VEX ROBOTICS COMPETITION
TOWER TAKEOVER

2019-2020
Game Manual

Table of Contents

Section 1
Introduction

Overview

This section provides an introduction to the VEX Robotics Competition and VRC Tower Takeover.

The VEX Robotics Competition

Our world faces a serious problem. It's a problem that, without explicit and intentional action, will eventually stagnate global progress and lead to a workforce that is unmotivated and ill-equipped to solve its future problems. As the world grows more technologically complex, the challenges we face every day will continue to escalate along with it. A cell phone has more failure modes than a landline. The internals of an electric car are more difficult to comprehend than a V8 combustion engine. Unmanned drone legislation is more nuanced than defining a maximum speed limit.

Dubbed "the STEM problem", the situation is equally simple to understand, yet difficult to solve. In many cases, the traditional methods of teaching science, technology, engineering, and math (STEM) will not be enough to adequately prepare students for this complex world. This is often coupled with the unfortunate reality that by the time they reach an age capable of grasping these critical topics, students may have already determined that they are "not cool" or "boring". Without the skills or passion necessary to approach these problems in an educated manner, you cannot possibly expect to be productive in making forward progress or even sustaining the status quo.

The VEX Robotics Competition exists to solve this problem. Through its uniquely engaging combination of teamwork, problem solving, and scientific discovery, the study of competitive robotics encompasses aspects of STEM. You're not building VEX EDR robots because your future job will involve tightening shaft collars on a metal bar – you're executing an engineering design and problem-solving process that resembles the same mindset used by rocket scientists, brain surgeons, and inventors around the world. VEX

Robotics Competition Tower Takeover is not just a game that we invented because it is fun to play – it is a vehicle for teaching (and testing) teamwork, perseverance in the face of hardship, and provides a methodology to approach and solve new challenges with confidence.

Contained in this manual are the rules that shape VRC Tower Takeover. These rules are designed to simulate the constraints that will outline any real-world project. They are intended to promote creativity without punishing innovation. They are balanced to promote fair play while encouraging competition.

We encourage you to keep in mind that a VEX Robotics Competition game is more than just a set of game objects worth varying amounts of points. It is an opportunity to hone the life-long skills that will characterize the problem-solving leaders of tomorrow.

Good luck, and we'll see you on the playing field!
Sincerely,

The VEX Robotics Game Design Committee, comprised of members from the Robotics Education & Competition Foundation, Robomatter, DWAB Technology, and VEX Robotics.

VEX Robotics Competition Tower Takeover: A Primer

VEX Robotics Competition Tower Takeover is played on a 12'x12' square field configured as seen below. Two (2) Alliances - one (1) "red" and one (1) "blue" - composed of two (2) Teams each, compete in Matches consisting of a fifteen (15) second Autonomous Period, followed by a one minute and forty-five second (1:45) Driver Controlled Period.
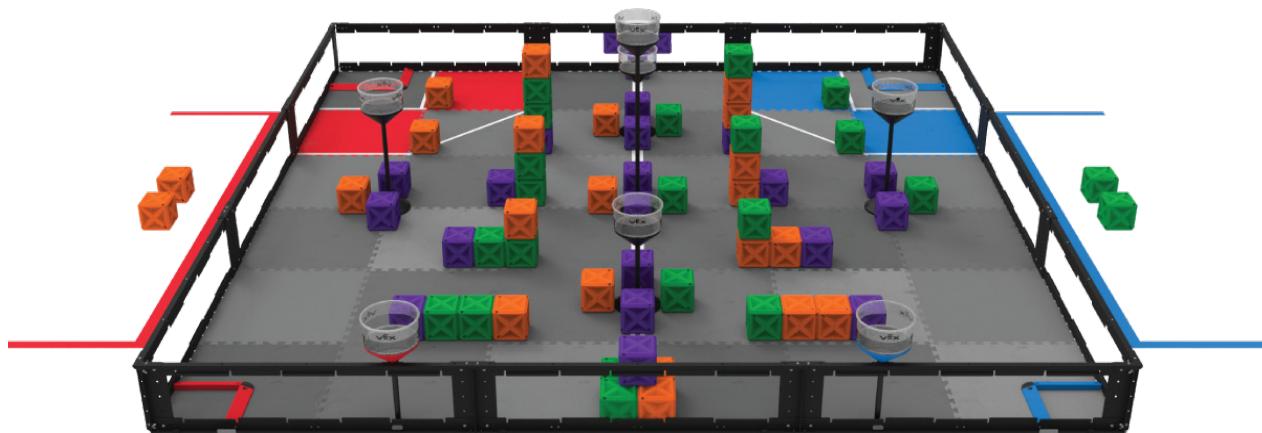
The object of the game is to attain a higher score than the opposing Alliance by Placing Cubes in Towers and Scoring Cubes in Goal Zones.

For more details and specific game-play rules, see "Section 2" – The Game.

For more information about VEX, visit www.vexrobotics.com. Follow us on Instagram, Twitter or Snapchat @VEXRobotics. Like us on Facebook at www.facebook.com/vexrobotics.

For more information about the Robotics Education & Competition Foundation, visit www.roboticse-ducation.org. Follow us on Twitter @REC_Foundation. Like us on Facebook at www.facebook.com/RECFoundation.

Visit www.RobotEvents.com for more information about the VEX Robotics Competition, including team registration, event listings, and results.

Section 2
The Game

Overview

This section describes the 2019-2020 VEX Robotics Competition game entitled VEX Robotics Competition Tower Takeover. It also lists the game definitions and game rules.

The VEX Robotics Competition

Matches are played on a field set up as illustrated in the figures throughout. Two *Alliances* – one "red" and one "blue" – composed of two *Teams* each, compete in each *Match*. The object of the game is to attain a higher score than the opposing *Alliance* by *Scoring Cubes*. The point value of each color of *Cube* is determined by how many *Cubes* of that color are *Placed* in *Towers*.

A point and *Cube* bonus is awarded to the *Alliance* that has the most points at the end of the *Autonomous Period*.
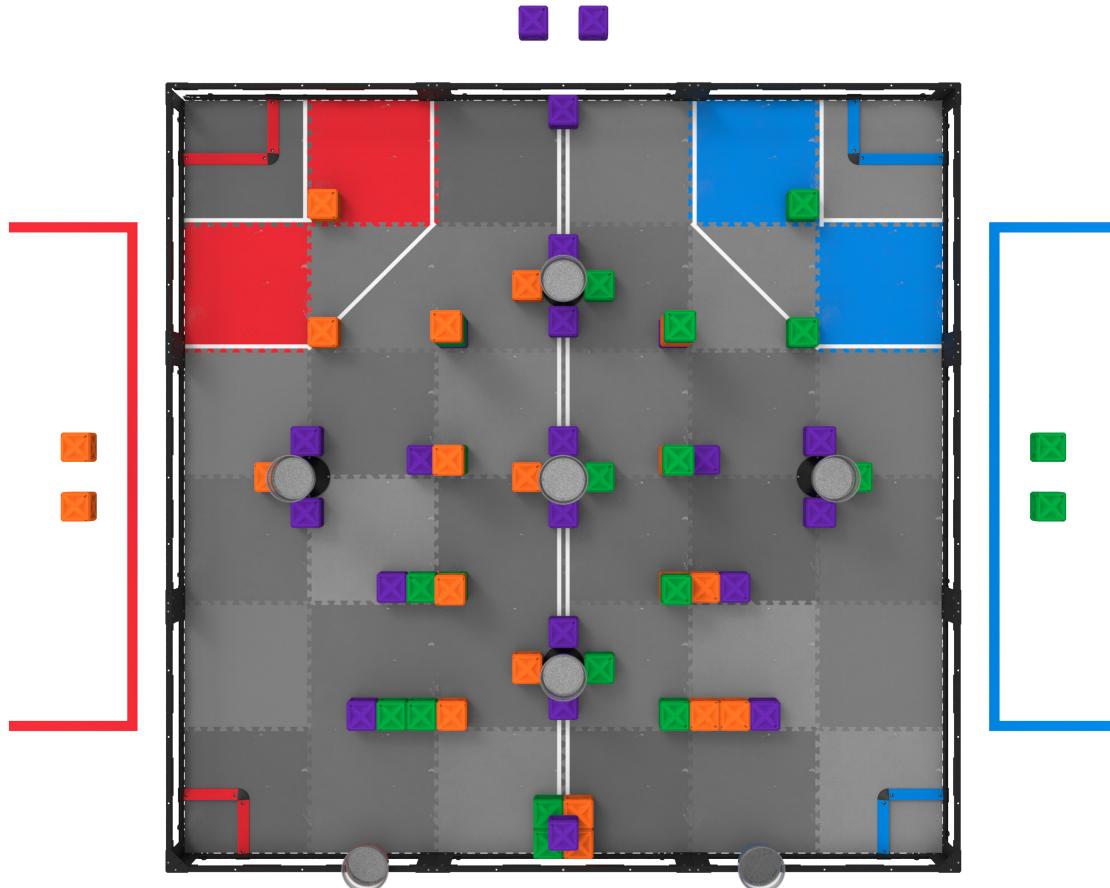

Figure 1: Top view of the field in its initial setup configuration.
Note: The illustrations in this section of the manual are intended to provide a general visual understanding of the game. Teams should refer to official field specifications, found in Appendix A, for exact field dimensions, a full field bill of materials, and exact details of field construction.

Each VEX Robotics Competition Tower Takeover *Match* includes the following:
- Sixty-six (66) *Cubes*
  - Twenty-two (22) orange *Cubes*, including two (2) used as *Preloads* by the red *Alliance*
  - Twenty-two (22) green *Cubes*, including two (2) used as *Preloads* by the blue *Alliance*
  - Twenty-two (22) purple *Cubes*, including two (2) given as part of the *Autonomous Bonus*
- Four (4) *Goal Zones*, two (2) per *Alliance*, used for *Scoring Cubes*
- Seven (7) *Towers*, of varying heights, used for *Placing Cubes*
  - Two (2) *Alliance Towers*, one per *Alliance*, that may only be used by that *Alliance*
 - Five (5) *Neutral Towers*
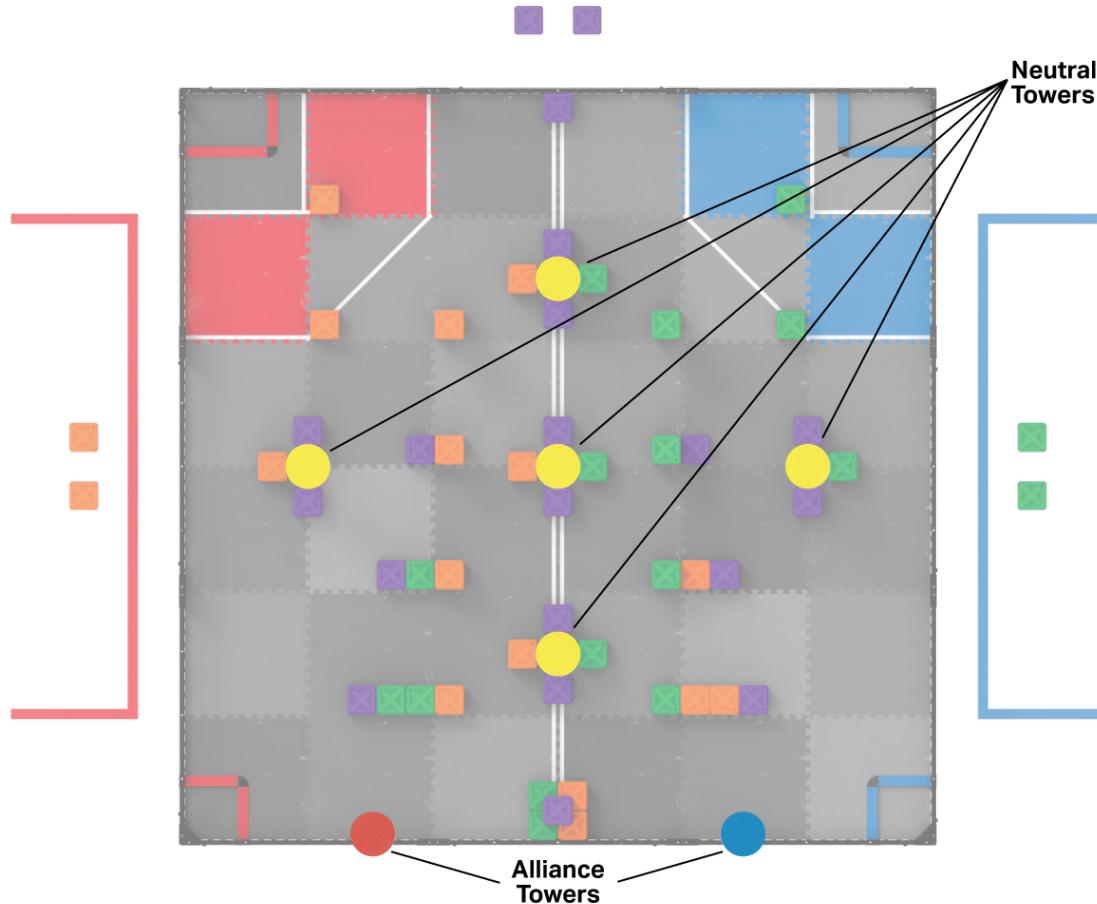
*Figure 2: Top view of the field with Towers highlighted.*
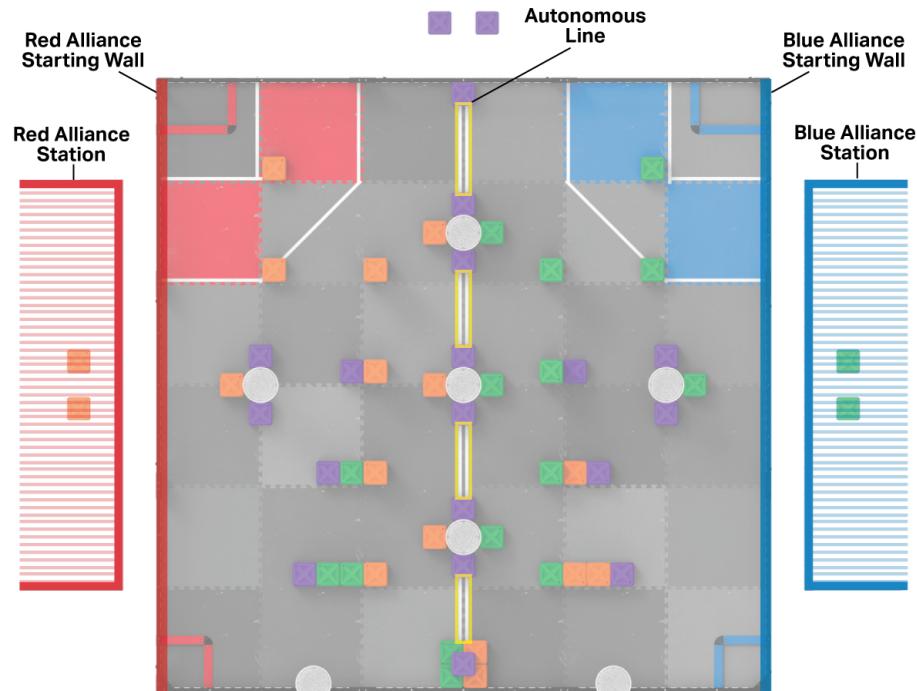
Figure 3: Top view of the field with starting positions, Alliance Stations, and Autonomous Line highlighted.

Game Definitions

Alliance - A pre-assigned grouping of two *Teams* that are paired together during a given *Match*.

Alliance Station - The designated region where the *Drive Team Members* must remain for the duration of the *Match*.

Autonomous Bonus - A bonus awarded to the *Alliance* that has earned the most points at the end of the *Autonomous Period*. The *Autonomous Bonus* consists of six (6) points added to the score at the end of the *Match*, and two (2) *Match Loads* that may be entered any time during the *Driver Controlled Period*.

> Note: If the *Autonomous Period* ends in a tie, each *Alliance* will receive an *Autonomous Bonus* of three (3) points and one (1) *Match Load*.

Autonomous Line - The pair of white tape lines that run across the center of the field Per <SG2>, *Robots* may not contact the foam field tiles on the opposite *Alliance*'s side of the *Autonomous Line* during the *Autonomous Period*.

Autonomous Period - A fifteen second (0:15) time period during which *Robots* operate and react only to sensor inputs and to commands pre-programmed by the *Students* into the *Robot* control system.

Barrier - The 2" (50.8mm) wide, 1" (25.4mm) tall, wedge-shaped plastic extrusion that borders each *Goal Zone* and all supporting materials.
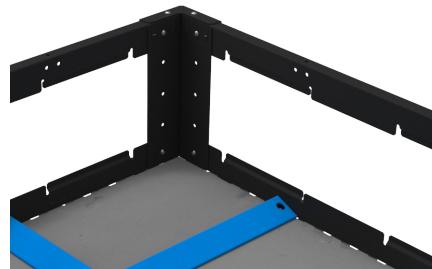

Figure 4: Close-up of a Goal Zone, depicting the Barrier.

Cube - A hollow plastic cube-shaped object, with an overall object width of 5.5" (139.7mm), that can be *Placed* in *Towers* or *Scored* in *Goal Zones*.
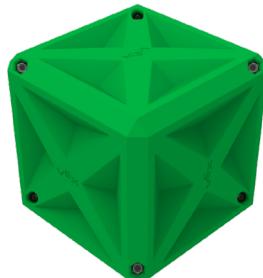

Figure 5: A Cube.

Disablement - A penalty applied to a *Team* for a rule violation. A *Team* that is *Disabled* is not allowed to operate their *Robot* for the remainder of the *Match*, and the *Drive Team Members* will be asked to place their controller(s) on the ground.

Disqualification - A penalty applied to a *Team* after a *Match* for a rule violation. A *Team* that is *Disqualified* in a *Qualification Match* receives zero (0) *Win Points*, *Autonomous Points*, and *Strength of Schedule Points*. When a *Team* is *Disqualified* in an *Elimination Match*, the entire *Alliance* is *Disqualified* and receives a loss for the *Match*. At the *Head Referee*'s discretion, repeated violations and *Disqualifications* for a single *Team* may lead to its *Disqualification* for the entire tournament.

Drive Team Member(s) - Up to three (3) *Students* who are allowed in the *Alliance Station* during a *Match* for each *Team*. Only *Drive Team Members* are allowed to touch the controls at any time during the *Match* or interact with the *Robot* as per <G9>. Adults are not allowed to be *Drive Team Members*. Per <G6>, *Drive Team Members* may only fulfill this role for one *Team*.

Driver Controlled Period - The one minute and forty-five second (1:45) time period during which *Drive Team Members* operate their *Robots*.

Entanglement - A *Robot* status. A *Robot* is *Entangled* if it has grabbed, hooked, or attached to an opposing *Robot* or a *Field Element*, as per <G16>.

Field Element - The foam field tiles, field perimeter, white tape, *Towers*, *Barriers*, and all supporting structures or accessories (such as driver station posts, field monitors, etc)..

Goal Zone - One of four (4) areas of foam field tiles defined by the inner edges of the *Barriers* and the field perimeter in which *Robots* can Score *Cubes*. The *Barrier* and field perimeter are not considered part of the *Goal Zone*.
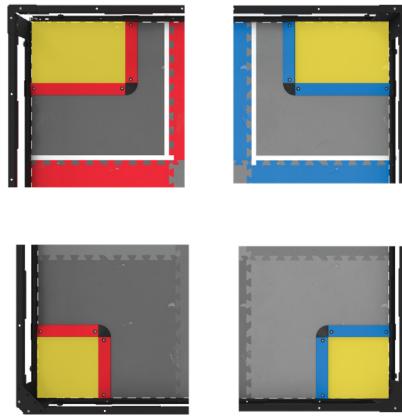

Figure 6: Close-ups of the four Goal Zones.

Match - A *Match* consists of an *Autonomous Period* followed by a *Driver Controlled Period* for a total time of two minutes (2:00).

Match Load - One of two (2) purple *Cubes* that may be entered at any point during the *Driver Controlled Period* by the winner of the *Autonomous Bonus* in accordance with <SG4>.

Match Affecting - A rule violation status determined by the head referee. A rule violation is *Match Affecting* if it changes the winning and losing *Alliances* in the *Match*. Multiple rule violations within a *Match* can cumulatively become *Match Affecting*.

Placed - A *Cube* status. A *Cube* is considered *Placed* in a *Tower* at the end of a *Match* if any part of it is breaking the plane defined by a given *Tower*'s *Placing Line*.

Note: Only one (1) *Cube* can be *Placed* in each *Tower*. If multiple *Cubes* meet the definition of *Placed* for a single *Tower*, then neither one is considered *Placed*.

Figure 7: A Cube that is Placed.

Figure 8: One Cube that is Placed, and one Cube that is not Placed.

Figure 9: A Cube that is not Placed.

Placing Line - The horizontal disc-shaped plane defined by the bottom edge of the textured surface on a given *Tower*. This textured surface extends roughly 2″ ± 0.25″ (50.8 ± 6.3mm) from the top edge of the *Tower*.

Figure 10: Close-up of a Tower, depicting the Placing Line.

Preload – The *Cube*, one (1) per *Robot*, that must be placed on the field such it satisfies the conditions in <SG1> prior to the start of the *Match*.

> Note: The red *Alliance* always uses orange *Cubes* as their *Preloads*. The blue *Alliance* always uses green *Cubes* as their *Preloads*.

Protected Zone - The area of the playing field made up of the *Outer Protected Zone* and the *Inner Protected Zone*, in which opponent *Robot* interaction is limited. See <SG3> for more details.

- **Outer Protected Zone** - The 3-dimensional volume extending upwards from the foam tiles and bound by the field perimeter, outer edge of the *Protected Zone* tape line, and the inner edge of the *Inner Protected Zone* tape line.
- **Inner Protected Zone** - The 3-dimensional volume extending upwards from the foam tiles and bound by the field perimeter and inner edge of the white tape line closest to one of each *Alliance*'s *Goal Zone*.
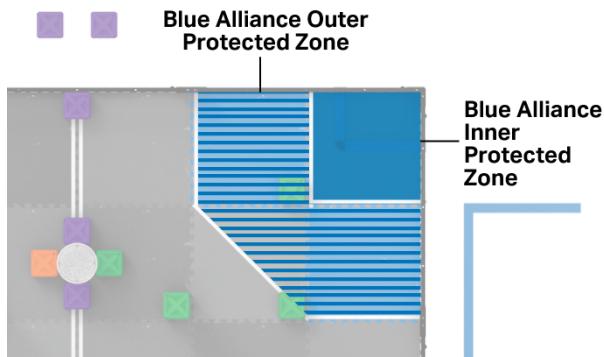

Figure 11: Close-up of a corner of the field, depicting the Protected Zones.

Robot - Anything that has passed inspection that a *Team* places on the field prior to the start of a *Match*.

Scored - A *Cube* status. A *Cube* is considered *Scored* in a *Goal Zone* at the end of a *Match* if it is not contacting a *Robot* of the same *Alliance* color as the *Goal Zone*, and meets the criteria of being either a *Base Cube* or a *Stacked Cube*.

- **Base Cube** - A *Cube* status. A *Cube* is considered a *Base Cube* if it meets the following criteria at the end of the *Match*:
    1. Contacting the gray foam tile within a *Goal Zone*.
    2. Level or "flush" with the gray foam tile.

The intent of criteria 2 is for a *Base Cube* to be "flat on the floor", and not "tilted up" against a *Barrier*, the field perimeter, or another *Cube*. If the *Cube* is resting on a small piece of debris (like a zip-tie), but is still "flat", then it would still be considered a *Base Cube*. Similarly, contact against a *Barrier* or field perimeter is okay, as long as the *Cube* is still resting "flat on the floor".
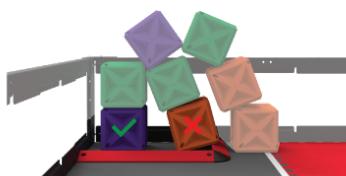
Figure 12: A Base Cube (green checkmark), and a Cube which is not a Base Cube (red "X"), because it is not "flush" with the gray foam tile.

- **Stacked Cube** - A *Cube* status. A *Cube* is considered a *Stacked Cube* if it meets the following criteria at the end of the *Match*:
    1. Contacting the *Top Surface* of a *Base Cube* or *Stacked Cube*.
    2. Not contacting the top of the field perimeter wall.
    3. Not contacting the *Top Surface* of any *Cubes* which are not *Scored*.
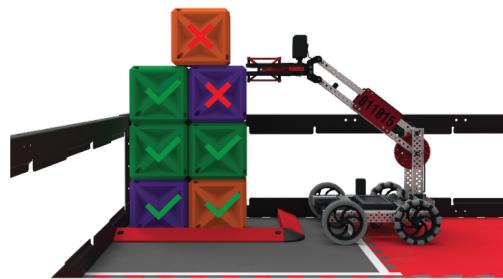
Figure 13: An example of a Goal Zone with Cubes are Scored (green checkmark) and not Scored (red "X"). This Cube is not Scored because it is being contacted by a Robot of the same Alliance color as the Goal Zone.

Figure 14: An example of a Goal Zone with Cubes that are Scored (green checkmark) and not Scored (red "X"). These Cubes are not Scored because they are contacting Top Surfaces of Cubes which are not Scored.

Figure 15: An example of a Goal Zone with Cubes that are Scored (green checkmark) and not Scored (red "X"). These Cubes are not Scored because they are contacting Top Surfaces of Cubes which are not Scored.

Student - A person is considered a Student if he or she meets both of the following criteria:

1. Anyone who is earning or has earned credit toward a high school diploma/certificate or its equivalent during the six (6) months preceding the VEX Robotics World Championship. Courses earning credits leading up to high school would satisfy this requirement.
2. Anyone born after May 1, 2000 (i.e. who will be 19 or younger at VEX Worlds 2020). Eligibility may also be granted based on a disability that has delayed education by at least one year.

- **Middle School Student** - A Student born after May 1, 2004 (i.e. who will be 15 or younger at VEX Worlds 2020). Middle School Students may "play up" and compete as a High School Student.
- **High School Student** - Any eligible *Student* that is not a *Middle School Student*.

Team - One or more *Students* make up a *Team*. A *Team* is classified as a middle school *Team* if all members are *Middle School Students*. A *Team* is classified as a high school *Team* if any of its members are *High School Students*, or made up of *Middle School Students* who declare themselves "playing up" as *High School Students* by registering their team as a High School *Team*. Once declared and playing as a High School *Team*, that team may not change back to a Middle School *Team* for the remainder of the season. *Teams* may be associated with schools, community/youth organizations, or a group of neighborhood *Students*.

Top Surface - The side of a *Cube* that is furthest away from (and roughly parallel to) the gray foam tiles. The inner indents on that *Cube*'s side are considered part of its *Top Surface*; the chamfered edges are not.
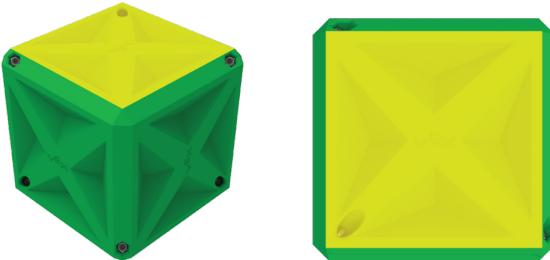
Figure 16: Close-up of a Cube, depicting the Top Surface.

Tower - One of seven (7) cylindrical field structures that can be used for *Placing Cubes*. There are three *Tower* heights: 18.83" (470.8mm), 24.66" (626.5mm), and 37.91" (963.0mm) from the field tiles to the top of the *Tower*. See Figure 2.
- **Neutral Tower** - One of the five (5) *Towers* with a black base that may be utilized by *Robots* from either *Alliance*.
- **Alliance Tower** - One of the two (2) *Towers* with a colored base, one red and one blue. See <SG3>for usage restrictions on *Alliance Towers*.
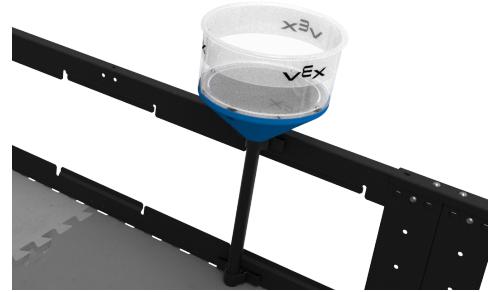
Figure 17: Close-up of an Alliance Tower.
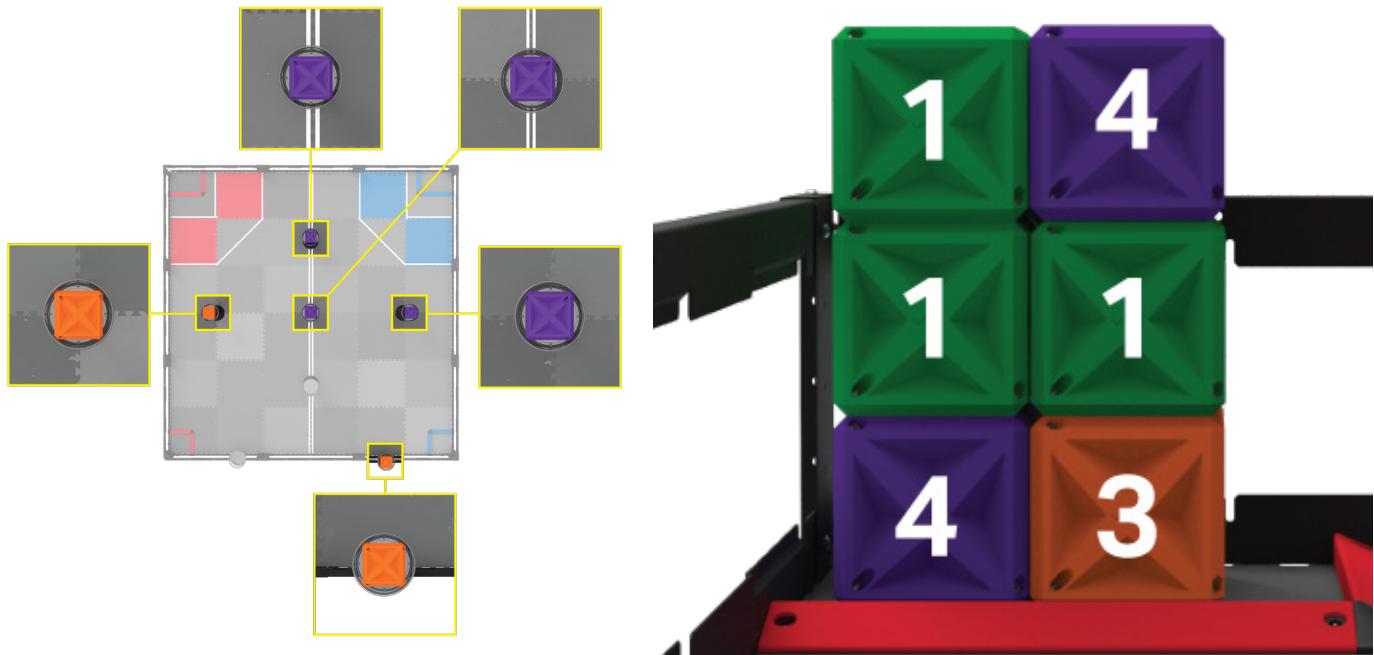
Trapping - A *Robot* is considered *Trapped* if an opposing *Robot* has restricted it into a small, confined area of the field, approximately the size of one foam field tile or less, and has not provided an avenue for escape. *Trapping* can be direct (e.g. pinning an opponent to a field wall) or indirect (e.g. preventing a *Robot* from escaping a corner of the field).

Scoring

Alliances receive points for each *Cube* that is *Scored* in their *Goal Zones* at the end of a *Match*. The point value of each *Cube* is defined by the number of *Cubes* that are *Placed* of the same color.

Number of Placed Cubes in a Tower of a Color	Point Value for Cubes of that Color
0	1
1	2
2	3
3	4
4	5
5	6
6	7
7	8

For example:

In this *Match*, three (3) purple *Cubes* were *Placed* in *Towers*, so each purple *Cube* is worth four (4) points when *Scored*. Two orange *Cubes* were *Placed*, so each orange *Cube* is worth three (3) points. No green *Cubes* were *Placed*, so each green *Cube* is worth one (1) point.

Safety Rules

\<S1\> If at any time the *Robot* operation or *Team* actions are deemed unsafe or have damaged the *Field Elements* or *Cubes*, the offending *Team* may be *Disabled* and/or *Disqualified* at the discretion of the referees. The *Robot* will require re-inspection before it may again take the field.

\<S2\> If a *Robot* is completely out-of-bounds (outside the playing field), it will be *Disabled* for the remainder of the *Match*.
　　　Note: The intent of this rule is NOT to penalize *Robots* for having mechanisms that inadvertently cross the field border during normal game play.

General Game Rules

\<G1\> Treat everyone with respect. All *Teams* are expected to conduct themselves in a respectful and professional manner while competing in VEX Robotics Competition events. If a *Team* or any of its members (*Students* or any adults associated with the *Team*) are disrespectful or uncivil to event staff, volunteers, or fellow competitors, they may be *Disqualified* from a current or upcoming *Match*. *Team* conduct pertaining to \<G1\> may also impact a *Team*'s eligibility for judged awards. Repeated or extreme violations of \<G1\> could result in a *Team* being *Disqualified* from an entire event, depending on the severity of the situation.

Robotics competitions often induce intense, high stress situations. These are good opportunities to model and/or gain experience in handling these situations in a positive and productive manner. It is important that we all exhibit maturity and class when dealing with any difficult situations that may present themselves in both the VEX Robotics Competition and our lives in general.

This rule exists alongside the REC Foundation Code of Conduct. Violation of the Code of Conduct can be considered a violation of \<G1\> and can result in *Disqualification* from a current *Match*, an upcoming *Match*, an entire event, or (in extreme cases) an entire competition season. The Code of Conduct can be found at https://www.roboticseducation.org/competition-teams/vex-robotics-competition/ .

\<G2\> VRC is a student-centered program. Adults may assist *Students* in urgent situations, but adults should never work on or program a *Robot* without *Students* on that *Team* being present and actively participating. *Students* should be prepared to demonstrate an active understanding of their *Robot*'s construction and programming to judges or event staff.

Some amount of adult mentorship, teaching, and/or guidance is an expected and encouraged facet of VEX competitions. No one is born an expert in robotics! However, obstacles should always be viewed as teaching opportunities, not tasks for an adult to solve without *Students* present and actively participating.

When a mechanism falls off, it is…
…okay for an adult to help a *Student* investigate why it failed, so it can be improved.
…not okay for an adult to put the *Robot* back together.

When a *Team* encounters a complex programming concept, it is…
…okay for an adult to guide a *Student* through a flowchart to understand its logic.
…not okay for an adult to write a pre-made command for that *Student* to copy/paste.

During *Match* play, it is…
…okay for an adult to provide cheerful, positive encouragement as a spectator.
…not okay for an adult to explicitly shout step-by-step commands from the audience.

Violations of this rule could be considered a violation of <G1> and/or the REC Foundation Code of Conduct.

<G3> Use common sense. When reading and applying the various rules in this document, please remember that common sense always applies in the VEX Robotics Competition.

<G4> Robots begin the Match in the starting volume. At the beginning of a *Match*, each *Robot* must be smaller than a volume of 18″ (457.2 mm) long by 18″ (457.2 mm) wide by 18″ (457.2 mm) tall. Using *Field Elements*, such as the field perimeter wall, to maintain starting size is only acceptable if the *Robot* would still satisfy the constraints of <R4> and pass inspection without the *Field Element*. *Robots* in violation of this limit will be removed from the field prior to the start of the *Match*, at the *Head Referee*'s discretion.

<G5> Keep your Robots together. *Robots* may not intentionally detach parts during the *Match* or leave mechanisms on the field.

Minor violations of this rule that do not affect the *Match* will result in a warning. *Match Affecting* offenses will result in a *Disqualification*. *Teams* that receive multiple warnings may also receive a *Disqualification* at the *Head Referee*'s discretion. Multiple intentional infractions may result in *Disqualification* for the entire competition.

 <G6>Drive your own Robot. Each Team shall include up to three (3) Drive Team Members. No Drive Team Member may fulfill this role for more than one Team in a given competition season.

When a Team qualifies for a Championship event (e.g., States, Nationals, Worlds, etc.) the Students on the Team attending the Championship event are expected to be the Students on the Team that was awarded the spot. Students can be added as support to the Team but should not be added as Drive-Team Members or programmers for the Team.

An exception is allowed if one (1) Student on the drive team or a programmer on the Team cannot attend the event. The Team can make a single substitution of a Drive Team Member or programmer for the Championship event with another Student, even if that Student has competed on a different Team. This Student will now be on this new Team and may not substitute back to the original Team.

Violations of this rule will be reviewed by the REC Foundation and may result in one or both Teams being disqualified for the event or the remainder of the season with all trophies and awards won that season being nullified.

\<G7\> Only Drivers, and only in the Alliance Station. During a *Match*, all *Drive Team Members* must remain in their *Alliance Station*. *Drive Team Members* are not allowed to use any sort of communication devices during their *Match*. Devices with communication features turned off (e.g. a phone in airplane mode) are allowed.

>Note: Per \<T2\>, *Drive Team Members* are the only *Team* members that are allowed to be in the *Alliance Station* during a *Match*.

>Note 2: During a *Match*, *Robots* may be operated only by the *Drive Team Members* and/or by software running on the *Robot*'s control system, in accordance with \<R16\> and \<G9\>.

Violations or refusal to comply with this rule could be considered a violation of \<G1\>.

\<G8\> Controllers must stay connected to the field towers. Prior to the beginning of each *Match*, *Drive Team Members* must plug their VEXnet Joystick or V5 Controller into the VEXnet Field Controller's Cat-5 cable via their controller's competition port. This cable must remain plugged in for the duration of the *Match*, and may not be removed until the "all-clear" has been given for *Drive Team Members* to retrieve their *Robots*.

>Note: The intent of this rule is to ensure that *Robots* abide by commands sent by the tournament software. Temporarily removing the cable to assist with mid-*Match* troubleshooting, with an *Event Partner* or other event technical staff present and assisting, would not be considered a violation.

Minor violations of these rules that do not affect the *Match* will result in a warning. *Match Affecting* offenses will result in a *Disqualification*. *Teams* that receive multiple warnings may also receive a *Disqualification* at the *Head Referee*'s discretion.

\<G9\> Hands out of the field. *Drive Team Members* may only touch the *Team*'s controls and *Robot* at specified times during a *Match* as per \<G9\>. *Drive Team Members* are prohibited from making intentional contact with any *Cubes*, *Field Element*, or *Robot* during a *Match*, apart from the contact specified in \<G9\>.
   a. During the *Driver Controlled Period*, *Drive Team Members* may only touch their own *Robot* if the *Robot* has not moved at all during the *Match*. Touching the *Robot* in this case is permitted for only the following reasons:
       1. Turning the *Robot* on or off.
       2. Plugging in a battery and/or power expander.
       3. Plugging in a VEXnet Key or V5 Robot Radio.
       4. Touching the V5 Robot Brain screen, such as to start a program.
   b. *Drive Team Members* are not permitted to break the plane of the field perimeter at any time during the *Match*, apart from the actions described in \<G9\>.

Note: Any concerns regarding the Cube(s) starting positions should be raised with the Head Referee prior to the Match; Teams members should never adjust the Cubes or Field Elements themselves.

Minor violations of these rules that do not affect the *Match* will result in a warning. *Match Affecting* offenses will result in a *Disqualification*. *Teams* that receive multiple warnings may also receive a *Disqualification* at the *Head Referee*'s discretion.

\<G10\> Autonomous means "no humans". During the *Autonomous Period*, *Drive Team Members* are not permitted to interact with the *Robot* in any way, directly or indirectly. This could include, but is not limited to:

- Activating any controls on their VEXnet Joysticks or V5 Controllers.
- Unplugging or disconnecting from the field in any way.
- Triggering sensors (including the Vision Sensor) in any way, even without touching them.

Violations of this rule would be considered a violation of \<G10\> and could result in the *Autonomous Bonus* being awarded to the opposing *Alliance*. *Teams* that receive multiple warnings may also receive a *Disqualification* at the *Head Referee*'s discretion.

\<G11\> All rules still apply in the Autonomous Period. Any infractions committed during the *Autonomous Period* that are not *Match Affecting*, but do affect the outcome of the *Autonomous Bonus*, will result in the *Autonomous Bonus* being automatically awarded to the opposing *Alliance*.

a. *Teams* are responsible for the actions of their *Robots* at all times, including during the *Autonomous Period*. Any infractions committed during the *Autonomous Period* that are *Match Affecting* can result in a *Disqualification*, if warranted by the rule.
b. If both *Alliances* cause infractions during the *Autonomous Period* that would have affected the outcome of the *Autonomous Bonus*, then no *Autonomous Bonus* will be awarded.

\<G12\> Don't destroy other Robots. But, be prepared to encounter defense. Strategies aimed solely at the destruction, damage, tipping over, or *Entanglement* of opposing *Robots* are not part of the ethos of the VEX Robotics Competition and are not allowed. If the tipping, *Entanglement*, or damage is ruled to be intentional or egregious, the offending *Team* may be *Disqualified* from that *Match*. Repeated offenses could result in *Disqualification* from the entirety of the competition.

a. VEX Robotics Competition Tower Takeover is intended to be an offensive game. *Teams* that partake in solely defensive or destructive strategies will not have the protections implied by \<G12\> (see \<G13\>). However, defensive play which does not involve destructive or illegal strategies is still within the spirit of this rule.
b. VEX Robotics Competition Tower Takeover is an interactive game. Some incidental tipping, *Entanglement*, and damage may occur as a part of normal gameplay without violation. It will be up to the *Head Referee*'s discretion whether the interaction was incidental or intentional.
c. A *Team* is responsible for the actions of its *Robot* at all times, including the *Autonomous Period*. This applies both to *Teams* that are driving recklessly or potentially causing damage, and to *Teams* that drive around with a small wheel base. A *Team* should design its *Robot* such that it is not easily tipped over or damaged by minor contact.
d. Game elements in possession of a *Robot* are an extension of that *Robot*. Therefore, *Entanglement* (e.g., grasping, hooking, attaching) with *Cubes* that are in the possession of an opposing *Robot* is a violation of this rule.

   Note: A *Robot* which has expanded horizontally in an effort to obstruct the field, or is legally covering the top of a *Tower* in a solely defensive manner, should expect vigorous interactions from opponent *Robots*. Damage that is caused by opponent *Robots* pushing, tipping, or *Entangling* with them would not be considered a violation of \<G12\>. Gratuitous damage or dangerous mechanisms may still be considered a violation of \<R3\>, \<S1\>, or \<G1\> at the *Head Referee*'s discretion.

Put simply: "wall-bots" and "cap-bots" are legal, but they are to be attempted at your own risk.

<G13> Offensive Robots get the "benefit of the doubt". In the case where referees are forced to make a judgment call regarding a destructive interaction between a defensive and offensive *Robot*, or an interaction which results in a questionable rules violation, the referees will err on the side of the offensive *Robot*.

<G14> You can't force an opponent into a penalty. Intentional strategies that cause an opponent to violate a rule are not permitted, and will not result in an infraction on the opposing *Alliance*.

Minor violations of this rule that do not affect the *Match* will result in a warning. *Match Affecting* offenses will result in a *Disqualification*. *Teams* that receive multiple warnings may also receive a *Disqualification* at the *Head Referee*'s discretion.

<G15> No Trapping for more than 5 seconds. A *Robot* may not *Trap* an opposing *Robot* for more than five (5) seconds during the *Driver Controlled Period*. A *Trap* is officially over once the *Trapping Robot* has moved away and the *Robots* are separated by at least two (2) feet (approximately one (1) foam tile). After ending a *Trap*, a *Robot* may not *Trap* the same *Robot* again for a duration of five (5) seconds; if a *Team* does *Trap* the same *Robot* again, the count will resume from where it left off when the *Trapping Robot* initially backed off.

Minor violations of this rule that do not affect the *Match* will result in a warning. *Match Affecting* offenses will result in a *Disqualification*. *Teams* that receive multiple warnings may also receive a *Disqualification* at the *Head Referee*'s discretion.

<G16> Don't clamp your Robot to the field. *Robots* may not intentionally grasp, grapple or attach to any *Field Elements*. Strategies with mechanisms that react against multiple sides of a *Field Element* in an effort to latch or clamp onto said *Field Element* are prohibited. The intent of this rule is to prevent *Teams* from both unintentionally damaging the field and/or from anchoring themselves to the field.

Minor violations of this rule that do not affect the *Match* will result in a warning. *Match Affecting* offenses will result in a *Disqualification*. *Teams* that receive multiple warnings may also receive a *Disqualification* at the *Head Referee*'s discretion.

<G17> Let go of Game Objects after the Match. *Robots* must be designed to permit easy removal of *Cubes* from any mechanism without requiring the *Robot* to have power after a *Match*.

<G18> It's not over until it's over. Scores will be calculated for all *Matches* immediately after the *Match*, once all *Cubes*, *Field Elements*, and *Robots* on the field come to rest.
   a. The determination of the *Autonomous Bonus* will occur for all *Matches* immediately after the *Autonomous Period*, after all *Cubes*, *Field Elements*, and *Robots* come to rest.

<G19> Be prepared for minor field variance. *Field Element* tolerances may vary from nominal by ±1.0". *Cube* tolerances may vary from nominal by ±0.10". *Cube* placement at the beginning of *Matches* may vary from nominal by ±1.5". *Teams* are encouraged to design their *Robots* accordingly. Please make sure to check Appendix A for more specific nominal dimension and tolerances.
      Note: The field perimeter should always be resting upon the Field Perimeter Rubber Feet, regardless of whether or not the tabs have been cut from the foam field tiles.

<G20> Replays are allowed, but rare. Replays are at the discretion of the *Event Partner* and *Head Referee*, and will only be issued in the most extreme circumstances.

<G21> This manual will have three scheduled updates. All rules in this manual are subject to changes, and not considered official until August 16th, 2019. There will also be scheduled manual updates on June 14th, 2019 and April 10th, 2020.
    a.   The GDC reserves the right to make changes to this manual in the April 10th, 2020 release specifically for the VEX Robotics World Championship. One specific change to be considered will be the point value of the *Autonomous Bonus*.

<G22> The Q&A system is an extension of this Game Manual. All *Teams* must adhere to all VEX Robotics Competition rules as written in this Game Manual, and must abide by any stated intents of these rules. Officially registered *Teams* have the opportunity to ask for official rule interpretations in the VEX Robotics Competition Question & Answer system. All responses in this system should be treated as official rulings from the VEX Robotics Competition Game Design Committee (GDC), and they represent the correct and official interpretation of the VEX Robotics Competition Rules.

Previous Definitions, Rules and Rulings found in documents and Q&A's from previous seasons do not apply to the current game. If clarification is needed, the question should be asked on the current Q&A.

The 2019 - 2020 Q&A is the ONLY official source for rulings besides the Game Manual. If there are any conflicts between the Game Manual and other supplemental materials (e.g. Referee Training videos, VRC Hub app, etc), the most current version of the Game Manual takes precedent.

The VRC Q&A system can be found at https://www.robotevents.com/VRC/2019-2020/QA

Specific Game Rules

<SG1> Starting a Match. Prior to the start of each *Match*, the *Robot* must be placed such that it is:

a. Contacting the field perimeter wall on the side that coincides with their *Alliance*'s *Goal Zone* and *Alliance Station*.
b. Contacting a foam field tile.
c. Not contacting a *Tower*.
d. Not contacting any *Cubes* other than the *Preload*.
e. Contacting a *Preload*.
   1. The *Preload* must be contacting exactly one (1) *Robot*.
   2. The *Preload* must be fully within the field perimeter.
f. Not contacting a *Goal Zone* or a *Barrier*.
g. Not contacting another *Robot*.

   Note: If a *Robot* is not present for their *Match*, then their *Preload* will instead be placed randomly by the *Head Referee* such that it satisfies all conditions 1-7 laid out above (contacting the field perimeter wall, not contacting a *Robot*, etc).
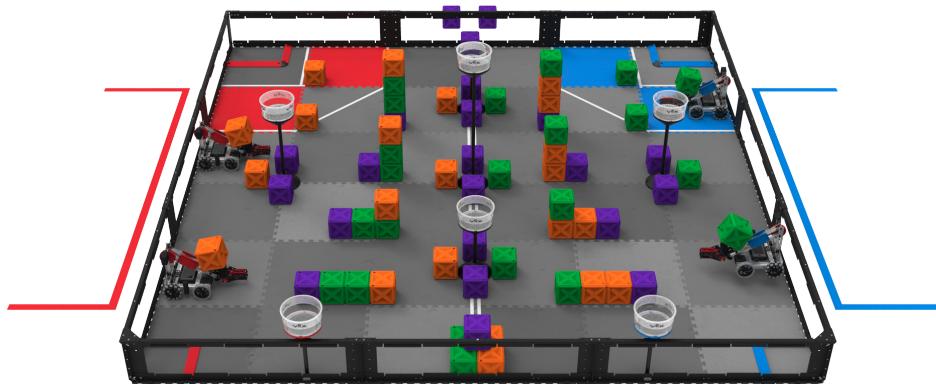
Figure 18: Four examples of Robots in valid starting positions.

<SG2> Stay on your side in Autonomous. During the *Autonomous Period*, *Robots* may not contact the foam tiles, *Towers*, or *Cubes* which are on the opposing *Alliance*'s side of the *Autonomous Line*.

Violations of this rule will result in the *Autonomous Bonus* being awarded to the opposing *Alliance*. Intentional, strategic, or egregious violations, such as intentional contact with an opposing *Robot* while completely across the *Autonomous Line*, will result in a *Disqualification*.

   Note: *Towers* and *Cubes* which begin the *Match* in contact with the *Autonomous Line* are not considered to be on either side, and may be utilized by either *Alliance* during the *Autonomous Period*. If attempting to utilize these *Towers* or *Cubes*, *Teams* should be cognizant of the possibility that opponent *Robots* may attempt to do the same. <SG7>, <G10>, <G11>, and <G12> will be taken into account when these types of *Robot* interactions occur.

<SG3> Stay away from your opponent's protected areas. *Robots* may not intentionally or accidentally, directly or indirectly, perform the following actions:

Case	Action	Violation
A	Contact an opponent *Robot* which is fully contained within their *Protected Zone*.	Minor violations of points A, B, C, or D that do not affect the *Match* will result in a warning. *Match Affecting* offenses will result in a *Disqualification*. *Teams* that receive multiple warnings may also receive a *Disqualification* at the *Head Referee*'s discretion.
B	Contact any *Scored Cubes* in either of opposing *Alliance*'s *Goal Zones*.	
C	Contact any *Placed Cubes* in the opposing *Alliance Tower*.	
D	Contact either of the opposing *Alliance*'s *Goal Zones* or *Barriers*.	
E	Contact an opposing *Alliance*'s *Inner Protected Zone*.	
F	Cause *Scored Cubes* within the opponent's *Protected Zone* to no longer meet the definition of *Scored* (i.e. "knock over their stack").	Any violation of points E, F, or G will result in a *Disqualification*, whether the interaction was *Match Affecting* or not.
G	Cause a *Cube* which is *Placed* in the opposing *Alliance Tower* to no longer meet the definition of *Placed* (i.e. "remove it from the *Alliance Tower*").	

Figure 19: Example of a Robot contacting an opponent Robot that is fully contained within its Protected Zone.
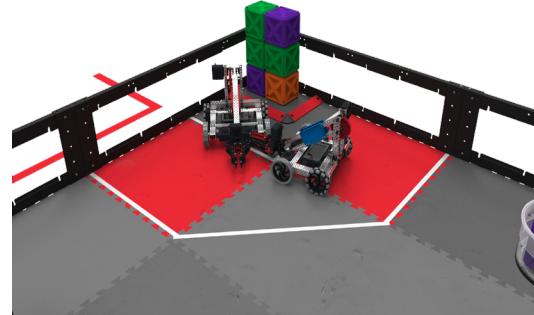

Figure 20: Example of a Robot contacting an opposing Alliance's Inner Protected Zone.

<SG4> Match Load entry. *Drive Team Members* may introduce *Match Loads* during the *Driver Controlled Period* by placing them gently onto a gray foam field tile such that they satisfy the following conditions:

    a. Contacting the field perimeter wall on the side that coincides with their *Alliance*'s *Goal Zones* and *Alliance Station*.

    b. Contacting the gray foam field tiles.

    c. Not contacting a *Tower*.

    d. Not contacting any *Cubes* besides another *Match Load*.

    e. Not contacting a *Goal Zone* or a *Barrier*.

    f. Not contacting a *Robot*.

The intent of this rule is to allow *Teams* to introduce *Match Loads* in a calm and safe manner. The intent is not for *Drive Team Members* to interact directly with their *Robots*.

    Note: It is expected that *Drive Team Members* may momentarily break the plane of the field while legally introducing these *Cubes*. *Teams* from both *Alliances* should be extremely mindful of <S1>, <G9>, and <G11> during this process.

Minor violations of this rule that do not affect the *Match* will result in a warning. *Match Affecting* offenses will result in a *Disqualification*. *Teams* that receive multiple warnings may also receive a *Disqualification* at the *Head Referee*'s discretion.

<SG5> Keep Cubes to yourself. *Robots* may not intentionally drop or place *Cubes* on an opponent *Robot*, into an opponent's *Goal Zone*, or into an opponent's *Alliance Tower*.

Minor violations of this rule that do not affect the *Match* will result in a warning. *Match Affecting* offenses will result in a *Disqualification*. *Teams* that receive multiple warnings may also receive a *Disqualification* at the *Head Referee*'s discretion.

<SG6> Keep Cubes in the field. *Teams* may not intentionally remove *Cubes* from the field. While *Cubes* may accidentally leave the field when attempting to *Score*, doing so intentionally or repeatedly would be a violation of this rule. *Cubes* that leave the field during *Match* play, intentionally or unintentionally, will not be returned.

Minor violations of this rule that do not affect the *Match* will result in a warning. *Match Affecting* offenses will result in a *Disqualification*. *Teams* that receive multiple warnings may also receive a *Disqualification* at the *Head Referee*'s discretion.

<SG7> Use Cubes to play the game. *Cubes* may not be used to accomplish actions that would be otherwise illegal if they were attempted by *Robot* mechanisms. Examples include (but are not limited to):

    • Encroaching upon an opponent's *Protected Zone* per <SG3>.

    • Interfering with an opponent's *Autonomous Period* per <SG2>.

Section 3
The Robot

Overview

This section provides rules and requirements for the design and construction of your *Robot*. A VEX Robotics Competition *Robot* is a remotely operated and/or autonomous vehicle designed and built by a registered VEX Robotics Competition *Student Team* to perform specific tasks when competing in VEX Robotics Competition Tower Takeover. Prior to competing at each event, all *Robots* will have to pass an inspection.

There are specific rules and limitations that apply to the design and construction of your *Robot*. Please ensure that you are familiar with these *Robot* rules before proceeding with *Robot* design.

Robot Rules

<R1> One Robot per Team. Only one (1) *Robot* will be allowed to compete per *Team* in the VEX Robotics Competition. Though it is expected that *Teams* will make changes to their *Robot* at the competition, a *Team* is limited to only one (1) *Robot*. As such, a VEX *Robot*, for the purposes of the VEX Robotics Competition, has the following subsystems:

> **Subsystem 1**: Mobile robotic base including wheels, tracks, legs, or any other mechanism that allows the robot to navigate the majority of the flat playing field surface. For a stationary *Robot*, the robotic base without wheels would be considered Subsystem 1.
> **Subsystem 2**: Power and control system that includes a legal VEX battery, a legal VEX control system, and associated motors for the mobile robotic base.
> **Subsystem 3**: Additional mechanisms (and associated motors) that allow manipulation of game objects or navigation of field obstacles.

Given the above definitions, a minimum *Robot* for use in any VEX Robotics Competition event (including Skills Challenges) must consist of 1 and 2 above. Thus, if you are swapping out an entire subsystem of either item 1 or 2, you have now created a second *Robot* and are no longer legal.
   a.   *Teams* may not compete with one *Robot* while a second is being modified or assembled.
   b.   *Teams* may not switch back and forth between multiple *Robots* during a competition. This includes using different *Robots* for Skills Challenge and *Qualification Matches / Elimination Matches*.
   c.   Multiple *Teams* may not use the same *Robot*. Once a *Robot* has competed under a given team number at an event, it is "their" *Robot* - no other *Teams* may compete with it for the duration of the competition season.

The intent of <R1a>, <R1b>, and <R1c> are to ensure an unambiguous level playing field for all *Teams*. *Teams* are welcome (and encouraged) to improve or modify their *Robots* between events, or to collaborate with other *Teams* to develop the best possible game solution.

However, a *Team* who brings and/or competes with two separate *Robots* at the same tournament has diminished the efforts of a *Team* who spent extra design time making sure that their one *Robot* can accomplish all of the game's tasks. A multi-*Team* organization that shares a single *Robot* has diminished the efforts of a multi-*Team* organization who puts in the time, effort, and resources to undergo separate individual design processes and develop their own *Robots*.

To help determine if a *Robot* is a "separate *Robot*" or not, use the Subsystem definitions found in <R1>. Above that, use common sense as referenced in <G2>. If you can place two *Robots* on a table next to each other, and they look like two separate legal/complete *Robots* (i.e. each have the 3 Subsystems defined by <R1>), then they are two *Robots*. Trying to decide if changing a screw, a wheel, or a micro-controller constitutes a separate *Robot* is missing the intent and spirit of this rule.

<R2> Robots must pass inspection. Every *Robot* will be required to pass a full inspection before being cleared to compete. This inspection will ensure that all robot rules and regulations are met. Initial inspections will take place during team registration/practice time.
    a. Significant changes to a *Robot*, such as a partial or full swap of Subsystem 3, must be re-inspected before the *Robot* may compete again.
    b. All possible functional *Robot* configurations must be inspected before being used in competition.
    c. *Teams* may be requested to submit to random spot-inspections by event personnel. Refusal to submit will result in *Disqualification*.
    d. *Robots* which have not passed inspection (i.e. who are in violation of one or more *Robot* rules) will not be permitted to play in any *Matches* until they have done so. <T2> will apply to any *Matches* that occur until the *Robot* has passed inspection.
    e. If a *Robot* has passed inspection, but is later found to be in violation of a *Robot* rule during a *Match*, then they will be *Disqualified* from that *Match* and <R2d> will apply until the violation is remedied and the *Team* is re-inspected.

<R3> Robots must be safe. The following types of mechanisms and components are NOT allowed:
    a. Those that could potentially damage playing field components such as the field perimeter or *Field Elements*.
    b. Those that could potentially damage other competing *Robots*.
    c. Those that pose an unnecessary risk of *Entanglement*.

<R4> Robots must fit in a sizing box. At the beginning of any *Match*, *Robots* must be smaller than 18" (457.2 mm) long by 18" (457.2 mm) wide by 18" (457.2 mm) tall.
    a. *Robots* may expand beyond their starting size constraints after the start of a *Match*.
    b. Any restraints used to maintain starting size (i.e. zip ties, rubber bands, etc.) MUST remain attached to the *Robot* for the duration of the *Match*.

Robots will be measured by either being placed in a "sizing box" with interior dimensions matching the above size constraints or by using the VEX Robotics Competition Robot Sizing Tool while the *Robot* is placed on a flat surface. A *Robot* may not touch the box walls or ceiling or the Robot Sizing Tool sides when being measured.

There are two VEX Robotics Competition Robot Sizing Tools that may be used: https://www.vexrobotics.com/276-2086.html and https://www.vexrobotics.com/276-5942.html

<R5> Robots are built from the VEX EDR system. *Robots* may be built ONLY using official VEX EDR components, unless otherwise specifically noted within these rules. *Teams* are responsible for providing documentation proving a part's legality in the event of a question. Examples of documentation include receipts, part numbers, official VEX websites, or other printed documentation.
    a. Products from the VEXpro, VEX IQ, or VEX Robotics by HEXBUG product line cannot be used for *Robot* construction, unless specifically allowed by a clause of <R7> or cross-listed as part of the

VEX EDR product line. For example, the Rubber Shaft Collar (228-3510) is a VEX IQ component that can be found on the VEX EDR "Shafts & Hardware" page, and is thus legal: https://www.vexrobotics.com/vexedr/products/accessories/motion/shafts-and-hardware.html

b. VEX IQ pins and corner connectors used solely for the purpose of attaching VEX Team Identification Number Plates are permitted.

c. Official VEX EDR components which have been discontinued are still legal for competition use. *Teams* must be cognizant of <R6> if attempting to use a discontinued part.

d. Any parts which are identical to legal VEX parts are permitted. For the purposes of this rule, products which are identical in all ways except for color are permissible. It is up to inspectors to determine whether a component is "identical" to an official VEX component.

e. Components obtained from the V5 beta program, including V5 beta firmware, are not legal for competition use.

   1. All V5 beta hardware can be identified by its lighter gray pre-production color. Robot Brains, Robot Batteries, Controllers, and Vision Sensors from the V5 beta have a "BETA TEST" stamp on them. Smart Motors and Radios do not have this stamp, but can still be identified by color.

> Using VEX apparel, competition support materials, packaging, or other non-robot products on a VEX Robotics Competition *Robot* goes against the spirit of this rule and is not permitted.

<R6> VEX products come from VEX Robotics or VEX Robotics Resellers. Official VEX products are ONLY available from VEX Robotics & official VEX Resellers. To determine whether a product is "official" or not, consult www.vexrobotics.com. A complete list of authorized VEX Resellers can be found at www.vexrobotics.com/find-a-reseller.

<R7> Certain non-VEX EDR components are allowed. *Robots* are allowed the following additional "non-VEX" components:

a. Any material strictly used as a color filter or a color marker for a VEX Light Sensor.

b. Any non-aerosol based grease or lubricating compound, when used in extreme moderation on surfaces and locations that do NOT contact the playing field walls, foam field surface, *Cubes*, or other *Robots*.

c. Anti-static compound, when used in extreme moderation (i.e. such that it does not leave residue on playing field walls, the foam field surface, *Cubes*, or other *Robots*).

d. Hot glue when used to secure cable connections

e. An unlimited amount of 1/8" (or local metric equivalent), braided, nylon rope

f. Commercially available items used solely for bundling or wrapping of 2-wire, 3-wire, 4-wire, or V5 Smart Cables, and pneumatic tubing are allowed. These items must solely be used for the purposes of cable protection, organization, or management. This includes but is not limited to electrical tape, cable carrier, cable track, etc. It is up to inspectors to determine whether a component is serving a function beyond protecting and managing cables.

<R8> Give the radio some space. The V5 Radio or VEXnet Key 2.0 must be mounted such that no metal surrounds the radio symbol on the V5 Radio or touches the VEXnet logo on the VEXnet Key 2.0.

    a. *Teams* may use a USB extension cable for the sole purpose of remote mounting of a VEXnet Key 2.0 to a VEX ARM® Cortex®-based Microcontroller.

Figure 21: A V5 Radio

Figure 22: A VEXnet Key 2.0

It is fine to loosely nest the V5 Radio or VEXnet Key 2.0 in *Robot* structure. The intent of this rule is to minimize radio connection issues by minimizing obstructions between VEXnet devices. If a radio is buried in a *Robot*, VEXnet is not able to connect as well and may result in *Robot* communication issues.

<R9> A limited amount of custom plastic is allowed. *Robots* may use non-shattering plastic from the following list; polycarbonate (Lexan), acetel monopolymer (Delrin), acetal copolymer (Acetron GP), POM (acetal), ABS, PEEK, PET, HDPE, LDPE, Nylon (all grades), Polypropylene, FEP; as cut from a single 12" x 24" sheet up to 0.070" thick.

    a. Shattering plastic, such as PMMA (also called Plexiglass, Acrylic, or Perspex), is prohibited.

    b. Plastic may be mechanically altered by cutting, drilling, bending etc. It cannot be chemically treated, melted, or cast. Heating polycarbonate to aid in bending is acceptable.

<R10> A limited amount of tape is allowed. *Robots* may use a small amount of tape when used for the following purposes:

    a. For the sole purpose of securing any connection between the ends of two (2) VEX cables.

    b. For labeling wires and motors.

    c. For covering the back of License Plates (i.e. the "wrong color").

    d. For the purposes of preventing leaks on the threaded portions of pneumatic fittings. This is the only acceptable use of Teflon tape.

    e. For securing and retaining a VEXnet Key 2.0 to the VEX ARM® Cortex®-based Microcontroller. Using tape in this manner is highly recommended to ensure a robust connection.

    f. In any other application that would be considered a "non-functional decoration" per <R12>.

<R11> Certain non-VEX screws, nuts, and washers are allowed. *Robots* may use any commercially available #4, #6, #8, M3, M3.5, or M4 screw up to 2" (50.8mm) long (nominal), and any commercially available nut, washer, and/or spacer (up to 2" / 50.8mm long) to fit these screws.

The intent of the rule is to allow teams to purchase their own commodity hardware without introducing additional functionality not found in standard VEX equipment. It is up to inspectors to determine whether the non-VEX hardware has introduced additional functionality or not.

<R12> Decorations are allowed. *Teams* may add non-functional decorations, provided that they do not affect *Robot* performance in any significant way or affect the outcome of the *Match*. These decorations must be in the spirit of the competition. Inspectors will have final say in what is considered "non-func-tional". Unless otherwise specified below, non-functional decorations are governed by all standard *Robot* rules.

In order to be "non-functional," any guards, decals, or other decorations must be backed by legal materials that provide the same functionality. For example, if your *Robot* has a giant decal that prevents *Cubes* from falling out of the *Robot*, the decal must be backed by VEX material that would also prevent the *Cubes* from falling out.

a. Anodizing and painting of parts is considered a legal nonfunctional decoration.
b. If using the VEX speaker (276-1504), the chosen audio must not be distracting and must be in good taste. The Head Inspector and *Head Referee* will make the final decision on the appropri-ateness of the audio.
c. Small cameras are permitted as non-functional decorations, provided that any transmitting functions or wireless communications are disabled. Unusually large cameras being used as ballast are not permitted.
d. VEX motors, or components of VEX motors, may not be used as non-functional decorations.
e. Decorations that visually mimic field elements or could otherwise interfere with an opponent's Vision Sensor are considered functional and are not permitted. This includes lights, such as the VEX Flashlight. The Head Inspector and *Head Referee* will make the final decision on whether a given decoration or mechanism violates this rule.
f. Internal power sources (e.g. for a small blinking light) are permitted, provided that no other rules are violated and this source only provides power to the non-functional decoration (e.g. does not directly or indirectly influence any functional portions of the *Robot*).
g. Decorations which provide feedback to the *Robot* (e.g. by influencing legal sensors) or to *Drive Team Members* (e.g. status indicators) would be considered "functional" and are not permitted.

<R13> No Wi-Fi. The Vision Sensor must have its wireless transmitting functionality disabled.

<R14> New VEX parts are legal. Additional VEX EDR components released during the competition season on www.vexrobotics.com are considered legal for use.

Some "new" components may have certain restrictions placed on them upon their release. These restrictions will be documented in the official Q&A forums, in a Game Manual Update, or on their respec-tive product webpages.

<R15> Robots have one microcontroller. *Robots* must use ONLY one (1) VEX EDR Microcontroller.
a. Examples of VEX EDR Microcontrollers are the VEX ARM® Cortex®-based Microcontroller (276-2194) and the V5 Robot Brain (276-4810).
b. Any other microcontrollers or processing devices are not allowed, even as non-functional deco-rations. This includes microcontrollers that are part of other VEX product lines, such as VEXpro, VEX RCR, VEX IQ, or VEX Robotics by HEXBUG; it also includes devices that are unrelated to VEX, such as Raspberry Pi or Arduino devices.

<R16> Robots use VEXnet. *Robots* must ONLY utilize the VEXnet system for all *Robot* communication.
a. VEX 75Mhz Crystal Radios are prohibited. (Some events may allow the use of 75Mhz Crystal Radios, please see the Special Event Rule Modifications later in this section.)

b. Electronics from the VEXpro, VEX RCR, VEXplorer, VEX IQ, or VEX Robotics by HEXBUG product line are prohibited.

c. Mixing and matching of VEXnet transmitters and receivers is prohibited. The VEXnet Joystick may only be used in conjunction with a VEX ARM® Cortex®-based Microcontroller. A VEXnet upgraded 75MHz Transmitter may only be used in conjunction with a PIC Microcontroller. A V5 Controller may only be used in conjunction with a V5 Robot Brain.

d. *Teams* are permitted to use the Bluetooth® capabilities of the V5 Robot Brain and/or V5 Controller in team pits or outside of *Matches*. However, VEXnet must be used for wireless communication during *Matches*.

<R17> **Robots use one control system.** *Robots* may use either:

Option 1: A VEX ARM® Cortex®-based Microcontroller, up to ten (10) 2-Wire Motors or VEX Servos (in any combination up to ten) and a legal VRC pneumatic system per <R19>.

Option 2: A VEX ARM® Cortex®-based Microcontroller, up to twelve (12) 2-Wire Motors or VEX Servos (in any combination up to 12) and no pneumatic components, excluding pneumatic tubing.

Option 3: A V5 Robot Brain, up to six (6) V5 Smart Motors, and a legal VRC pneumatic system per <R19>.

Option 4: A V5 Robot Brain, up to eight (8) V5 Smart Motors, and no pneumatic components, excluding pneumatic tubing.

Option	Control System	Pneumatics	2-Wire Motors or Servos	Smart Motors
1	Cortex	Y	10	0
2	Cortex	N	12	0
3	V5	Y	0	6
4	V5	N	0	8

Table 1: The four combinations of control system, motors, and pneumatics that are legal.

a. 2-Wire Motors must be controlled by a 2-Wire Motor Port, either directly on a VEX microcontroller, or on a VEX Motor Controller 29 module (276-2193).

b. Teams may NOT use multiple 2-wire Motor Ports, 3-wire PWM Motor Ports, or Motor Controller 29 modules on a single motor.

c. V5 Smart Motors, connected to Smart Ports, are the only motors that may be used with a V5 Robot Brain. The 3-wire ports may not be used to control motors of any kind.

<R18> **One motor or Y cable per motor port.** If using a VEX ARM® Cortex®-based Microcontroller, a maximum of one (1) VEX Y-cable can be used per Motor Port of the Microcontroller or Power Expander. (You cannot "Y off a Y" to have more than two (2) motors controlled by the same Motor Port.)

a. Teams using the VEX ARM® Cortex®-based Microcontroller may only power one (1) 2-wire Motor per each of the two 2-wire motor ports on the Microcontroller. It is illegal to "Y" off a 2-wire Motor Port.

b. Teams may not "Y" off of a Motor Controller 29 (276-2193).

<R19> Electrical power comes from VEX batteries only. The only allowable source(s) of electrical power are as follows:

a. If using a VEX ARM® Cortex®-based Microcontroller, *Robots* may use (1) VEX 7.2V Robot Battery Pack of any type.

    1. *Robots* utilizing the VEX Power Expander may use a second VEX 7.2V Robot Battery of any type. *Robots* are permitted to use a maximum of one (1) VEX Power Expander.

    2. The only legal means for charging a VEX 7.2V Battery Pack is via one of the following VEX Battery Chargers: Smart Charger (276-1445); Smart Charger v2 (276-2519); 276-2221 (discontinued), 276-2235 (discontinued). All other chargers are strictly prohibited.

    3. *Teams* must connect a charged 9V backup battery to their VEXnet system using the VEXnet Backup Battery Holder (276-2243).

    4. VEXnet Joysticks must only be powered by AAA batteries.

b. If using a V5 Robot Brain, *Robots* may use (1) V5 Robot Battery (276-4811).

    1. There are no legal power expanders for the V5 Robot Battery.

    2. V5 Robot Batteries may only be charged by the V5 Robot Battery Charger (276-4812).

    3. V5 Wireless Controllers may only be powered by their internal rechargeable battery.

        i. *Teams* are permitted to have an external power source (such as a rechargeable battery pack) plugged into their V5 Controller during a *Match*, provided that this power source is connected safely and does not violate any other rules, such as <G7>, <R21>, or <R22>.

	VEX ARM® Cortex®-based Microcontroller			V5 Robot Brain		
Component	Legal Parts	Legal Chargers	Maximum Quantity	Legal Parts	Legal Chargers	Maximum Quantity
Robot Battery	276-1456 276-1491	276-1445 276-2519 276-2221 276-2235	1 (2 with Power Expander)	276-4811	276-4812	1
Power Expander	276-2271	N/A	1	None	None	0
Transmitter Battery	AAA Battery	Any safe AAA charger	6 (per transmitter)	276-4820 (internal)	Any safe Micro-USB cable	1 (per transmitter)
Transmitter Field Power	276-1701	N/A	1	None	None	0
Backup Battery	9V battery	N/A	1	None	None	0

Table 2: The legal sources of electrical power for robots.

Some events may choose to provide field power for VEXnet Joysticks and V5 Wireless Controllers. If this is provided for all *Teams* at the event, then this is a legal power source for the wireless remotes.

<R20> One or two controllers per Robot. No more than two (2) VEX wireless remotes may control a single *Robot* during the tournament.
   a.   No modification of these transmitters is allowed of ANY kind.
   b.   No other methods of controlling the *Robot* (light, sound, etc) are permissible.
      1.   Using sensor feedback to augment driver control (such as motor encoders or the Vision Sensor) is acceptable.
   c.   *Teams* may not "mix-and-match" wireless remote types, such as using a VEXnet Joystick and V5 Wireless Controller at the same time.

<R21> No modifications to electronic components are allowed. Motors (including the internal PTC or Smart Motor firmware), microcontrollers (including V5 Robot Brain firmware), extension cords, sensors, controllers, battery packs, reservoirs, solenoids, pneumatic cylinders, and any other electrical component or pneumatics component of the VEX EDR platform may NOT be altered from their original state in ANY way.
   a.   External wires on VEX electrical components may be repaired by soldering, using twist/crimp connectors, electrical tape or shrink tubing such that the original functionality / length is not modified in any way. Wire used in repairs must be identical to VEX wire. *Teams* may make these repairs at their own risk; incorrect wiring may have undesired results.
   b.   *Teams* are advised to use the latest official VEXos firmware updates, found at www.vexedr.com. Custom firmware modifications are not permitted.
   c.   *Teams* may change or replace the gears in the "2-Wire 393" or "2-Wire 269" motors with the corresponding official VEX Replacement Gears
   d.   *Teams* may change or replace the gear cartridge in the V5 Smart Motor with other official replacement gear cartridges

<R22> Most modifications and repairs to non-electrical components are allowed. Physical modifications such as bending or cutting are permitted and may be done to legal VEX Robotics Competition metal structure or plastic components.
   a.   Physical modifications to electrical components such as a legal microcontroller or radio is prohibited unless otherwise explicitly permitted, per <R21>.
   b.   Internal or external mechanical repairs of VEX Limit and Bumper switches are permitted. Modifying the metal arm on the Limit Switch is permitted. Using components from these devices in other applications is prohibited.
   c.   Metallurgical modifications that change fundamental material properties, such as heat treating, are not permitted.
   d.   *Teams* may cut pneumatic tubing to a desired length.
   e.   *Teams* are permitted to fuse/melt the end of the 1/8" nylon rope to prevent fraying.
   f.   Welding, soldering, brazing, gluing, or attaching in any way that is not provided within the VEX EDR platform is NOT permitted.
   g.   Mechanical fasteners may be secured using Loctite or a similar thread-locking product. This may ONLY be used for securing hardware, such as screws and nuts.

<R23> Custom V5 Smart Cables are allowed. *Teams* must use official V5 Smart Cable Stock but may use commodity 4P4C connectors and 4P4C crimping tools. *Teams* who create custom cables acknowledge that incorrect wiring may have undesired results.

<R24> Keep the power switch accessible. The *Robot* on/off switch must be accessible without moving or lifting the *Robot*. The microcontroller lights and/or screen should also be visible by competition personnel to assist in diagnosing *Robot* problems.

<R25> Robots are ready when they are at the field. *Teams* must bring their *Robots* to the field prepared to play. *Teams* who use VEX pneumatics must have their systems charged before they place the *Robot* on the field.

<R26> Pneumatics are limited. Pneumatic devices may only be charged to a maximum of 100 psi. *Teams* may only use a maximum of two (2) legal VEX pneumatic air reservoirs on a *Robot*.

> The intent of this rule is to limit *Robots* to the air pressure stored in two reservoir tanks, as well as the normal working air pressure contained in their pneumatic cylinders and tubing on the *Robot*. *Teams* may not use other elements (e.g. surgical tubing) for the purposes of storing or generating air pressure. *Teams* who use cylinders and additional pneumatic tubing for no purpose other than additional storage are in violation of the spirit of this rule and will fail inspection.

<R27> Teams must be registered in order to compete. To participate in an official VEX Robotics Competition Tournament, a *Team* must first register on www.robotevents.com. *Teams* that are not registered will not be eligible to compete.
Upon registering, the *Team* will choose or receive their VEX Team Identification Number (VEX Team ID#) and a Welcome Kit containing a VRC License Plate Kit.
   a. License Plates must be placed on the *Robots* built, programmed, and driven by *Students* associated with the stated plate number (see <R1> and <R27>).

<R28> Robots must have team identification plates. License Plates with VEX Team ID# must be clearly visible and legible at all times on a minimum of two opposing sides. License Plates must not be in a position that would be easily obstructed by a *Robot* mechanism during standard *Match* play.
   a. *Robots* must use the colored plates that match their *Alliance* color for each *Match* (i.e. red *Alliance Robots* must have their red plates on for the *Match*). It must be abundantly clear which color *Alliance* the *Robot* belongs to.
        i. If the plates are attached to opposite-color plates, then the incorrect color must be covered, taped over, or otherwise obscured to ensure that the correct *Alliance* color is abundantly clear to *Head Referees* during a *Match*. Since License Plates are considered non-functional decorations, this is a legal non-functional use of tape.
   b. The VRC License Plates are considered a non-functional decoration, and cannot be used as a functional part of the *Robot* per <R12>.
   c. License Plates must fulfill all *Robot* rules (i.e. they must fit within the 18" cube per <R4>, they cannot cause entanglement, etc.)

> The intent of this rule is to make it very easy for *Head Referees* to know which *Alliance* and which *Team* each *Robot* belongs to. Being able to "see through" a *Robot* arm to the wrong color License Plate on the opposite side of the *Robot* would be considered a violation of <R28>.

<R29> Use the "Competition Template" for programming. The *Robot* must be programmed to follow control directions provided by the VEXnet Field Controllers.

During the *Autonomous Period*, *Drive Team Members* will not be allowed to use their hand-held controllers. As such, *Teams* are responsible for programming their *Robot* with custom software if they want to perform in the *Autonomous Bonus*. *Robots* must be programmed to follow control directions provided by the VEXnet Field Controllers (i.e. ignore wireless input during the *Autonomous Period*, disable at the end of the *Driver Controlled Period*, etc).
Teams should use a provided "competition template", or functional equivalent, to accomplish this.
All *Robots* will be required to pass a functional enable/disable test as part of inspection. For more information on this, *Teams* should consult the help guides produced by the developers of their chosen programming software.

<R30> There is a difference between accidentally and willfully violating a Robot rule. Any violation of *Robot* rules will result in a *Team* being unable to play until they pass inspection (per <R2d>). In addition, *Teams* who intentionally or knowingly circumvent or violate rules to gain an advantage over their fellow competitors are in violation of the spirit and ethos of the competition. Any violation of this sort may be considered a violation of <G1> and/or the REC Foundation Code of Conduct.

<R31> Special event modifications. Some events may choose to make the following rule exceptions to fit their unique circumstances:
   a. Utilize the VEX 75 MHz Crystal Radio Transmitter & Receiver instead of or in conjunction with the VEXnet Wireless link
   b. Allow AA batteries to power the robot instead of a VEX 7.2V Battery Pack.

   Note: If an event makes these changes, they must inform all attending *Teams*. Any 75 MHz events make sure their *Teams* are using the correct communication type

Section 4
The Tournament

Overview

The main challenge of the VEX Robotics Competition will be played in a tournament format. Each tournament consists of *Qualification Matches* and *Elimination Matches* and may include *Practice Matches*. After the *Qualification Matches*, *Teams* are ranked based on their *WP*, *AP*, and *SP*. The top ranked *Teams* will then participate in *Elimination Matches* to determine the tournament champions.

Tournament Definitions

Alliance Captain - The *Team Representative* of the highest ranked *Team* in an *Alliance* during *Elimination Matches*. The *Alliance Captain* invites available *Teams* to join his or her *Alliance* until the *Alliance* is formed.

Alliance Selection - The process of choosing the permanent *Alliances* for the *Elimination Matches*. *Alliance Selection* proceeds as follows:
1. The highest ranked *Team* at the end of *Qualification Matches* becomes the first *Alliance Captain*
2. The *Alliance Captain* invites another *Team* to join their *Alliance*
3. The invited *Team Representative* either accepts or declines as outlined in <T11>
4. The next highest ranked *Team* at the end of *Qualification Matches* becomes the next *Alliance Captain*.

Alliance Captains continue to select their *Alliances* in this order until all *Alliances* are formed for the *Elimination Matches*

Autonomous Points (AP) - The second basis of ranking *Teams*. An *Alliance* who wins the *Autonomous Bonus* during a *Qualification Match* earns six (6) *Autonomous Points*. In the event of a tie, both *Alliance* will receive three (3) *Autonomous Points*.

Disqualification - A penalty applied to a *Team* for a rules violation. When a *Team* is *Disqualified* in a *Qualification Match*, they receive zero (0) *WP*, *AP*, and *SP*.
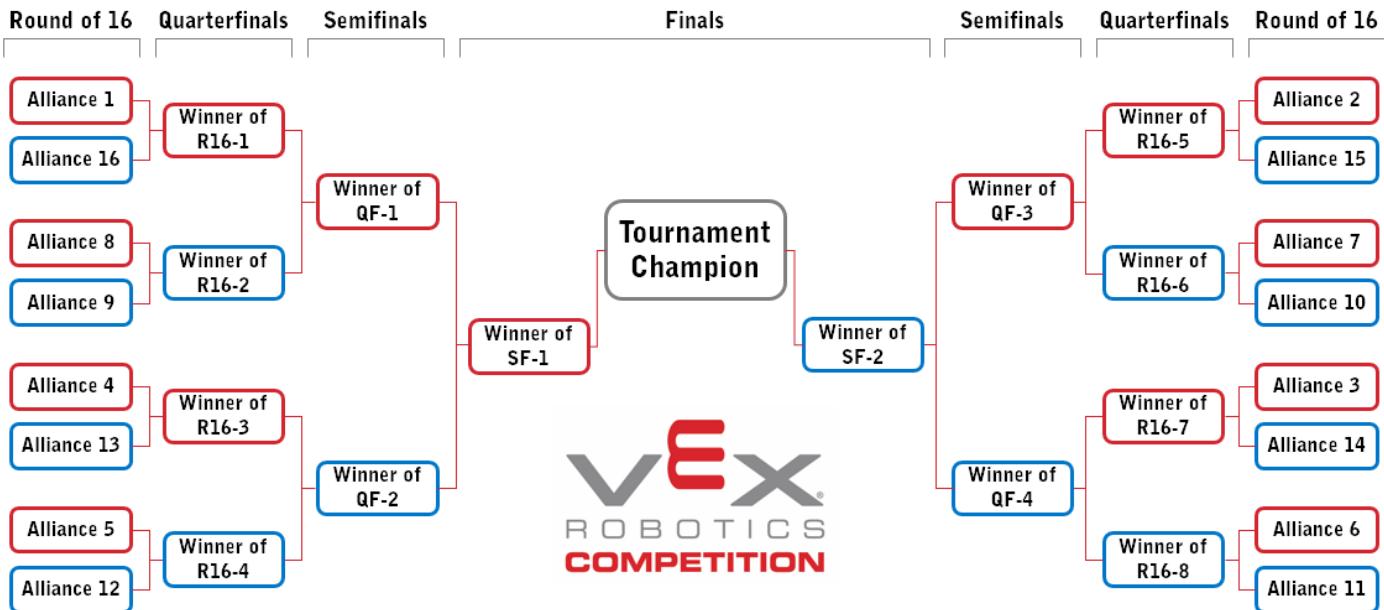
Note 1: If the *Team* receiving the *Disqualification* is on the winning *Alliance*, then *Teams* on the opposing *Alliance* who are not also *Disqualified* will receive two (2) *WP*.

Note 2: If the *Match* was a tie, then each *Team* on the opposing *Alliance* (the *Alliance* that did not contain the *Disqualification*) will receive two (2) *WP*. If both *Alliances* have a *Team* receiving a *Disqualification*, then all non-*Disqualified Teams* will receive one (1) *WP*.

Note 3: When a *Team* is *Disqualified* in an *Elimination Match*, the entire *Alliance* is *Disqualified* and they receive a loss for the *Match*.
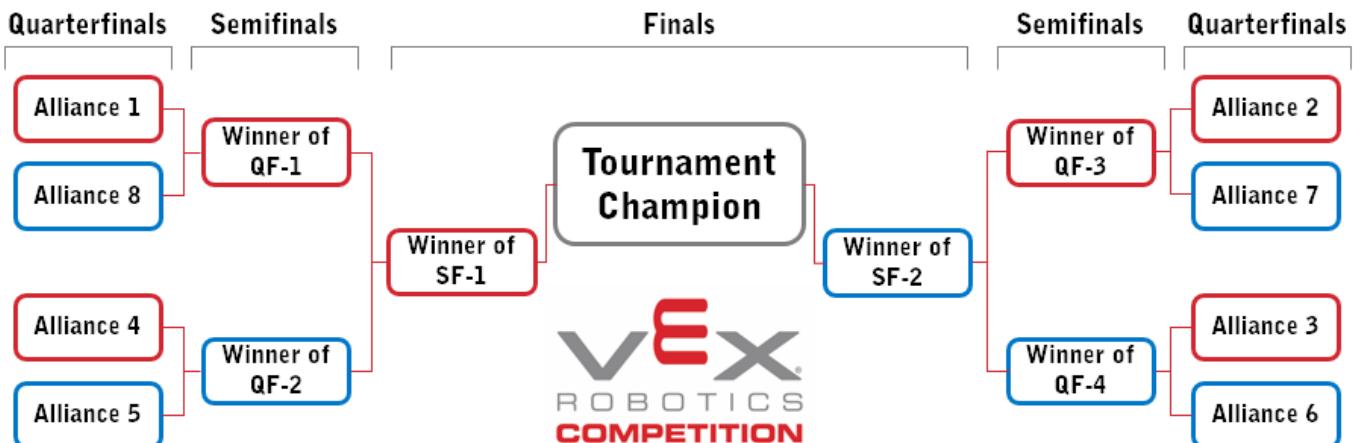
Elimination Bracket - A schedule of *Elimination Matches*. Between eight (8) and sixteen (16) *Alliances* are used to fill the *Elimination Bracket*. The exact quantity of *Alliances* in an *Elimination Bracket* is determined by the *Event Partner* based on the event schedule and number of *Teams* in attendance.

A sixteen (16) *Alliance* bracket would play as follows:

If an event chooses to run with fewer than sixteen (16) *Alliances*, then they will use the bracket shown above, with byes awarded when there is no applicable *Alliance*. For example, in a tournament with fourteen (14) *Alliances*, *Alliances* 1 and 2 would automatically advance.

Thus, an eight (8) *Alliance* bracket would run as follows:

Elimination Match - A *Match* used in the process of determining the champion alliance. *Alliances* of two (2) *Teams* face off according to the *Elimination Bracket*; the winning *Alliance* moves on to the next round.

Event Partner - The VEX Robotics Competition tournament coordinator who serves as an overall manager for the volunteers, venue, event materials, and all other event considerations. *Event Partners* serve as the official liaison between the REC Foundation, the event volunteers, and event attendees.
Head Referee - An impartial volunteer responsible for enforcing the rules in this manual as written. *Head Referees* are the only people who may discuss ruling interpretations or scoring questions with *Teams* at an event.

Practice Match - An un-scored *Match* used to provide time for *Teams* to get acquainted with the official playing field.

Qualification Match - A *Match* used to determine the rankings for the *Alliance Selection*. *Alliances* compete to earn *Win Points*, *Autonomous Points*, and *Strength of Schedule Points*.

Strength of Schedule Points (SP) - The third basis of ranking *Teams*. *Strength of Schedule Points* are equivalent to the score of the losing *Alliance* in a *Qualification Match*. In the event of a tie, both *Alliances* receive *SP* equal to the tie score. If both *Teams* on an *Alliance* are *Disqualified*, the teams on the losing (not *Disqualified*) *Alliance* will receive their own score as *SP* for that *Match*.

Time Out - A break period no greater than three minutes (3:00) allotted for each *Alliance* during *Elimination Matches*.

Team Representative - A *Student* chosen to represent their *Team* during *Alliance Selection* for the final *Elimination Matches*.

Win Points (WP) - The first basis of ranking *Teams*. Two (2) *Win Points* are awarded for winning a *Qualification Match*. One (1) *WP* is awarded for tying a *Qualification Match*. Zero (0) *WP* are awarded for losing a *Qualification Match*.

Tournament Rules

<T1> No video replays, and post-Match questions must be in a timely fashion. The *Head Referee* has the ultimate authority during the competition. The *Head Referee*'s rulings are final.

    a. The referees will not review any photo or video *Match* recordings.

    b. Any questions for the referees must be brought forward by a *Student Drive Team Member* (not an adult) from the affected *Team* within a time period of two (2) *Qualification Matches*, or immediately after the score is announced of an *Elimination Match*.

    c. Any concerns regarding the *Match* score must be raised by a *Student Drive Team Member* (not an adult) before the playing field has been reset for the next *Match*. Once the field has been cleared, scores may no longer be disputed.

    d. *Head Referees* may seek insight from the *Event Partner* or REC Foundation staff to help make a final decision, but *Students* should never approach these individuals in lieu of presenting the dispute to the *Head Referee*.

<T2> The Team's Robot or a Drive Team Member should attend every Match. A *Robot* or a *Student* member of the *Team* must report to the field for the *Team*'s assigned *Match*. If no *Students* report to the field, the *Team* will be considered a "no-show" and receive zero (0) *WP*, *AP*, and *SP*.

<T3> Wear safety glasses. All *Drive Team Members* must wear safety glasses or glasses with side shields while in the *Alliance Station* during *Matches*. While in the pit area, it is highly recommended that all *Team* members wear safety glasses.

<T4> Robots at the field should be ready to play. *Teams* must bring their *Robots* to the field prepared to play. *Teams* who use VEX pneumatics must have their systems charged before they place the *Robot* on the field.

    a. *Robots* must be placed on the field promptly. Repeated failure to do so could result in a violation of <G1>.

> The exact definition of the term "promptly" is at the discretion of the *Head Referee* and the *Event Partner* who will consider event schedule, previous warnings or delays, etc.

<T5> The red alliance, or the highest seed, places last. In *Qualification Matches*, the red *Alliance* has the right to place its *Robots* on the field last. In *Elimination Matches*, the higher (better) seeded *Alliance* has the right to place its *Robots* on the field last. Once a *Team* has placed its *Robot* on the field, its position cannot be readjusted prior to the *Match*. If a *Team* violates this rule, the opposing *Alliance* will be given the opportunity to reposition their *Robots* promptly.

<T6> Practice Matches may be run at some events. If *Practice Matches* are run, they will be conducted on a first-come, first-served basis with every effort made to equalize practice match time for all *Teams*.

<T7> Qualification Matches follow the Qualification Match schedule. A *Qualification Match* schedule will be available on the day of competition. The *Qualification Match* schedule will indicate *Alliance* partners, *Match* pairings, and *Alliance* color. For tournaments with multiple fields, the schedule will indicate which field the Match will take place on.

    a.   *Alliances* are randomly assigned during *Qualification Matches*

Note: The official Match schedule is subject to changes at the Event Partner's discretion.

<T8> All Team rankings are determined by the same number of Qualification Matches. In some cases, a *Team* will be asked to play an additional *Qualification Match*. That *Team* will not receive *WP*, *AP*, or *SP* for that *Qualification Match*. *Teams* are reminded that <G1> is always in effect and *Teams* are expected to behave as if the additional *Qualification Match* counted.

<T9> Qualification Match tiebreakers. *Team* rankings are determined throughout *Qualification Matches* as follows:

    a.   *Win Points*
    b.   *Autonomous Bonus*
    c.   *Strength of Schedule Points*
    d.   Highest *Match* score
    e.   Second highest *Match* score
    f.   Random electronic draw

<T10> Send a Team Representative to Alliance Selection. Each *Team* must send one (1) *Team Representative* to the playing field for *Alliance Selection*. If a *Team Representative* fails to report to the playing field for *Alliance Selection*, their *Team* will be ineligible for participation in the *Alliance Selection* process.

<T11> Teams may only be invited to join one Alliance. If a *Team Representative* declines an *Alliance Captain*'s invitation during *Alliance Selection*, that *Team Representative* may not accept a later *Alliance Captain*'s invitation. However, they are still eligible to play *Elimination Matches* as an *Alliance Captain*.

For example:
- *Alliance Captain* 1 invites *Team* ABC to join their *Alliance*.
- *Team* ABC declines the invitation.
- No other *Alliance Captains* may invite *Team* ABC to join their *Alliance*.
- However, *Team* ABC may still form their own *Alliance*, if *Team* ABC ranked high enough after *Qualification Matches* to become an *Alliance Captain*.

<T12> Each Alliance gets one Time Out. Each *Alliance* may request one (1) *Time Out* during the *Elimination Bracket* between *Elimination Matches*, as permitted by the *Head Referee* and *Event Partner*. *Alliances* may not use their *Time Out* during a *Match*.

<T13> Elimination Matches are "Best of 1". For Tournaments that do not qualify teams to VEX Worlds, the first Alliance to win a Match advances to the next round of the Elimination Bracket. Any ties will result in additional Matches until one Alliance wins and advances or wins and receives the title of "Tournament Champion."

In Tournaments that qualify teams to VEX Worlds,

- **When there is only one Division in the Tournament** - Elimination Matches are "Best of 1" from Round-of-16 up through the Semi-Finals Matches. The Finals Matches are played as a "Best of 3" where an Alliance needs two wins to receive the title of "Tournament Champion."

- **When there are multiple Divisions in the Tournament** –
  - **In the Division Elimination Matches** - Elimination Matches are "Best of 1" from Round-of-16 up through the Semi-Finals Matches. The Division Finals Matches are played as a "Best of 3" where an Alliance needs two wins to receive the title of "Division Champion."
  - **When the Division Champions play each other** – The Finals Matches are played as a "Best of 3" where an Alliance needs two wins to receive the title of "Tournament Champion."

<T14> Small tournaments may have fewer Alliances. Events with fewer than 32 *Teams* (i.e. the requisite amount for sixteen full *Alliances*) may limit the number of *Alliances* by dividing the number of *Teams* by two, less any remainder. (e.g. If there are 19 *Teams*, 19/2 = 9.5 -> 9 picking *Teams*)

Note: The REC Foundation's Qualifying Criteria document should be considered an extension of this rule, and is used to define many tournament structure guidelines beyond the scope of this Game Manual. This document can be found at:
https://www.roboticseducation.org/documents/2019/05/vrc-qualifying-criteria-2019.pdf

<T15> Fields may be raised or on the floor. Some tournaments may choose to place the playing field on the floor, or elevated off the floor (common heights are 12" to 24" [30.5cm to 61cm]). No *Drive Team Members* may stand on any sort of object during a *Match*, regardless of whether the field is on the floor or elevated.

The 2020 VEX Robotics World Championship field will be elevated 24" (61cm) from the floor.