face a significant challenge. The global population now exceeds 8 billion people, and while there is normally enough food to support all the people alive on the planet, data shows that there is a steady increase in food insecurity, affecting 10% of the world population. Compounding the food shortages of today are the economic effects of the COVID-19 pandemic and the war in Ukraine. And looking ahead, it's calculated that we must increase food production by 70% to meet the needs of a population of 10 billion people by the year 2050. Unless we change the way we currently farm, more food production will mean more carbon emissions and increasing deforestation. Scientists are investigating the causes of the agricultural crisis, considering the impact of a changing climate and emerging patterns of resistance in what were disease and insect-resistant food plants. Engineers are considering different ways to solve the crisis. Pesticides, which are dangerous to humans and animals, do not seem like the best solution. The scientists and engineers at BioBuilder and Robot Drone League need your help!

The Challenge: Synthetic biology is an emerging field that fuses the mindset and tools of engineering with the understanding and know-how of life science. By applying modern biotechnology tools at scale, it is increasingly possible to counter harmful biology in all its forms and origins. The positive impact of synthetic biology on agriculture has grown over the last few years. The starting point is this: DNA is the coding language for all life forms. And because the code has common features across species, programming that code is becoming reliable, faster, and less expensive all the time. So, in much the same way that a software developer could write a computer program and execute it with an operating system, a synthetic biologist could write a DNA program and execute it in a cell. Depending on the complexity of the "genetic circuits," the DNA code can function predictably and reliably when implemented in living organisms. (Amack, Atunes; 2020)

The team at BioBuilder has offered to help engineer a solution that will fight off the fungi that are infesting the global corn crops. Their first step is to identify which fungus is killing the corn, and their second step is to precisely engineer a small section of the corn's DNA to make it resistant to the infection. The work will be challenging. Not only does the BioBuilder team need dozens of samples to test and analyze, but the reprogrammed corn seeds must be generated and then returned to the field quickly, before they germinate.

It is not possible to know in advance how successful this work will be, but the need is urgent, time is critical, and not one moment can be wasted. Therefore, BioBuilder has developed a Mobile Accelerator which is at the ready with automated processes to reprogram samples supplied by the robots and drones. Within the Mobile Accelerator, the fungal infection will be identified and a small snippet of the corn's DNA will be rewritten to make the crop disease-resistant. A BioBuilder scientist embedded within the Robot Drone League team will need to inspect the corn sample prior to returning it to the field.

BioBuilder needs the aid of the Robot Drone League for sample collection and the processing of expedited genetic testing. There are concerns and challenges in and around the fields where testing is to be conducted. Due to recent heavy storms and unusually large amounts of rainfall, likely attributed to climate change, the agricultural fields where the testing needs to take place are likely not accessible by humans. The field soil where rows of both healthy and diseased corn are growing is unstable and muddy. Therefore, specialized machines must be used to inspect and access the field to perform the work of collecting specimens for experimental bioengineering.

Robotics teams will need to be cautious and innovative. Power outages in the area have been reported and must be restored before work can begin in the lab. A downed power line is the likely culprit and must be repaired and power restored to the area. Access to the agricultural field is controlled by an electric gate and the BioBuilder accelerator operates from the same power source. The accelerator also requires ample amounts of water to operate but due to the extreme flooding and downed power lines, has been turned off at the main shut-off valve. The water main supply can be turned on mechanically or electrically at the valve.

The onsite BioBuilder Mobile Accelerator will help speed up the process of precisely programming the agricultural products. The Robot Drone League has intentionally challenged specialized and independent teams to compete for the best use of this synthetic biology processing technology in the SCARECROW arena.

Game Rules

Object of the Game

The object of the game is to successfully complete as many of these tasks as possible within a ten-minute match, with the first sixty seconds being the autonomous period (**QUADRUPLE** points). RDL - SCARECROW is played on a 7.3 m by 11.0 m indoor enclosed field, surrounded and separated into equal halves by a combination of game elements designed for the current RDL challenge, SCARECROW. The two field sides are mirror images of each other. Two teams make up an alliance, and compete against two other teams, making up an opposing alliance. The goal: score higher than the opposing alliance. In the last two minutes of the match, teams are allowed to cross the field into the opposing alliance side and score elements once brought to their alliance side.

Alliances & Matches

Alliance Selection and Point System:

- There will be two alliances competing against each other: the Red Alliance and the Blue Alliance.
- Each alliance will consist of two teams. The teams will be assigned to alliances after random selection at the start of the competition, during round-robin matches, alliances will change.
- The competition will consist of several matches, with each alliance competing against another alliance.
- After the initial placement matches, the top-performing teams with the highest **match scores** will be allowed to select the alliance they want to join. The team with the highest alliance score (of their two runs) will be chosen to select first, followed by the team with the second-highest alliance score, and so on.
- Once all teams have been assigned to alliances, the alliances will compete against each other in an elimination-style tournament.
- Points will be awarded to each alliance based on their performance in each round.
- After the completion of each match, the winning alliance will continue on in the tournament, with the losing alliance (both teams) being eliminated from the bracket.
- At the end of the tournament, there will remain one undefeated alliance that will be pronounced “RDL Alliance Champions”

In addition to the alliance competition, individual teams may also be eligible for prizes based on their performance in specific tasks or objectives.

Mission Task: "Water Works Repair" - 100 Points

Assigned Mission Task - program or operate a robot that can repair a broken water irrigation pipe. The robot must navigate to the location of the broken pipe, turn off the water flow by turning a valve, replace the damaged section of the pipe with a new section, and finally, turn the water back on.

Specific requirements for the mission include:

1. Navigation: The robot must navigate to the location of the broken pipe without colliding with any obstacles. The teams will know which pipe replacement is theirs, as the pipe section will be either red or blue.

2. Valve Control: The robot must be able to locate and turn off the valve that controls the water flow to the damaged section of the pipe. Once the valve is turned off, the robot may proceed with the next task. **+ 20 Points**

3. Pipe Replacement: The robot must remove the damaged section of the pipe and replace it with a new section. The robot must ensure that the new section is securely attached and that there are no leaks. **+ 25 Points** for retrieval; **+ 35 Points** for replacement

4. Water Turn-On: After replacing the damaged section of the pipe, the robot must turn the water back on by turning the valve back to its original position. The robot must confirm that the water flow has been restored. **+ 20 Points**

Teams will be judged based on their ability to complete the task accurately and efficiently within the given match. Good luck!

Mission Task: "Solar Panel Optimization" - 100 Points

Assigned Mission Task - program or operate a robot that can optimize the placement of a solar panel. The human participants must first determine the optimal angle and location for the solar panel using mathematical calculations at the lab station. Upon determining the optimal angle and location, the participants must use a drone to clean the solar panel of leaves and debris. Once the solar panel is clean, your robot must place the solar panel in the optimal location as determined by the human participants and adjust its angle to match the optimal angle previously determined at the lab station.

Specific requirements for the mission include:

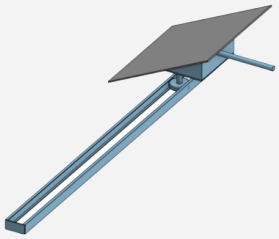
1. *Math Calculations*: The human participants must calculate the optimal angle and location for the solar panel using the provided data. The angle and location will be determined by the position of the sun and the location of the solar panel. **+ 50 Points**

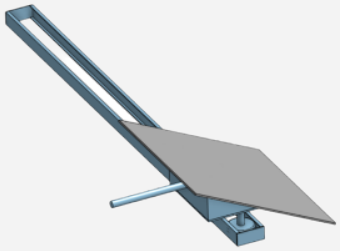
2. *Drone Cleaning:* The human participants must use a drone to clean the solar panel of all leaves and debris. The drone must be flown over the solar panel and use its downward prop wash to blow away any leaves and debris. **+ 15 Points**

3. *Solar Panel Placement*: The robot must navigate to the solar panel and pick it up. The robot must then place the solar panel in the optimal location as determined by the human participants. **+ 15 Points**

4. *Solar Panel Angle Adjustment:* Once the solar panel is in the optimal location, the robot must adjust the angle of the solar panel to match the optimal angle previously determined at the lab station. **+ 20 Points**

Subtask 1 (*Math Calculations)* and Subtask 2 (*Drone Cleaning)* **can** be done in any order. What is important, is that the panel must be clean before it is able to produce electricity, (thus giving the team points.)





Mission Task: "Corn Field Harvest" - 240 Points

Assigned Mission Task - program or operate a robot that can harvest corn from a field. The field is enclosed by a fence structure that is only accessible at the gate entrances. The robot must first approach the field and make solid contact with the gate button to release the gate and gain access to the field. After gaining access to the field, the robot must collect the harvestable corn for points. There will also be dead and diseased corn that the robot must retrieve and take to the lab station for genetic editing to generate new corn that can fight the various types of fungi that are killing it.

Specific requirements for the mission include:

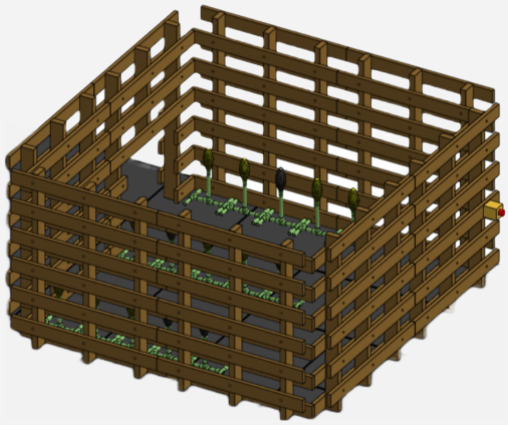
1. *Button Access*: The robot must navigate to the button and hit it to gain access to the field. The button will open the gate that grants the robot access to the field. **+ 15 Points**

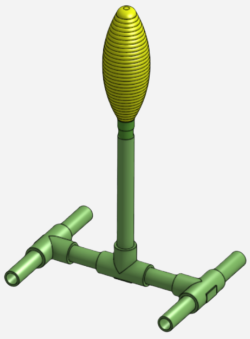
2. *Corn Harvest*: The robot must navigate through the cornfield and collect the good harvestable corn for points. **+ 5 points (low stalk); 10 points (middle stalk) 15 points (high stalk)**

3. *Dead and Diseased Corn Retrieval*: The robot must also collect the dead and diseased corn and bring it to the lab station for genetic editing. **+ 5 points (low stalk); 10 points (middle stalk)**

4. *Genetic Editing*: The human participants at the lab station will perform genetic editing on the dead and diseased corn to generate new corn that can fight the various types of fungi that are killing it.

Teams will be judged based on their ability to accurately and efficiently collect the harvestable corn, retrieve the dead and diseased corn, and deliver it to the lab station. The robot must also navigate the field without damaging the plants or other corn. Good luck!





Mission Task: "Power Line Repair" - 125 Points

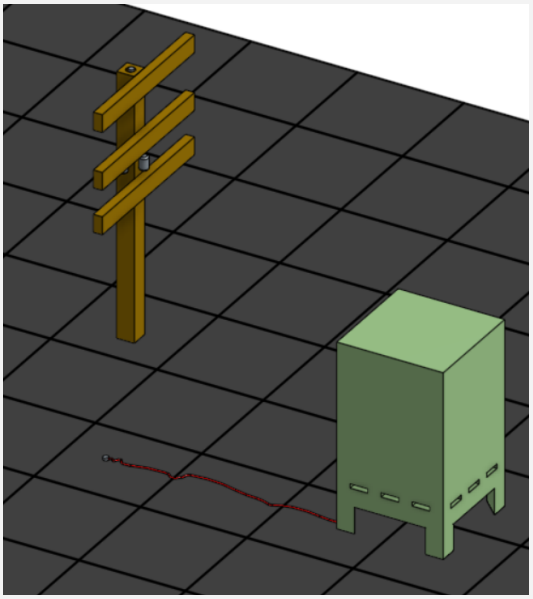
Assigned Mission Task - program or operate a drone that can repair a downed power line by picking it up from the ground and re-establishing the connection to the power pole. The power line will have a magnet attachment that allows it to snap into its proper place.

Specific requirements for the mission include:

1. Pick up the Power Line: The drone must use its gripping/hook mechanism to pick up the power line from the ground. The power line will have a magnet attachment that allows it to snap into its proper place. **+ 25 points**

2. Re-Establish Connection: The drone must fly the power line to the power pole and re-establish the connection. The magnet attachment will snap the power line into its proper place. **+ 100 Points**

Teams will be judged based on their ability to accurately and efficiently locate the downed power line, pick it up from the ground, and re-establish the connection to the power pole using the magnet attachment. Good luck!



Mission Task: "Power Line Backup" - 25 Points

Assigned Mission Task - program or operate a robot that can provide a backup solution for a downed power line by attaching it to a solar panel. If the drone cannot complete the mission "Power Line Repair," then the robot must take the power cable that is lying on the ground and attach it to the solar panel. The solar panel will have a spot with a magnet attachment that is the proper attachment point.

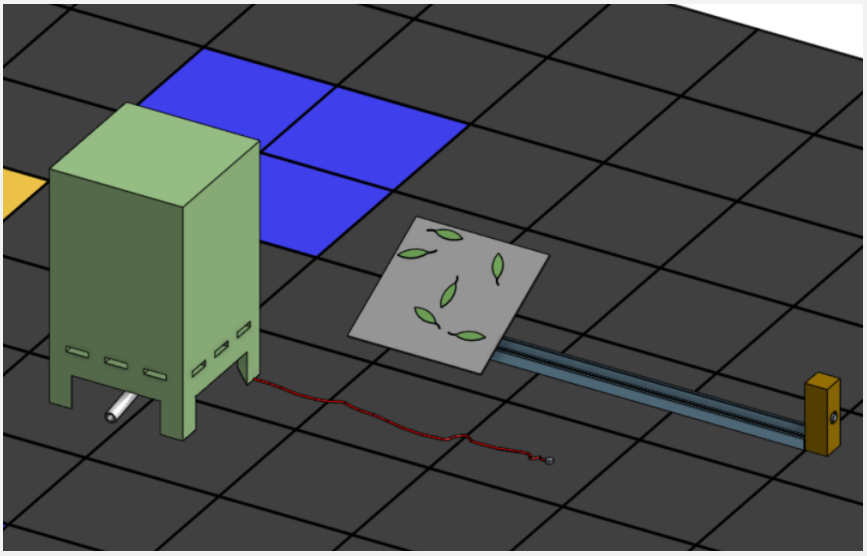
Specific requirements for the mission include:

1. Locate the Downed Power Line: The robot must locate the downed power line and prepare to do the following:

2. Pick up the Power Line: The robot must use its gripping mechanism to pick up the power line from the ground. **+ 5 Points**

3. Attach the Power Line to the Solar Panel: The robot must carry the power line to the solar panel and attach it to the spot with a magnet attachment. The magnet attachment will snap the power line into its proper place. **+ 20 Points**

Teams will be judged based on their ability to accurately and efficiently locate the downed power line, pick it up from the ground, and attach it to the solar panel using the magnet attachment. Good luck!



Mission Task: "Beetle Control" - 100 points

Assigned Mission Task - program or operate - program or operate a robot that can remove invasive beetles from an orchard. The robot must go over to the orchard and take one beetle back and properly identify which species of beetle they have retrieved. Teams will then attempt to retrieve and identify each of the 10 total beetles one by one.

Specific requirements for the mission include:

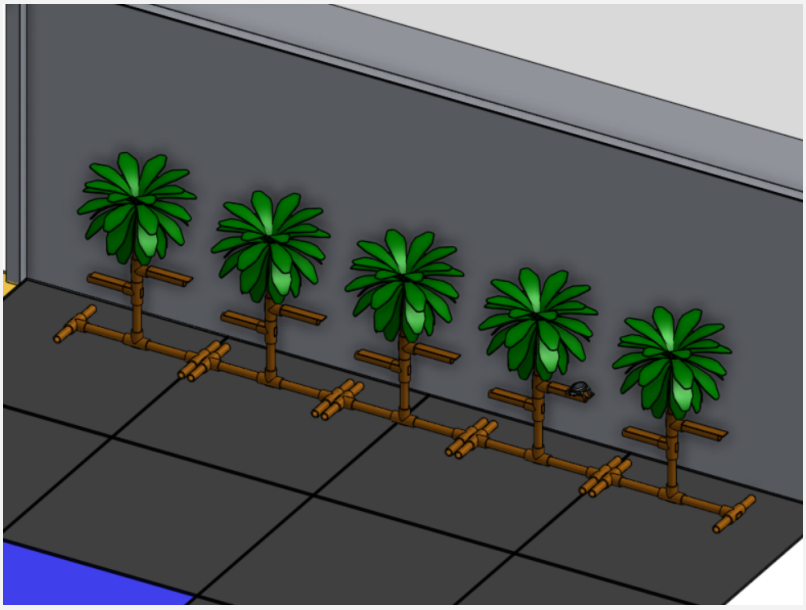
1. Locate the Beetles: The robot must locate the beetles in the orchard and prepare to do the following:

2. Pick up **one (1)** Beetle (at a time): The robot must use its gripping mechanism to pick up one beetle from the orchard and bring it to the driver station. **+ 5 Points per retrieval**

3. Identify the Species: The robot must carry the beetle to the driver station and properly identify which species of the beetle by using their *Beetle Identification Sheet.* **+ 5 Points per proper identification**

4. Remove All Beetles: Teams are encouraged to retrieve and identify all beetles for maximum points.

Teams will be judged based on their ability to accurately and efficiently locate the beetles in the orchard, pick up beetles, identify the species, and remove all the beetles. Good luck!



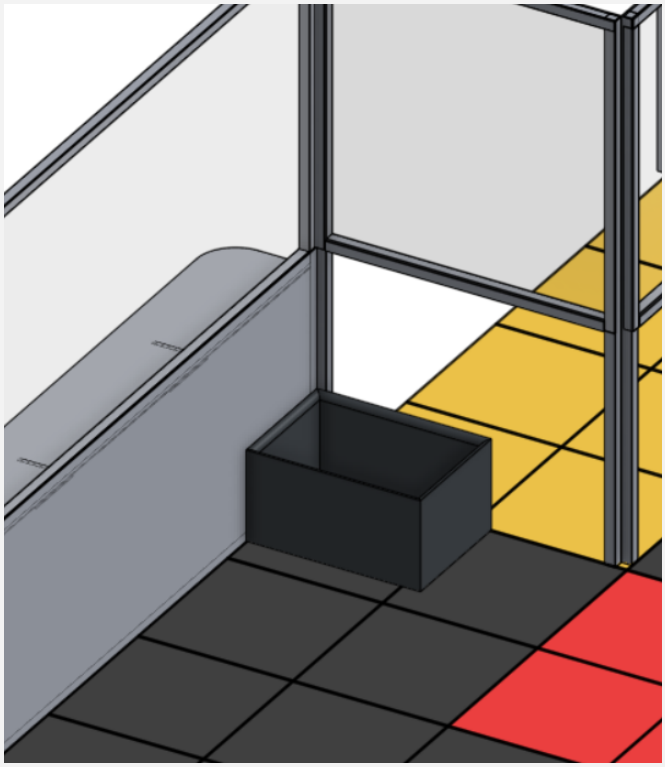
Mission Task: "Methane Generator" - 200 points

Assigned Mission Task - program or operate a robot or drone to collect food scraps and deliver them to the methane generator for points.

Specific requirements for the mission include:

1. Search for scattered food scraps in a centralized location on the field.
2. Use the robot to pick up the food scraps.
3. Deliver the food scraps to the methane generator by the robot for points. **+ 10 Points**
4. Utilize the human player to drop the food scraps into the methane generator for a reduced amount of points per food scrap dropped. (Optional)
   + 5 Points

Teams will be judged based on their ability to accurately and efficiently locate and collect the food scraps, dropping them into the methane generator. Good luck!



Mission Task: "Field Mapping" - 60 Points

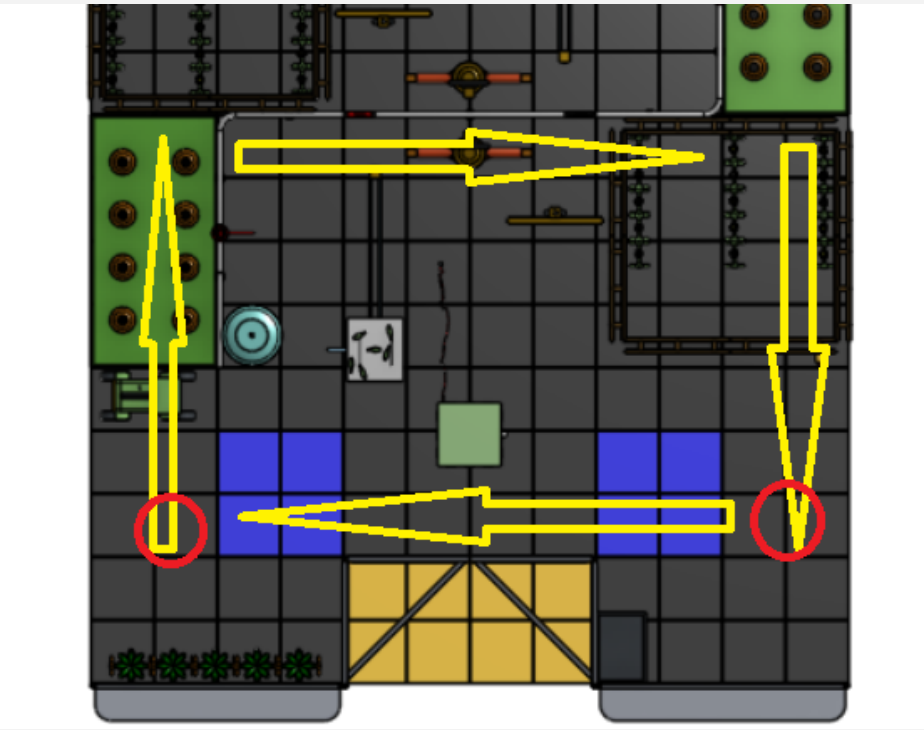
Assigned Mission Task - program or operate the drone to fly out the perimeter of the assigned alliance section of the competition field in a box pattern during the autonomous period. This is simulated "Aerial mapping of the field".

Specific requirements for the mission include:

1. *Autonomous Flight*: The drone must fly autonomously without any human input during the first minute of the match. During this autonomous period, points are quadrupled. After the first minute, teams are allowed to fly the perimeter in teleop. **+ 60 points (**during autonomous period**) + 30 Points** (in autonomous during teleop)

2. *Teleop Flight*: The drone must fly out the perimeter of the assigned alliance section (of the competition field in a box pattern. This simulates the action of taking mapping data. Teams may start in either square starting zones. Teams can go in either direction, being clockwise or counter-clockwise. **+ 15 Points**

Teams will be judged based on their ability to fly autonomously or remotely and to follow the box pattern accurately, Good luck!



Mission Task: "Water Quality Test" - 135 Points

Assigned Mission Task - program or operate a drone to fly over the top of the water reservoir on the competition field and take a water sample using some sort of implement, i.e. hook or gripper. The water sample will be a 3D-printed "H2O" sample. The reason for testing the water is to make sure that it is good for the crops. Water quality is an essential factor in crop growth and can have a significant impact on the health and yield of the crops.

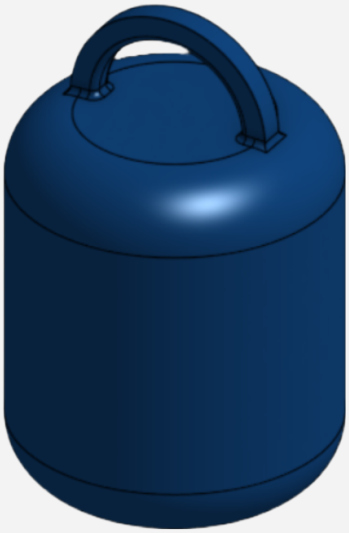
Specific requirements for the mission include:

1. *Water Sample Retrieval*: The drone must use its hook or gripper to take a water sample (3D printed "H2O" sample) from the top of the water reservoir and bring it back to the lab stations. **+ 100 Points**

2. *PH Test*: The human participants at the lab stations must do a PH test on the water sample retrieved by the drone. **+ 10 Points**

3. *PH Test Success*: When the test receives correct results, teams will be awarded points. **+ 25 Points**

Teams will be judged based on the drone's ability to retrieve the water sample, the accuracy of the PH test, and the overall effectiveness of the water quality test. Good luck!



Mission Task: "Beacon Capture" - 50 Points (Teleop)

Assigned Mission Task - there are two beacons on the field, both being on the arms of the scarecrow. Both begin at a neutral gray color. The beacons do not require a hover; instead, for better consistency, your drone will need to land on the pads. The pads will be a 12x12 inch square. On the bottom of your drone will be a small RFID chip that will be given to you at the competition. Once you have landed, the beacon will illuminate with your alliance's color, indicating you have captured the beacon.

Specific requirements for this mission include:

Teleop Beacon Capture: Landing on the beacon during the teleop period is an automatic 50 points. The beacon will stay illuminated with your alliance color for 60 seconds, indicating it is uncapturable by the opposition during this time. After 60 seconds, it turns gray, becoming neutral and available for capture by either alliance. Drones are not allowed to remain on the beacon for the entire 60 seconds to prevent monopolizing it. Drones must leave the captured beacon until it is time to land again.

Autonomous Beacon Capture *(Teleop Period)*: If a drone completes an autonomous beacon capture sequence during the teleop period, the alliance will be awarded double points for a 100 point capture.

Autonomous Beacon Capture *(Autonomous Period)*: If this is done during the Autonomous Period, teams will be awarded quadruple points for a 200 point capture.

Note: Ensure that your drone is equipped with the proper provided RFID chip for beacon recognition.

Genetically Engineered Seeds (GES):

Assigned Mission Task - program or operate a robot and drone for this task to generate genetically engineered seeds resistant to fungi to be planted in the fallow.

Specific requirements for the mission include:

1. Inspect the bad corn taken by the robot from the crop field and look for a colored dot on the bottom.

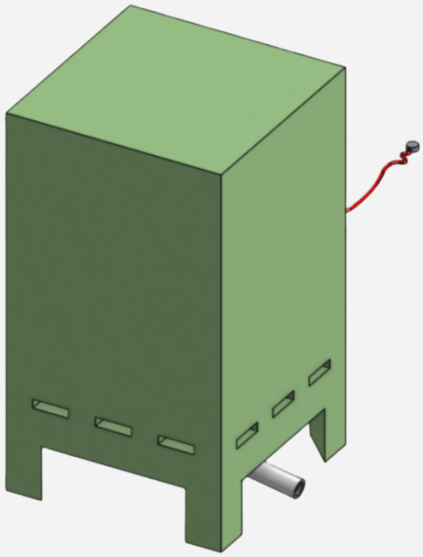
2. Use the "Fungi Identification Sheet" to identify which fungus is causing the corn to be diseased. **+ 5 Points Per Identification**

3. Take the petri dish of the identified fungus's DNA to the corresponding section of the accelerator.

4. Place the petri dish in the section and allow the *BioBuilder* Accelerator to treat the corn with various types of light. **+ 35 Points Per Petri Dish**

5. Retrieve the genetically engineered seed (GES) produced by the *BioBuilder* Accelerator. The output will drop from a tube below the Accelerator.

6. Utilize the robot to transport the GES to the lab station.

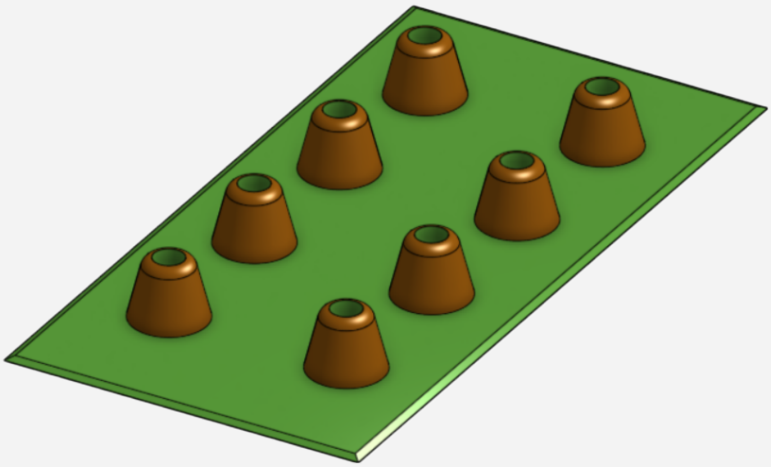


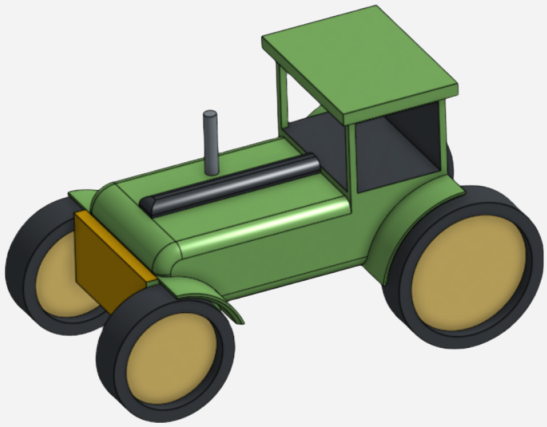
Genetically Engineered Seeds (GES) - CONTINUED:

7. Choose to drop off the GES into the fallow using the drone (for extra points) or take it to the fallow. **+ 75 Points Per Seed (with drone)** or **+ 30 Points Per Seed (with robot)**

8. If taking the GES to the fallow, move the debris (an old piece of farm equipment) to gain access to the holes. **+ 35 Points-**

The purpose of this mission is to demonstrate teams' ability to use multi-step critical thinking and problem-solving to generate real-world solutions to biology.





STEM Questions - 300 Points

Assigned Mission Task - program or operate a drone to view and answer STEM questions in order to test the teams' knowledge of STEM topics.

Specific requirements for the mission include:

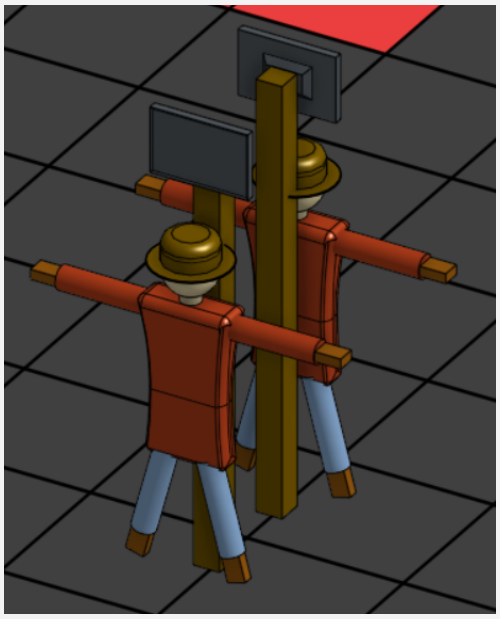
1. Drones must fly to the other alliance's side and view the TV on the SCARECROW.

2. On the SCARECROW will be displayed a STEM question related to science, technology, engineering, or math

3. The human players in the driver stations must answer the STEM question. (They will tell their answer to the driver station official who will submit their answer.)

4. After they answer the initial question, they will receive two more STEM questions for a maximum of three (3) STEM questions. Each correct answer will earn them points. **+ 100 Points Per Correct Answer (+400 if done in autonomous period)**

STEM questions are aligned with NGSS, Common Core, ISTE, and P21 Standards and directly correlated to what students learn in the classroom. Question difficulties are dependent on a team's division *(see League Overview)*, which are arranged and aligned with the appropriate grade level to each division, either DIV I, II, or III. Teams must correctly answer the question and receive points from the RDL official prior to advancing to the next STEM question.



Autonomous Period

At the beginning of a 10-minute match, the first 60 seconds is considered the autonomous period. Human control of the robot or drone is not allowed. Teams are awarded points for autonomous movement of the robot or drone as depicted in the scoring table below. **NOTE: Drones and robots will not be reset during this time in the event of task failure.** Completing these tasks autonomously results in **quadrupled (x4)** points during the autonomous period.

Teleop Period

Upon completion of the 60-second autonomous period, the remaining 9 minutes are considered a teleop (human control) period. Autonomous functions are not restricted during the teleop period; however, human operators will maintain hands-on control of the robot or drone during the 9-minute period. Teams should announce to the RDL Alliance Official if they're attempting a specific task autonomously and will also need to provide a visual indication of autonomous operations (AUTO sign). If autonomous functionality is used within the 9-minute teleop period, points are **doubled (x2)**.

Team Organization

Teams may consist of an unlimited number of members; however, there is a limit of six players allowed in the driver's station (per team). There is a designated pit area where team members not in the driver's station may stay to encourage teammates during competition.

Lab Stations

For each alliance side, there is a designated area for interaction between human players and robots called the lab station. The lab floor is identified by the yellow mats both in the lab and adjacent to the perimeter of the lab. Each team needs to assign a lab technician who is responsible for accepting elements and identifying samples (for a total of two lab technicians per alliance side). Robots and drones either deploy from or bring collected elements to the lab station, where the lab technician can then accept or attach game items. The lab technician may retrieve these elements such as the corn, petri dishes, etc. The lab technician is only permitted to touch the robot or drone when in the neutral and non-moving configuration and fully in the yellow safety zone. Lab technicians may not reach out into the field with anything but their arms. (Reaching in where your head crosses the lab station onto the field will constitute a yellow card. Repeated violations will constitute a red card.)

League Guidelines

League Overview

The Robot Drone League season runs from early September through January. RDL is a multi-week game where a percentage of scoring elements are changed each year, and point values are adjusted to meet the requirements of the game. Teams should benefit from the guidance of teachers or mentors, with the constraint that only the students are the only ones allowed to build the robot and drone and compete. When faced with a challenging problem, students appreciate guidance on different methods the problems can be solved or solutions to improve upon an existing student-driven design.

RDL Team Showcase

Teams are **required** to submit a five (5) to seven (7) minute video.

In this video, teams will be expected to showcase their robot, drone, and supplemental devices (such as grippers, hooks, etc.). Apart from material aspects, teams will also be expected to discuss different things such as team funding, fundraising, community outreach, team & project management, and anything else teams feel necessary to describe the scope of accomplishments of the team for the competition season.

As an option, teams are allowed to include technical documents (less than 10 pages), reports, posters, and published materials to aid the RDL Team Showcase in support of the team's presentation to the judging panel.

Engineering Notebook

An engineer's notebook is a book in which an engineer will formally document, in chronological order, all of his/her work that is associated with a specific design project. For RDL, the engineering notebook serves a unique purpose in recording the teams' actions and discoveries throughout the RDL season. Although the engineering notebook is not required to officially compete or to participate in the RDL Team Showcase presentation (which is required), teams should know that the engineering notebook is strongly recommended for teams competing for all award categories. The engineering notebook should have your team number and school name on the front cover. Engineering notebooks may contain other pertinent information such as community outreach, budgets, sponsorships, mentor notes, goals, and lessons learned. Each team session should be recorded with accurate dates and times of meetings. Team members contributing engineering notebook entries must initial all entries responsible for inclusion. Illustrations and CAD diagrams are highly suggested. Only one notebook per team shall be submitted. Teams will leave notebooks with the judges' panel and must retrieve them prior to the end of the competition day.

Driver Station

The primary concern during any event is safety. To ensure the safety of all participants and observers, safety restrictions within the driver station must be followed at all times. The number of team members allowed in the driver station during a match is limited to four to six. Mentors are never allowed at the driver's stations during match play. All players in the driver's station must wear closed-toe shoes, as well as safety glasses. Long hair must be pulled back and secured. No loose clothing or dangling jewelry is permitted.

SAFETY GLASSES ARE MANDATORY WHEN IN THE VICINITY OF ROBOTS AND DRONES.

Starting Position

Robots and drones need to be placed in the starting position prior to beginning the match. The starting position is marked by a 122 cm x 122 cm square, colored to correspond with the alliance. There will be two different starting positions for each alliance side for each of the two teams making up the alliance. Alliances can choose to have each of their two teams deploy in the starting position in front of their respective driver station or, teams are welcome to deploy in any combination, their drones or robots on either starting position. What matters is that the drones and robots start within a "starting position mat." Robots and drones may start with a scoring element or sensor preloaded at the base. Alignment tools and devices are allowed onto the playing field as long as the tools pass safety inspection and do not interfere with the ability of the opposing alliance to retrieve game elements and score points.

Valid preloaded objects for scoring include:

1. **Beetle**
2. **Food scraps**
3. **Power line hook**

Safety Check

The game has numerous scoring strategies which impact the design and construction of the team robots and the programming of the drones. Following the Four Laws of Robotics, safety is the primary concern for humans, robots, and drones related to inspection. Each robot and drone are required to successfully pass a safety check before competing in the tournament. To pass a safety check, robots and drones need to successfully meet the specifications defined below. If a robot or drone is not deemed safe, it is not allowed to compete. After a robot and drone have passed safety checks, teams will be given a safety card that is required to bring on deck and present to the alliance official when competing in scoring matches. **Please note that when practicing for or competing in an event, safety should always be the priority. Unsafe operations of both robots and drones can result in serious injuries in the occurrence of misuse or malfunctions.**

Robot Specifications

Robots must undergo and pass all of the following criteria in order to pass safety inspection:

- No more than 61.0 cm wide, 61.0 cm long, and 61.0 cm high (in starting configuration)
- Must have a 20 amp ***in-line*** fuse
- Robots are limited to using no more than 20 amps
- Wires should be attached to the frame and/or organized in a safe and secured configuration
- Robots must have **no exposed wires**
- Robots not use batteries greater than 12V
- All robots **must have an ON/OFF control switch**
- Robots must not have sharp edges that would allow the robot to intentionally disregard any of the Four Laws of Robotics
- Hydraulic systems **are not allowed**
- Pneumatic systems, while legal, must have a pressure relief valve and be **limited to 50 PSI**

Drone Specifications

Drones must undergo and pass all the following criteria in order to pass safety inspection:

- Must not exceed 50.0 cm diagonal length from tip of propeller to tip of propeller (Extended to fullest)
- Must not exceed 50.0 cm tall
- Drone propellers must be shrouded with protective devices

Teams can use any means of programming the drone. When not in use or during transportation, it is advised to remove propellers to ensure safety.

Team Members

During a match, a team cannot use other participants outside of the driver station to guide robots or drones. If the team is viewed as using external participants to gain an advantage, a yellow card can be issued. If the issue persists, the team can be issued a red card. Team members are not allowed on the field during a match and must remain in the driver station or pit at all times, with the exception of the lab technician, who is in the lab station. **Under no circumstances shall a team member (including the lab technician) reach in with their head onto the field.** The only human interaction with robots is to be from the lab technician and is limited to the safety zone (orange mats). If the robot or drone is not working, an RDL official will place the robot or drone into the lab area for the team to work on. Team members who violate the field access rules are awarded a penalty card at the discretion of the RDL official.

Team Pits

Teams are assigned a designated space during the competition which is referred to as the "Pit Area". Robot and drone testing operations are not allowed in these areas. A designated area for testing and practice is available at the ETSU championship and, depending on each regional's venue and resources, may or may not be available.

Match Scoring

Each team is recommended to designate a scoring captain. The scoring captain is responsible for keeping track of the team's points during the match. If a scoring captain sees a possible error after an RDL official has calculated the final scores for both teams, the scoring captain may bring up the issue with two different RDL officials. The two RDL officials will reconsider the team's score. Scoring captains need to present evidence for any scores to be reconsidered, including, but not limited to, video evidence.

Championship Match and Queue Procedures

At the championship event competition, remaining on schedule is a must. Therefore, teams are required to check in with the Lead Queue Coordinator (LQC) 10 minutes prior to the team's scheduled match. Once the Lead RDL Official (LRO) gives team field access, 1-2 team members from each team will be allowed on the field to place and power on robots and drones into the initial starting positions. The total time for this setup is 3 minutes. The 3-minute set-up period is a firm 3-minute countdown with no pause or restarts. Teams are not allowed to test robots and / or drones during this time. At the end of the 3-minute timer, the 10-minute match will immediately begin. If a team or team representative is not present at the beginning of the match, the match continues, and the team will forfeit that particular match and no potential points earned.

Upon conclusion of the match, teams will then have 2 minutes to remove the robot and drone equipment from the field and depart the driver stations.

For example: Team A is scheduled to play at 10:00 am, so that means that Team "A" needs to check in with the LQC at the designated queue area at 9:50 am. At approximately 4 minutes prior to the beginning of the scheduled match, the LRO gives access to a couple of Team "A" members to enter into the RDL field to place in starting position and power on robots and drones. The LRO will commence the 3-minute setup clock. Once time expires and at the discretion of the LRO, the match will promptly begin. The match concludes at the end of the 10-minute round and the team takes 2 minutes to remove robot and drone equipment from the field and then safely departs the driver station.

Penalties

Definitions

Yellow cards serve as warnings to teams. Red cards result in a fifty (50) point deduction from a team's score **for each occurrence**. Three consecutive red cards constitute the driver or pilot whom the red card was issued to sit out of the following match.

1. Following the intent of the Four Laws of Robotics, a robot may not purposely harm another robot, unless that somehow violates the First Law related to the safety of a human. The field is large, and it is expected that robots from each team might come in proximity to each other. Robots should not intentionally contact another robot to play defense or prevent the other robot from accomplishing a task.
2. Purposely blocking a robot with another robot to prevent scoring or movement of the robot results in a yellow card.
3. Drones that intentionally crash into a robot as a way to prevent scoring result in a red card for the offending drone pilot. Drones that purposely crash into an opposing robot are not eligible to be rescued during the match. (RDL Officials reserve the right to constitute what is intentional vs. accidental crashing.)
4. If a drone collision occurs, pilots are awarded a yellow card. If, in the opinion of a referee, a drone was intentionally crashed into another drone or did not show clear intent to avoid a collision, a red card can be issued for the offending drone's pilot.

Yellow Card

A yellow card serves as a warning for robot or drone behavior that is not in the spirit of the Robot Drone League. Any yellow card that is issued can be reviewed by league officials at the end of the match to determine if the actions of the robot under the control of the driver were intentional to gain an advantage and disregard of rules. If the league officials determine that the rule violation was intentional, it can become a red card.

Red Card

A red card issued for poor robot or drone behavior will result in the designated driver's absence in the next match, as well as a fifty (50) point deduction from the offending team's final score. The driver is allowed in the driver's station during the next match. A drone that is awarded a red card requires that the pilot of the drone sit out the following match.

Excessive Mentorship

Mentoring is essential in everything, especially robotics. That said, STREAMWORKS values the sound learning principles of project-based learning and self-directed discovery as it pertains to STEM learning and career interest. It is very simple, teach your students the fundamentals and then get out of the way!

During an RDL event, if mentors, parents, or any adults are seen by an RDL Official or Judge actively working on a team's robot, this will result in a verbal warning from the competition director, possible team disqualification from competition matches and any awards related to the competition matches or design of the robots. Additionally, if judges/officials have a suspicion of excessive mentorship which has affected the outcome of the design of the robot, the judges/officials have the right to conduct an investigation into a more thorough understanding of the team's knowledge of their own robot.

Video Replay

If video-captured evidence, by RDL, clearly shows that a yellow card or red card should not have been issued, a team can appeal to the head referee to have the penalty overturned. If in the opinion of RDL officials, the video shows clear evidence that the penalty should not have been awarded, the penalty is removed. If RDL officials conclude the appeal had no merit and the video does not provide any evidence that the penalty should be reversed, an additional yellow card can be issued.

The 2023 SCARECROW game is designed to be a challenging and fun game. In the interest of fairness and clarity, rules may need clarification or additional rules added during the season.

Awards

World / Regional Champion – Awarded to the top team that encompasses the overall best in competition, both on and off the challenge field. The following factors are taken into consideration for this prestigious award:

Challenge field scores

Team Showcase presentation

Community Outreach

Tournament Professionalism

Collaborative Spirit

Top Score Award – Awarded to the 1st place team based solely on scores finalized at the end of the challenge field play.

Professor's Award – Awarded to the team demonstrating the best of community outreach that helps to promote STEM learning in their community. Submission for this award is optional and must include a team essay not to exceed 500 words. Pictures, articles, and letters of appreciation or acknowledgment are recommended for serious consideration of the award. Submissions be submitted no later than midnight on December 1st, 2021.

Engineering Award – Awarded to the team that best demonstrates innovation in design and provides best evidence of documented engineering practices to a panel of SME professionals. An engineering notebook is required for award consideration.

Judge's Award* – Awarded to the team that best demonstrates team grit and tenacity no matter the scoreboard. *Note* (This award is optional and awarded at the discretion of the Head Judge).*

Top Dog Award – Awarded to the team demonstrating the highest competition autonomous scores.

Top Rookie Award – Awarded to the best of the best Rookie team competing in their first RDL season.

Index

Sample STEM Questions

1) Calculate the amount, in g, of Copper Sulphate produced when 5g of Copper Oxide is reacted with 20ml of 0.5M of Sulphuric acid.
CuO + H_2SO4 --> $CuSO_4$ + H2O

2) Fluid pressure is always directed?

   a. Up
   b. Down
   c. Sideways
   d. In All Directions

3) It costs $\$\mathbf{2.5}$ MUSD to make each AUV and $\$\mathbf{1.75}$ MUSD to make each drone for exploration on Titan. Which equation represents the cost, $\boldsymbol{C}$, of making $\boldsymbol{x}$ AUV's and $\boldsymbol{y}$ drones?

   A $C = 1.75x - 2.50y$
   B $C = 1.75x + 2.50y$
   C $C = 2.50x - 1.75y$
   D $C = 2.50x + 1.75y$

4) Which best describes an angle?

   A two distinct rays that originate from a common point
   B two parallel lines on a plane
   C the set of all points equidistant from a particular point
   D a line with a starting point that extends to infinity

Sample STEM Questions cont.

1) A magazine reports that a robot sent to Mars drilled on the surface to collect rock samples. What kind of technological instrument is the robot?

   A satellite
   B space observatory
   C space probe
   D spectroscope

2) How do greenhouse gases in Earth's atmosphere interact with heat from the Sun?

   A Greenhouse gases block heat from the Sun by forming clouds.
   B Greenhouse gases use heat from the Sun to generate light.
   C Greenhouse gases decrease the amount of heat created from the Sun.
   D Greenhouse gases trap some of the heat from the Sun.

3) What is the product of $\mathbf{14.7} \times \mathbf{5.32}$?

   A 7.8204
   B 78.204
   C 782.04
   D 7,820.4

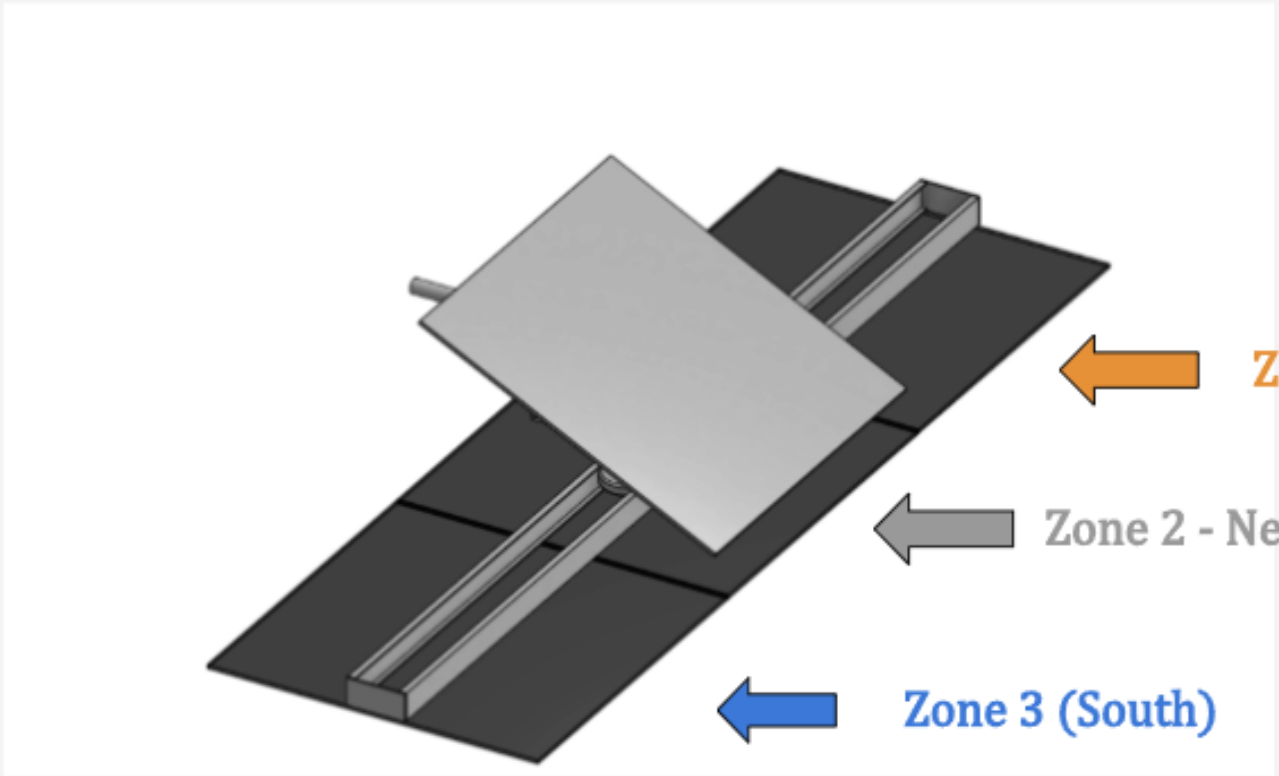
4) What is the value of 63 − 12p when p = 2?

   A 12
   B 24
   C 192
   D 202

Solar Panel Optimization (Prompt B)

The Photon farm has requested solar panels on their property in order to power their BioBuilder Accelerator. A survey crew has determined that the **Northern** zone was the optimum location for the placement of the solar panel. The time of day is **5:37pm**.

*NOTE: Before the solar panel can be optimized, it is necessary to have cleaned off the panel using a drone's downward thrusting force or "prop-wash". ALSO: Zone 2 is starting "neutral" zone. Zone 2 is optimized for 12:00pm. When determining angle, teams are to consider that any given time after 12:00 pm suggests the panel needs to be in the left-hand angle, pointed **West**. Any given time before 12:00 pm suggests the panel needs to be in the right-hand angle, pointed **East**.*



Fungi Identification Sheet

Fusarium spp.

Ustilago maydis

Penicillium spp.

Aspergillus flavus

Beetle Identification Sheet

Dynastes hercules

Allomyrina dichotoma

Chalcosoma atlas

Dorcus curvidens

Xylotrupes gideon

Lucanus cervus

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