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Maryland 4-H Robotics Engineering Challenge

The 4-H Robotics Challenge provides an opportunity for 4-H members interested in STEM (Science, Technology, Engineering, Math) to participate in a hands-on, team-based activity of building robots and programming them to complete specific tasks. Successful teams will display technical excellence in robot design, engineering, and programming, as well as a high level of skill on the field in competition.

Please direct questions and/or concerns to Mark DeMorra, 4-H STEM Specialist, at mdemorra@umd.edu, or Willie Lantz, 4-H Robotics Superintendent, at wlantz@umd.edu.

Background, Theme, and STEM Connections

The theme for the 2020 4-H Robotics Engineering Challenge (REC) is called “Space Race!” With the recent 50th anniversary of the Apollo moon landing in 1969, plus the 2020 4-H National Youth Science Day Experiment directly connected to long-standing NASA directives for manned missions to Mars, space science is once again constantly in the news and at the forefront of technological innovation.

4-H REC teams will be tasked with building a robot using various parts, sensors, motors, and other components in order to complete missions and score points. Team robots will start, as human beings would, on “Earth” and attempt to make their way to the 8 other “Extraterrestrial Planets” featured on the REC field. An image of the full 2020 REC field follows.

Figure 1: 2020 REC Field- Labeled

= GEMS
= MOONS
= 8in TALL WOOD BARRIER

### Figures

- **Figure 1:** 2020 REC Field- Labeled
9 planets in our solar system (including dwarf planet Pluto) are featured. Note, of course, that this field is in no way an accurate representation of our actual heliocentric (sun-centered) solar system, and relative distances between planets are also not meant to be scientifically accurate, as this would be difficult to represent on a REC field.

To provide symmetry on the field, while the 8 Extraterrestrial planets are separated distinctly from each other and either team can score using any or all of these planets, each planet has a corresponding “partner” located on the opposite side of the field from it. The setup and missions for corresponding partner planets are the same (just with their orientation symmetrically flipped if needed), however the following should be made note of:

- Successful scoring by a team on a planet is not dependent on any other planets or missions
- A team is not required to do any specific mission(s) on the field
- A team is not required to score with one planet in order to score with another, including a planet’s partner on the opposite side of the field.

**STEM Connections (Our Solar System!)

The missions for each planet are related in some form to interesting characteristics that have been discovered about these planets, through centuries of work by scientists, engineers, NASA, the ESA, and others. The logic behind the partnering of different planets is related to common characteristics they share. For example, Venus and Mars are the two planets closest to Earth, our “neighbors,” and the most well-studied of the Extraterrestrial planets in our solar system thus far. They are a set of “partners” in the 2020 REC game. Numerous pictures and research with telescopes and satellites have given us a significant understanding of their atmospheres. Mars is similar in many ways to Earth, but with a much thinner atmosphere and a cold, rocky, dusty surface. On the contrary, Venus’s atmosphere is toxic, comprised primarily of Carbon Dioxide and clouds of Sulfuric Acid. Because of this, Venus is actually the hottest planet in the solar system, even though it’s not the closest to the sun! The setup of Venus and Mars on the REC field reflects their proximity to Earth.

Saturn and Jupiter are another partner group for this year’s REC game, as they are the two largest planets in our solar system. Saturn and Jupiter are called “gas giants” because of their enormous size and the largely gaseous composition of their volumes. The two planets also have the largest number of moons of any of the planets in our solar system, Jupiter’s being especially noteworthy due to the work of Galileo. Jupiter’s moons Io, Europe, Ganymede, and Callisto are called the “Galilean Moons” because he discovered them with the assistance of his famous invention, the telescope, in the early 17th century. They are the 4 largest satellites of Jupiter and are 4 of the largest moons in our solar system overall. Saturn has the second largest number of moons, including the 4 Cassinian moons Tethys, Dione, Iapetus, and Rhea, discovered by Giovanni Domenico Cassini in the 17th century. The missions on the 2020 REC field for Jupiter and Saturn allude to these planets’ moons.

Neptune and Uranus are also partners in this year’s REC game. These two are called “Ice Giants” because of their very low average temperatures, their size, and overall similar composition. Their extreme temperatures make it difficult for Astronauts and vehicles to enter the planets’ atmospheres and survive, so any Astronauts that land on these planets must be careful in their approach. The REC missions for Neptune and Uranus reflect these concepts.
Finally, two smaller but well-known bodies in our solar system, Pluto and Mercury, have the smallest footprints. Mercury is the smallest planet by definition according to the modern classification of planets in our solar system, while Pluto’s classification changed from a regular planet to a “Dwarf Planet” in 2006. These objects are smaller than any of the other planets in the solar system, which means that the goal of “landing” Astronauts on them can be significantly more difficult, with a high level of accuracy needed to ensure space vehicles don’t miss or “overshoot” their targets. The smaller sizes of Pluto and Mercury on the REC field were designed with this in mind.

Vocabulary, Terms, and Definitions

**Astronaut:** A yellow figurine that teams must use their robots to deliver to the 8 extraterrestrial planets on the REC field. Each team gets 16 astronauts at the start of the game. Astronauts are deposited onto the field via the team’s *Loading Chute*. A team can have a maximum of only 2 of their Astronauts on the entirety of *Earth* at a time (including the opposing team’s side of *Earth*). See Figure 3 for visual.

**Autonomous Period:** The first 30 seconds of a REC match are the Autonomous Period. As opposed to the *Driver-Controlled Period*, this period of time is when a team’s robot must operate on its own without the use of human input through the controller. A team will have to write an autonomous code before REC competition day, and can have multiple autonomous codes created to use, depending on their situation, for a REC match.

**Colonization (Bonus):** The ability for a team to have successfully landed at least one of their *Astronauts* on a planet is called Colonization. See Figures 3 to 5. Each Astronaut that successfully Colonizes an *Extraterrestrial Planet* is worth 5 or 10 points, depending on the planet. A maximum of 2 of a team’s *Astronauts* can colonize any one *Extraterrestrial Planet*. A Colonization “Bonus” is awarded to teams at the end of a match dependent on the number of planets they have successfully Colonized during both the *Autonomous Period* and *Driver-Controlled Period* of a match. The Colonization Bonus is exponential in its value, with 1 *Extraterrestrial Planet* colonized by a team worth 2 bonus points and all 8 *Extraterrestrial Planets* being Colonized by that team worth 256 bonus points.

**Crash:** When a team’s robot runs into one or more of the *Moons* located on the borders of *Jupiter* or *Saturn*, they have “Crashed.” A Crash results in a penalty that will cost a team 5 points per *Moon* they dislocate from its original position, or the equivalent of one successful *Astronaut* landing on *Jupiter* or *Saturn*.

**Depository:** The taped-off area next to a team’s *Launchpad* is called the Depository. This is the area where teams deposit any *Gems* they collect during a match and is approximately the size of one foam field tile (2ft by 2ft). A Depository is considered to be part of that team’s side of Earth, and extends from the outer edge of a team’s correspondingly-colored tape borders through to the edge of the field perimeter and the team’s *Launchpad*.

**Driver-Controlled Period:** The Driver-Controlled Period follows the 30-second *Autonomous Period* and lasts for 2 minutes. This period will have teams control their robots directly using remote controls that remotely communicate with the robot’s electronics to operate. The end of the Driver-Controlled Period constitutes the end of a match.
Earth: Earth is the starting area for robots in the 2020 REC game. It is split into two halves, corresponding to the two teams (red and blue) competing in a match. In addition, each team’s side of Earth consists of a Launchpad tile and a Depository tile. A team’s robot is started in their Launchpad and can be parked in their Launchpad at specific times throughout a match to earn points. Teams deposit collected Gems into their designated Depository throughout a match. A team also loads their Astronauts via the Loading Chute onto Earth during a match, and only a maximum of two of a team’s Astronauts are allowed in the entirety of Earth (including on the opposing team’s side) at any point during a match.

Event Official: Any individual who is leading or assisting with the operation and execution of refereeing, judging, scoring, and officiating a REC tournament is considered an Event Official. Decisions made by them are believed to be unbiased and done using their best judgment. These individuals have been asked to assist in some manner with a REC tournament by, and report to, the 4-H Robotics Superintendent and 4-H STEM Specialist. Questions about decisions made by robot game referees must be brought to their attention immediately following a match, when a referee asks a team to review and sign-off on their score sheet. After a match’s scoring has been posted, it is considered final and CANNOT be changed.

Extraterrestrial Planets: These are the 8 non-Earth planets in the game. Specific descriptions follow:

**Mars:** Mars is a 2ft x 2ft sized planet on the red side of the REC Field which features a white taped border and two Gems to collect near its center. Either team can score with this planet. Astronauts deposited onto Mars are worth 5 points each (with a maximum of 2 allowed per team). Its Partner Planet is Venus.

**Venus:** Venus is a 2ft x 2ft sized planet on the blue side of the REC Field which features a white taped border and two Gems to collect near its center. Either team can score with this planet. Astronauts deposited onto Venus are worth 5 points each (with a maximum of 2 allowed per team). Its Partner Planet is Mars.

**Jupiter:** Jupiter is a 2ft x 2ft sized planet on the red side of the REC Field which features a white taped border and two Gems to collect near its center. It also features four Moons on its perimeter that teams must avoid or else result in 5-point penalties applied for each Moon Crashed into. Either team can score with this planet. Astronauts deposited onto Jupiter are worth 5 points each (with a maximum of 2 allowed per team). Its Partner Planet is Saturn.

**Saturn:** Saturn is a 2ft x 2ft sized planet on the blue side of the REC Field which features a white taped border and two Gems to collect near its center. It also features four Moons on its perimeter that teams must avoid or else result in 5-point penalties applied for each Moon Crashed into. Either team can score with this planet. Astronauts deposited onto Saturn are worth 5 points each (with a maximum of 2 allowed per team). Its Partner Planet is Jupiter.

**Neptune:** Neptune is a 2ft x 2ft sized planet on the REC Field, in the far corner opposite the red side of Earth. It features an 8in tall wooden border on its interior edges facing the Sun, with the rest of its border dictated by the Field Perimeter. Either team can score with this planet. Astronauts deposited over the wooden border onto its surface on the Field are worth 10 points each (with a maximum of 2 allowed per team). Its Partner Planet is Uranus.
Uranus: Uranus is a 2ft x 2ft sized planet on the REC Field, in the far corner opposite the blue side of Earth. It features an 8in tall wooden border on its interior edges facing the Sun, with the rest of its border dictated by the Field Perimeter. Either team can score with this planet. Astronauts deposited over the wooden border onto its surface on the Field are worth 10 points each (with a maximum of 2 allowed per team). Its Partner Planet is Neptune.

Pluto: Pluto is a small 1ft x 1ft sized planet on the opposite side of the field from the Red Launchpad on the REC Field, featuring a white taped border. Either team can score with this planet. Astronauts deposited onto Pluto are worth 10 points each (with a maximum of 2 allowed per team). Its Partner Planet is Neptune.

Mercury: Mercury is a small 1ft x 1ft sized planet on the opposite side of the field from the Blue Launchpad on the REC Field, featuring a white taped border. Either team can score with this planet. Astronauts deposited onto Mercury are worth 10 points each (with a maximum of 2 allowed per team). Its Partner Planet is Pluto.

Field: The 12ft by 12ft playing area for the REC game. The field consists of the foam tiles and all game elements that are located within the Field Perimeter. It is expected that, during the course of a REC match, all robots, robot components, game elements, and scoring elements (outside of pre-inserted Astronauts), will be contained on Field and inside the Field Perimeter.

Field Perimeter: The 1ft tall black aluminum and clear acrylic border of a REC Field, whose purpose is to keep all Field elements contained within its borders throughout the game. The Field Perimeter is 12ft in length on each side and can be a VEX VRC Field Perimeter or FTC Field Perimeter from Andymark.

Gems: Gems are valuable resources that robots can collect to score points. They are represented by 2in gold blocks, and two each can be found in: Mars, Venus, Jupiter, and Saturn. The goal for robots are to deliver the Gems to their side’s Depository, which is worth 10 points for each Gem. A Gem must be FULLY contained in a team’s Depository when time is called in order for the points to be counted.

Images: Above 6 of the planets are Images that teams can use for easy identification. If desired, they can use these images in conjunction with imaging programs such as Vuforia to assist with their robot’s movement and operation around the field. Neptune and Uranus will have their images on the field itself.

Launchpad: A team’s Launchpad is the 2ft x 2ft foam tile, contained fully within that team’s side of Earth, where their robot begins a match and where it must be fully parked in order to score Parking points. A team’s Launchpad is located directly adjacent to their Depository on the Earth side of the REC Field.

Loading Chute: The Loading Chute is a custom mechanism through which Astronauts are inserted onto the Field. Each team will need a human player to load Astronauts onto the REC field by inserting them through the top of the Loading Chute pipe, which will direct their Astronauts towards their side of Earth. The Loading Chute is built using a 3in diameter PVC pipe, and is approximately 26 inches tall. A chute’s exit aligns with the middle of a team’s Launchpad as viewed when facing the field from behind Earth.

Moons: Moons are located on the borders of Jupiter and Saturn. They are represented by white wiffle balls approximately 2.75in in diameter, situated on a black rubber O-Ring. If a robot dislocates a Moon from its O-Ring, this is called a Crash, and will cost that team 5 points for every Moon they crash into.
Parking (Landing): A team’s robot is said to have successfully Parked (or Landed) when it is FULLY contained in that team’s Launchpad at the end of the Autonomous and Driver-Controlled Periods. Successfully Parking (Landing) a team’s robot requires it to fully leave the Launchpad area during that portion of the match. Successful Parking (Landing) at the end of Autonomous is worth 10 points to a team. Successful Parking (Landing) at the end of Driver-Control is worth 20 points to that team.

“Partner” Planets: Partner Planets are located on opposite sides of the Field, are oriented symmetrically to each other (as viewed from the Earth side of the Field if an invisible line ran down the middle through the Sun and between Pluto and Mercury), and have the same mission structures and points. The 4 Partner Planets are: Mars & Venus, Jupiter & Saturn, Neptune & Uranus, and Pluto & Mercury.

Planets (also see “Extraterrestrial Planets”): The term Planets encompasses both the Extraterrestrial Planets plus Earth in the 2020 REC game. Some rules apply only to Earth or the Extraterrestrial Planets, while some rules apply to both. See the individual rules and definitions for both which explicitly define the rules for these specific components of the REC Field.

Resources (See Gems): The term Resources is used synonymously with Gems in the 2020 REC game.

Space (Outer Space): The areas between planets where the majority of movement during a REC match will occur is referred in general as Space or Outer Space. Incidental contact between robots in this area may occur, especially during Autonomous, but repeated incidents and/or deliberate contact with or disruption of another team’s robot will lead to penalties and possible disqualification for a match.

Sun: Represented by corrugated plastic roofing pieces, the Sun is towards the center of the REC Field, comprising a 4ft x 2ft area normally filled by two foam tiles, and is meant as an obstacle for teams to contend with when moving around. Much as in the solar system, the Sun is a significant obstacle that most instruments need to stay a great distance away from or else significant damage can occur. The position of the Sun vs. Earth and the other planets over time must also be taken into account when satellites and other devices are launched to study space phenomenon.

Figure 2: The “Sun,” as represented on the REC Field. At some tournaments, the color might vary, but its size, dimensions, and field position will always be the same.
Challenge Overview

Robot Game Structure

During each match, two teams will compete head-to-head, and teams will be competing in multiple matches throughout the day. The objective is for a team to score the most points by completing as many of the missions on the field as they can. This is primarily done by delivering a team’s Astronauts to the 8 different Extraterrestrial Planets, each with their own unique setup that may inhibit the robot’s (and Astronauts’) safe arrival. Other scoring mechanisms also exist, and missions range in difficulty, meant to challenge veteran teams while also allowing for new teams to have a chance to compete. With this in mind, and considering each planet’s unique setup, teams will need to get very comfortable operating their robot and its attachments with precision and within tight space constraints.

Each match will last for a total of 2.5 minutes and will be divided into two separate timed periods – the Autonomous period and the Driver Control period. The robot must remain in its final resting position at the end of the Autonomous period and cannot be moved until the start of the Driver Control period. More detailed descriptions of each period follow:

1. The Autonomous period: Teams will have 30 seconds to score points with their robot using only code previously installed on their robot, and without any operator control. Remote controls must be out of the drivers’ hands during this period.

2. The Driver Control (Teleoperation) period: At the conclusion of the Autonomous period, drivers from both teams will be allowed to operate their robot by remote control for 2 minutes. At the conclusion of this period, the referee/scorer will calculate the final scores for both teams and declare a winner.

Scores will be tallied by referees and other event officials at the end of the Driver Control period. Scores may not immediately be revealed to teams, but will be posted shortly after a match’s conclusion, after scoring officials have verified and entered them into the system.

Scoring Elements

Each team will start with 16 Astronauts that they control and can perform missions with. Each Astronaut is an Andymark “Climber” from the 2016 FTC game “Res-Q.” The Astronauts will be partly blue or red to represent which team they belong to. Before a match begins, a team can start with 2 Astronauts preloaded on or next to their robot on their side of Earth. After the match begins, teams must use the provided “loading chute” to deposit their remaining Astronauts onto their side of Earth, specifically on the field itself and/or their robot for the robot to control and maneuver them to the 8 Extraterrestrial planets to score points.
A team can only have 2 of their own Astronauts contained within the boundaries of Earth at any one time. If more than two Astronauts are deposited onto a team’s side of Earth, only the first two astronauts deposited will count and be allowed to score. The remaining Astronauts will be decommissioned and not be able to be scored with. If a team’s Astronaut makes its way onto the REC field through any mechanism or method besides the team’s loading chute, that Astronaut will be decommissioned and not be able to be scored with.

For an Astronaut to successfully land or “colonize” an Extraterrestrial Planet, the Astronaut figure must be ENTIRELY within the planet’s borders on the field. This means the entirety of an Astronaut figure must be contained within the outside edge of a planet’s border, indicated by a taped edge or piece of wood. If an Astronaut is not fully in a planet’s borders when deposited, but is partly contained in the planet’s borders, it will not count for any points at that time, but is still within the planet’s “gravitational pull” and can be moved by the robot fully onto the planet, with the time left, to score. A team CANNOT interfere with their opponent’s Astronauts anywhere on the field.
Figure 5: Red and Blue Astronauts are on the taped border, but both have successfully colonized Mars and will earn points for their teams.

Figure 6: Red Astronaut has successfully colonized Mars, but the Blue Astronaut is NOT fully on the planet, and thus will not earn points if left in this state at the end of a match.
Jupiter and Saturn are each surrounded by 4 moons that are obstacles for a team’s robot to get around. The Moons are regulation baseball size (approximately 2.75” in diameter) wiffle balls, and were used in the 2018/2019 FTC game “Rover Ruckus.” Four moons will be positioned around the perimeter of each of the planets Saturn and Jupiter. If a team’s robot comes into contact with a planet’s moon, they will lose 5 points for each moon that is dislocated from the ring it sits atop of, aka “crashed” into.

![Figure 7: Jupiter and Saturn each have 4 Moons (the wiffle balls) located on their perimeter tape line. Both planets also contain 2 Gems, represented by the gold blocks.](image)

When a team successfully delivers at least one Astronaut to a planet, that team has “Colonized” that planet. At the end of the game, teams will receive an additional “Colonization Bonus” based on how many planets they have colonized successfully. The bonus is exponential in value, and follows the table below:

<table>
<thead>
<tr>
<th>Planets Colonized (n)</th>
<th>Colonization Bonus (2^n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
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<td>7</td>
<td>128</td>
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<td>8</td>
<td>256</td>
</tr>
</tbody>
</table>
Gems, located on Mars, Venus, Jupiter, and Saturn, are valuable resources represented by gold-colored cubes that are 2in each in length, width, and height, and were used in the 2018/2019 FTC game “Rover Ruckus.” To score points, a team must return the Gems to Earth. Specifically, Gems must be delivered back to a team’s designated “Depository,” located adjacent to the team’s Launchpad, to score 10 points each. The Gems need to be fully contained within a team’s Depository to count for points. Gem points will be counted at the end of a match.

More information on the materials used to build the 2020 REC game can be found in the 2020 REC Build Guide, including the websites where items can be purchased.

Judging and the Engineering Notebook

During the course of the season, teams should document their work in an Engineering Notebook, which should summarize the team’s entire process of designing, building, programming, and testing their robot. It is expected that teams update their Engineering Notebook every meeting. At State Fair, on the morning of the REC Tournament, each team must submit their Engineering Notebook when they Check-In that morning. The judges will not review Engineering Notebooks before judging rounds begin.

During the day of the REC tournament, each team will have a scheduled time to give a presentation about their work during the season, both technical and non-technical, to a panel of judges. These sessions will last approximately 10 minutes, but teams must leave time for judges to ask questions at the end. It is recommended teams aim to have their presentations last approximately 5 minutes with 5 minutes left for questions. If the judges feel a team’s presentation is running too long, they reserve the right to stop the team at whatever point deemed necessary, and the judges will score the team on what they heard and what questions they’re able to ask with the time left. The team’s Engineering Notebook and their presentation will determine their final judging score. The rubric used by judges to score notebooks and presentations can be found in the appendix of this document.

State Fair Competition Structure

During the State REC Tournament, REC teams will compete in at least 3 matches against other teams of their same age group. Seniors will compete only against seniors, intermediates only against intermediates, and juniors only against juniors. The age group of a team is determined by the age of the oldest member of the team that is competing, and the age group that individual would fall under in Maryland 4-H will be the age group the team, as a whole, will compete in for REC.

The winning team from each match will be awarded 2 match points for a win, with the losing team receiving no points. In the event of a tie, each team will receive 1 match point. Overall match rankings will be determined by the total number of match points awarded to each team.

The highest possible final judging score will be equal to the highest possible match point total a team can earn over the course of the tournament. For instance, if a team had 3 matches during the day, they could possibly earn 6 match points. In this case, the max judging score would also be 6 points. Thus, the highest max combined score a team can earn for the entire competition would be 12 points.

Final tournament rankings will be determined by combining each team’s match points with their judging score. The team with the highest combined total will be declared Maryland 4-H REC Champion.
The Field and Field Elements

The Field

Matches are played on a standard 12’ x 12’ VEX VRC field, with perimeter walls 12” high, and a field surface of standard foam VEX or AndyMark FTC tiles measuring 24” x 24”. Before each match, each of the two teams will be assigned to one of two starting tiles – either red or blue. The starting tiles are on one side of the field, indicated by their red or blue color. These tiles are called the “Launchpads.” The red and blue Launchpads will be directly next to each other on Earth.

Each team will also have a designated “Depository” that is also one tile in size, and located directly next to the team’s Launchpad (left of the Launchpad for red, right of the Launchpad for blue from the driver’s perspective).

![Figure 8: The Depository for the blue team is the grey foam tile bounded by and including the blue tape. Note its position next to blue’s Launchpad and Venus.](image)

For the field itself, the terms “Space” or “Outer Space” may be used interchangeably to describe areas between planets that is not designated specifically as anything else (including Earth). The four sides of the field are identified by the planet(s) near their center. Earth is located directly opposite of Pluto and Mercury, and Jupiter is opposite of Saturn (Jupiter closest to red Launchpad and Saturn closest to blue).

Field Elements

The field elements are broken down by the planets featured and what the goals are for each. “Partner Planets” are located symmetrically opposite from each other on the field, and any team can score with any of the 8 extraterrestrial planets. Teams must make the determination, with the distances involved compared to where they “Launch” from, what is the best use of the time they have to score points.
Earth

The four tiles which comprise the two teams’ Launchpads and Depositories are designated as “Earth” and are where games will begin. The red side and blue side of earth are distinguished by appropriately colored foam tiles for the teams’ Launchpads and one taped off tile adjacent, for each team, representing their Depository. Earth has an invisible 2 foot height. All robots, attachments, and components must be FULLY contained in Earth at the start of a match. Each team will be provided 16 “Astronauts” and will use their provided “loading chute” to load them onto their robot or Launchpad. The loading chute is located outside of the field next to a team’s Launchpad.

A team can only have a maximum of 2 of their own Astronauts on Earth at any one time. If a team deposits a third Astronaut onto the field or their robot, the third Astronaut will be decommissioned and cannot be scored for any points. To score points, teams will transport their Astronauts around the field to the 8 Extraterrestrial (non-Earth) planets in order to “colonize” them and score points. Only a maximum of two Astronauts can be placed on a planet by a team’s robot. A team with more than 2 of their Astronauts located on a planet at the end of the match will only have 2 of the Astronauts count for points. The Jupiter side of Earth is the red team’s side of the planet, while the Saturn side of Earth is the blue team’s side of the planet.
While any team can score points on any of the 8 Extraterrestrial planets, teams CANNOT enter (park, pass through, etc.), interfere, or manipulate their opponent’s side of Earth, with one exception. If a team’s Astronaut, whether through the dynamics of the Loading Chutes or their own robot’s movement, ends up on their opponent’s side of Earth, they can retrieve their own team’s Astronaut ONLY and bring it back to their side. Teams, however, CANNOT interfere and should not interact with their opponent’s Astronauts anywhere on Earth or with their opponent’s collected Gems. Robots can also ONLY be “launched” into space from a team’s designated Launchpad, and can only park in their Launchpad in order to score “Parking” points.

Venus and Mars
On the REC field, Venus and Mars are located on opposite ends of the field and are the closest planets to the teams’ Launchpads. Each planet comprises a 2ft by 2ft tile, minus the tile’s teeth. Each Astronaut successfully landed on Venus and/or Mars is worth 5 points apiece (20 points max=2 Astronauts X 2 Planets X 5 Points).

![Figure 10: Venus and Mars have the simplest setup on the field and are the easiest for teams’ astronauts to reach. Note the 2 gold blocks representing Gems placed towards the middle.](image)

Also on Venus and Mars are 2 “Gems” apiece (4 total between the two). A robot can bring the Gems back to their side’s “Depository” on Earth to score points. Gems fully inside a team’s Depository at the end of a match are worth 10 points apiece.
Gems are distributed evenly on the two planets, aligned halfway between the front and back of
each planet as seen from the middle of the field. One gem is placed 7 inches inside the left inner line of the planet’s taped border, and the other gem is placed 7 inches inside the right inner line (opposite side of the planet) of the tape border. If done correctly, this means the gems should be 5 inches apart from each other.

**Saturn and Jupiter**
Saturn and Jupiter are situated on opposite sides of the REC field. They are each surrounded by 4 moons, represented by wiffle balls. Each planet comprises a 2ft by 2ft tile, minus the tile’s teeth.

The mission is for the Astronauts to successfully reach Jupiter and/or Saturn WITHOUT having the robot interfere or make contact with the moons (aka, a crash). Successfully depositing a max of 2 Astronauts apiece onto Saturn and/or Jupiter without causing any of the wiffle balls to move is worth 5 points per Astronaut (20 points max=2 Astronauts X 2 Planets X 5 Points). If a team’s robot comes in contact with a planet’s moon during the course of play, a 5 point penalty is applied for each moon dislocated, or “crashed” into (as per page 12).

Moons will be located in the same places on the field each game, held in place by rubber O-rings. If a moon is dislocated from its original position due to other factors besides robot contact (wind, vibrations, uneven playing field, etc.), this will not cause a team to lose points or be penalized. The moon will remain on the field until the match’s end, and will be put back into its original location before the next match. Only when the actions of a team, their robot, Gems under their control, and/or other actions by a team end up causing a moon to dislocate will penalties be applied.
Also on Jupiter and Saturn are 2 “Gems” apiece (4 total between the two). Gems fully inside a team’s Depository at the end of a match are worth 10 points apiece.

Gems are distributed evenly, aligned halfway between the front and back of each planet as seen from the middle of the field. One Gem is placed 7 inches inside the left inner line of the planet’s taped border, and the other Gem is placed 7 inches inside the right inner line (opposite side of the planet) of the tape border. If done correctly, this means the Gems should be 5 inches apart from each other.

**Neptune and Uranus**

Neptune and Uranus are each one 2ft by 2ft tile in size. Both planets have an 8in tall barrier representing their hostile terrains. Robots must maneuver their Astronauts onto these surfaces (their respective foam tiles), which is wholly contained inside these barriers. Each successfully landed Astronaut is worth 10 points per Astronaut (40 points max=2 Astronauts X 2 Planets X 10 Points).

![Figure 12: Neptune and Uranus are each surrounded by an L-shaped wood barrier that is 8 inches tall and encloses each planet in a 2ft x 2ft square. The 2 wood pieces are hinged together for easy storage.](image)

**Pluto and Mercury**

Pluto and Mercury are only 1ft by 1ft in size on the REC playing field, making the successful delivery of Astronauts to these planets much more difficult.
Each Astronaut successfully colonizing Pluto and/or Mercury (fully inside the planet!) is worth 10 points per Astronaut (40 points max=2 Astronauts X 2 Planets X 10 Points). NOTE: See “Field Elements” and “Scoring Elements” sections for specific information regarding what a successful “Landing” is on an Extraterrestrial Planet in this game.

Attached to the glass, centered above 6 of the planets, will be an image of that planet that teams can use, if they so decide, to help align and direct their robot to that planet (using Vuforia or other imaging software). Images of these planets are included in the appendix, and can be printed on 8.5x11 sheets of paper and taped to the field perimeter itself. The images should be taped to the field in portrait orientation. The planets with images are Mercury, Venus, Jupiter, Saturn, Mercury, and Pluto.

**Challenge & Game Rules**

**Robot Rules**

1. Robots can weigh a maximum of 20 lbs.
2. Robots may be constructed using a wide variety of materials. Creativity is encouraged! Legos, VEX robotics parts, FIRST components, plastic, cardboard, duct tape, fasteners of various types, etc. are all permitted.
3. Components that pose risk of harm to an opponent’s robot are not permitted, even if the risk is unintentional or rare. This includes, but is not limited to, sharp, explosive, radioactive, or liquid components. Robot inspectors, judges, and referees all will be monitoring for these potential risks.
4. At the beginning of a match, no robot may exceed 18 inches in any dimension, height, width, or length.
5. Once a match begins, a robot may expand in size but may not exceed 24 inches in length, width, or height. Teams are urged to use common sense when designing their robot expansions.
6. No component of a robot may be intentionally detached during a match. This can present a safety hazard.
7. The robot’s power source CANNOT exceed a total of 12 volts.
8. The total capacity of the robot’s power source CANNOT exceed 6000 mAh.
9. During a match, robots MUST be controlled wirelessly. No tethered or wired connections are allowed.
10. A robot’s Autonomous program, if it has one, MUST be able to be started remotely by a team. After being placed in its starting position on the field, touching the robot or its components in any way to start it, change its programming or operation, or otherwise control it in some manner, is not allowed until after the event officials signal it is clear for robots to be removed. Starting and/or controlling robots by hand in this manner could present safety hazards.
11. Any microprocessor may be used in the robot’s design.
12. Any wireless controller may be used, as long as the setup allows for the robot’s operation in Autonomous and Driver Control to be done remotely, in accordance with Robot Rule 10 above.
13. A robot can have a MAXIMUM of 10 motors and/or servos total.
14. On Challenge Day, all robots must be inspected before they will be permitted to compete in any match. Any issues inspection judges find with a robot design or setup must be rectified first before it is allowed to compete.

**Participation Restrictions**

1. 4-H REC Teams may consist of 3 up to 8 4-H youth members total.
2. All team members MUST be enrolled in 4-H Online by July 15, 2020 in order to participate in REC at State Fair. Failure to be an enrolled 4-H member, paid in full, and in good standing will result in those individuals not being able to participate in the challenge in any form.
3. Each group of youth must have two certified 4-H mentors and/or volunteers established to compete and remain in compliance with established 4-H program rules and protocols.
4. Coaches and Mentors are allowed to run, assist, and/or oversee more than one 4-H REC team.
5. A team’s age group designation will be determined by the oldest member of the team. The age groups are as follows (Note: age is determined by a child’s age as of 1/1/2020)
   5.1. Senior Age Group: 14+ years
   5.2. Intermediate Age Group: 11 through 13 years
   5.3. Junior Age Group: 8 through 10 years

**Safety Rules**

1. Each team in the pit areas and/or at the field during a match must wear safety glasses. NO EXCEPTIONS!
2. If a robot becomes disabled or behaves erratically, an event official may authorize a team member to enter the field of play and shut off the robot. This is the ONLY time a team member may be allowed to enter the field while play is ongoing. Penalties may be applied if team members enter the field without permission by an event official, while a match is ongoing.
3. Robots that repeatedly or purposefully damage other robots and/or the field or field elements may be removed from the tournament by an event official.

**General Challenge Rules**

1. All decisions regarding scoring and rules violations are made by event officials. Every effort will be made to ensure matches are fairly and evenly officiated. Concerns about match scoring, penalties, and violations must be brought to the attention of event officials at the end of the match in question, and before the robots are removed from the playing field.

2. Unless given explicit permission by an event official, team members must remain in the designated driver/team areas marked off behind the starting tiles for the duration of the match.

3. At no point during a match may anyone other than a teammate at the field give coaching or instruction.

4. Each match will last a total of 2 minutes and 30 seconds: 30 seconds for Autonomous and 2 minutes for Driver Control.

5. Each team is permitted to have a maximum of three team members at the field during a match: a Pilot, a Co-Pilot, and coach. Team mentors are not allowed at the field during matches.

6. After robots have been setup on the field and event officials have given the “ready” signal, team members CANNOT enter the field or change the position of their robots without explicit permission from the officials.

7. In order to receive parking points at the end of both the autonomous and driver-controlled periods of a match, a robot MUST fully leave Earth (and thus their Launchpad) before returning to the Launchpad.

8. A team can only have a maximum of 2 of their Astronauts within Earth’s boundaries at any time, including if their Astronauts end up on their opponent’s side of Earth.

9. If team has a third astronaut (or more) end up on Earth at one time during a game, those astronauts past the first two that arrived on Earth will be decommissioned and CANNOT be scored for points. When deemed necessary or due to an interference, an Event Official has the right to remove these decommissioned Astronauts from the field during a match.

10. A team CANNOT interfere with their opponent’s Astronauts, Gems, or other materials, except for incidental contact. Final scoring will be determined at the end of the match.

11. During each match, a countdown timer will be clearly visible to all teams competing in the current match.

12. Event officials may be encouraged, but are not required, to give a countdown in the closing seconds of each match.

13. A buzzer sound plus a signal from an event official will indicate time has expired for each match. At this point, teams must IMMEDIATELY set down their controller to make it obvious they are no longer operating their robot. Any missions completed after the 2.5 minute period will not count towards the scoring.

14. If a robot malfunctions at the conclusion of a match such that the robot continues to operate, teams must receive an “OK” from the event official before manually disabling their robot.

15. If a team continues to operate their robot after time has expired, an event official will give a Warning for the first violation. Additional violations may result in a team being disqualified from the current match and subsequent matches.

16. If and only if extreme circumstances arise that compromise the integrity of the game, as decided by event officials, the decision to replay a match or a portion of it may be made.
**Autonomous Period**

1. The Autonomous period will last for the first 30 seconds of the match.
2. A team can preload 2 Astronauts total onto their side of Earth, whether on the robot, on the field, or a combination of the two, before the Autonomous period starts.
3. If neither team has an Autonomous program, a match will proceed directly to the 2-minute Driver Control period.
4. 10 points will be awarded to the team that scores the highest during the Autonomous period.
5. In the event of a tie at the end of Autonomous, both teams will be awarded the 10 bonus points.
6. Teams must either use a VEXNET match controller or the FTC Robot Controller app to stop their Autonomous, or must have another approved method to stop their robot’s Autonomous function immediately upon expiration of the 30-second Autonomous period.
7. Incidental contact between robots is permitted during the Autonomous period. Intentional contact is not permitted in any form and may result in penalties being applied.
8. During the Autonomous period, a team must not handle their remote control, so as to ensure that no driver-controlled operations are happening during this time.
9. Teams may be asked at any time by an event official to demonstrate proper functionality of their Autonomous operation. Failure to do such may lead to disqualification.
10. Once the Autonomous period has begun, teams may not touch their robot for any reason unless they have received explicit approval from an event official.
11. A team may terminate their Autonomous operation at any time during the Autonomous period. They must indicate to an event official that they are doing such beforehand.
12. Once an Autonomous program is terminated, teams may not resume Autonomous operation for the rest of that match.
13. If a robot continues operation past the end of the Autonomous period, any missions it completes after the 30-second time will NOT be counted for points. The first time a team’s robot does this, they will be given a Warning. At the 2nd instance, their robot will be disqualified from participating and scoring in the Autonomous portion of matches for the rest of the competition.
14. Failure to comply with the rules in this section will result in an immediate disqualification from the match at the discretion of an event official.
15. At the conclusion of the Autonomous period, an event official will calculate the score of each team and announce the winner of the Autonomous bonus points.

**Driver Control Period**

1. The Driver Control period will last for 2 minutes.
2. During Driver Control, each team must control their robot exclusively through wireless controllers.
3. Controlling the robot using wired or tethered means is not permitted.
4. Each team may have a maximum of 2 drivers present during any single match.
5. During the Driver Control period, teams may not touch their robot for any reason unless the team has received explicit permission from an event official to do so.
6. In general, teams may not make contact with their opponent’s robot during Driver Control.
7. During Driver Control, incidental contact between robots may happen, but is frowned on. Repeated incidents of robot contact may lead to penalties and/or other actions by event officials.
8. During Driver Control, the following are NOT permitted for any reason: pushing your opponent’s robot, pinning your opponent’s robot, restricting movement of your opponent’s robot in any way.
9. On the first violation of rules regarding robot contact and restricting the movement of opposing
robots, the referee will issue the offending team a Warning. Subsequent infractions by the same team will result in disqualification from a match, and the win being credited to the offended team.

10. Teams may not block an opponent’s access to a planet and/or to their Launchpad or Depository.

11. Teams may not intentionally make contact with their opponent’s Astronauts at any time, or intentionally make contact with their opponent’s Gems once collected and deposited.

12. At the conclusion of Driver Control, teams may not touch, move, or otherwise handle their robot until granted permission from an event official. This is to ensure final scoring is done accurately.

**Match Scoring**

1. Before scoring is begun at the end of the match, any robot in contact with a field element may be moved by an event official in order to break contact between the robot and field element.

2. Teams may ask for scoring or rules clarification before removing their robot from the field of play.

3. Once the signal has been given for robots to be removed from the field, all scoring decisions are final.

4. Astronauts may be determined to be on a planet by using a flat plate that would be placed along the outer edge of the planet’s bordering tape line or wood barrier. To count for points, the Astronaut must rest entirely within the invisible plane extending upward from the outer edge of that planet’s tape line or wood barrier.

5. Any Gems (Resources) located fully in a team’s Depository will award 10 points to that team. These points will be calculated based on the final state of the field at the end of Driver Control.

6. For a robot to be considered “parked” at the end of the Autonomous and/or Robot Control periods, it must be contained ENTIRELY within their assigned “Launchpad” on their side of Earth. This includes the wheels, extensions, arms, and any other robot components.

7. If a robot is holding Gems and is correctly “parked” in Earth at the end of a match, the Gems would thus not be located in a team’s Depository at the end of the match, so the Gems would NOT count for any points.

8. The team that is in the lead at the end of the Autonomous portion of the game will receive a 10 point bonus. If there is a tie at the end of the Autonomous period, both teams will receive 10 bonus points.

9. A theoretical maximum of **496 points** can be scored by a team in a single match:
   - Two Astronauts landed on each of the 8 planets: **120 points**
     - Venus & Mars: 20 points
     - Jupiter & Saturn: 20 points
     - Pluto & Mercury: 40 points
     - Neptune & Uranus: 40 points
   - Robot parked fully in Launchpad: **30 points**
     - End of Autonomous: 10 points
     - End of Driver Controlled: 20 points
   - Resources successfully returned to Team’s Depository: **80 points**
     - Gems: 8 x 10 points each = 80 points
   - Autonomous Bonus: **10 points**
   - Planet Colonization Bonus: **256 points**
     - \(2^n\) points, where \(n\)=number of planets with at least one of a team’s Astronauts successfully landed on it. (See Table on Page 12.)
<table>
<thead>
<tr>
<th>MISSION</th>
<th>DONE?</th>
<th>QUANTITY (IF APPLICABLE)</th>
<th>POINTS +/-</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASTRONAUTS DEPOSITED ON VENUS &amp; MARS (5 Points per Astronaut, 2 MAX)</td>
<td></td>
<td></td>
<td>/10</td>
</tr>
<tr>
<td>Venus</td>
<td></td>
<td></td>
<td>/10</td>
</tr>
<tr>
<td>Mars</td>
<td></td>
<td></td>
<td>/10</td>
</tr>
<tr>
<td>ASTRONAUTS DEPOSITED ON JUPITER &amp; SATURN (5 Points per Astronaut, 2 MAX)</td>
<td></td>
<td></td>
<td>/10</td>
</tr>
<tr>
<td>Jupiter</td>
<td></td>
<td></td>
<td>/10</td>
</tr>
<tr>
<td>Saturn</td>
<td></td>
<td></td>
<td>/10</td>
</tr>
<tr>
<td>ASTRONAUTS DEPOSITED ON NEPTUNE &amp; URANUS (10 Points per Astronaut, 2 MAX)</td>
<td></td>
<td></td>
<td>/20</td>
</tr>
<tr>
<td>Neptune</td>
<td></td>
<td></td>
<td>/20</td>
</tr>
<tr>
<td>Uranus</td>
<td></td>
<td></td>
<td>/20</td>
</tr>
<tr>
<td>ASTRONAUTS DEPOSITED ON PLUTO &amp; MERCURY (10 Points per Astronaut, 2 MAX)</td>
<td></td>
<td></td>
<td>/20</td>
</tr>
<tr>
<td>Pluto</td>
<td></td>
<td></td>
<td>/20</td>
</tr>
<tr>
<td>Mercury</td>
<td></td>
<td></td>
<td>/20</td>
</tr>
<tr>
<td>PARKING: Robot MUST be fully within Launchpad (10 Points-Auto, 20 Points-TeleOp)</td>
<td></td>
<td></td>
<td>/10</td>
</tr>
<tr>
<td>Autonomous PARK</td>
<td></td>
<td></td>
<td>/10</td>
</tr>
<tr>
<td>TeleOp PARK</td>
<td></td>
<td></td>
<td>/20</td>
</tr>
<tr>
<td>GEMS COLLECTED AND RETURNED (FULLY) IN DEPOSITORY (10 Pnts Each, 8 MAX)</td>
<td></td>
<td></td>
<td>/80</td>
</tr>
<tr>
<td>Gems in Depository</td>
<td></td>
<td></td>
<td>/80</td>
</tr>
<tr>
<td>BONUS FOR LEADING TEAM AT AUTONOMOUS END (10 Pnts, Tie=10 Pnts for both teams)</td>
<td></td>
<td></td>
<td>/10</td>
</tr>
<tr>
<td>Autonomous Bonus</td>
<td></td>
<td></td>
<td>/10</td>
</tr>
<tr>
<td>COLONIZATION BONUS FOR PLANETS TEAM HAS DEPOSITED ASTRONAUTS ONTO (Exponential, 2^n Points for “n” number of planets colonized, n=0-8, 256 Points Maximum)</td>
<td></td>
<td></td>
<td>/256</td>
</tr>
<tr>
<td>Colonization Bonus</td>
<td></td>
<td></td>
<td>/256</td>
</tr>
<tr>
<td>TEAM MEMBER INITIALS________</td>
<td></td>
<td></td>
<td>TOTAL /496</td>
</tr>
</tbody>
</table>

Field Layout (Blank)

- = GEMS
○ = MOONS
= 8in TALL WOOD BARRIER
MARS (Image courtesy of NASA)
VENUS (Image courtesy of NASA)
SATURN (Image courtesy of NASA)
MERCURY (Image courtesy of NASA)
PLUTO (Image courtesy of NASA)
NEPTUNE (Image courtesy of NASA)

**Image will be located on Floor of Neptune for Audience Recognition and Understanding**
**Image will be located on Floor of Uranus for Audience Recognition and Understanding**
### Judging Rubric

<table>
<thead>
<tr>
<th>Quality of Display Elements</th>
<th>Awarded Points</th>
<th>Possible Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visual elements were well organized.</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Visual elements were helpful (i.e. not just &quot;eye candy&quot;).</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td><strong>SECTION TOTAL:</strong></td>
<td><strong>10</strong></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Quality of Presentation</th>
<th>Awarded Points</th>
<th>Possible Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Each team member spoke and information presented matches what is recorded in Engineering Notebook.</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Team clearly presented overview and technical information about major subsystems of robot (scoring mechanisms, drivetrain, choice of materials, battery info, power supply, gear ratios, etc.).</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Team provided clear and detailed explanation of code and programming.</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Team provided an explanation of design process, problem solving process.</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Clearly demonstrated understanding of game, rules, and strategy.</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td><strong>SECTION TOTAL:</strong></td>
<td><strong>40</strong></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Quality of Engineering Notebook</th>
<th>Awarded Points</th>
<th>Possible Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Each team member has a brief biography in notebook.</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>The team includes information, which matches what is included in their presentation, about their service projects throughout the year that align with the goals and priorities of MD 4-H and 4-H REC.</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>The team clearly demonstrates &amp; records their process of robot design, building, programming, and testing, including goals, important milestones, significant changes, evaluation and testing methods, etc.</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>The team clearly demonstrates the problems they identified, the work they did to solve each particular problem, the testing methods used to verify the solutions, and adequately explained the resolutions.</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td><strong>SECTION TOTAL:</strong></td>
<td><strong>50</strong></td>
<td></td>
</tr>
</tbody>
</table>

**GRAND TOTAL** 100