ROBOTICS EDUCATION & COMPETITION FOUNDATION

Presents:

Mobile Robotics Technology Game Manual
Post-Secondary Teams
2019-2020

Adapted from VEX Robotics Competition
Tower Takeover Robot Skills Challenge

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OVERVIEW

Students will display their knowledge of the Engineering Process and demonstrate their ability to keep and maintain an engineering notebook as they engage in mobile robotics. Students will be judged on basis of their robot in design, construction, and programming by performing tasks in both autonomous and driver control functions, by the quality of their notebook, and by their ability to communicate their design process to the judges. The game that will be played is an adaptation of the VRC Tower Takeover Robot Skills Challenge. Although the field element positions are the same, many rules about scoring have been changed.

ELIGIBILITY

Open to a team of two active SkillsUSA members enrolled in a coherent series of courses or a career major that prepares them for further education and/or employment related to technology, the health industry, trades or industry. College/postsecondary contestants must be earning credit toward a postsecondary degree/certificate during the school year immediately preceding the National Leadership and Skills Conference.

CLOTHING REQUIREMENT

Class E: Contest specific – Business Casual

For men: Official SkillsUSA white polo shirt, black dress slacks, black socks, black leather shoes.

For women: Official SkillsUSA white polo shirt with black dress skirt (knee-length) or black slacks; black socks or black or skin-tone seamless hose; black leather dress shoes. These regulations refer to clothing items that are pictured and described at: www.skillsusastore.org. If you have questions about clothing or other logo items, call (800) 401-1560 or (703) 956-3723.

Note: Contestants must wear their official contest clothing to the contest orientation meeting.

THE GAME

A Primer

Matches are played on a 12 ft x 12 ft foam-mat, surrounded by a sheet-metal and polycarbonate perimeter. There are sixty-six (66) Cubes; twenty-two (22) of each color (orange, green, and purple). There are seven (7) towers around the field. Cubes are scored into four (4) Goal Zones and two Outer Protection Zones. Cubes can be placed into Towers to gain additional time in the Overtime Period, but be careful, the wrong colored Cube in a Zone or Tower will deduct from your score and any time advantage you may have achieved.
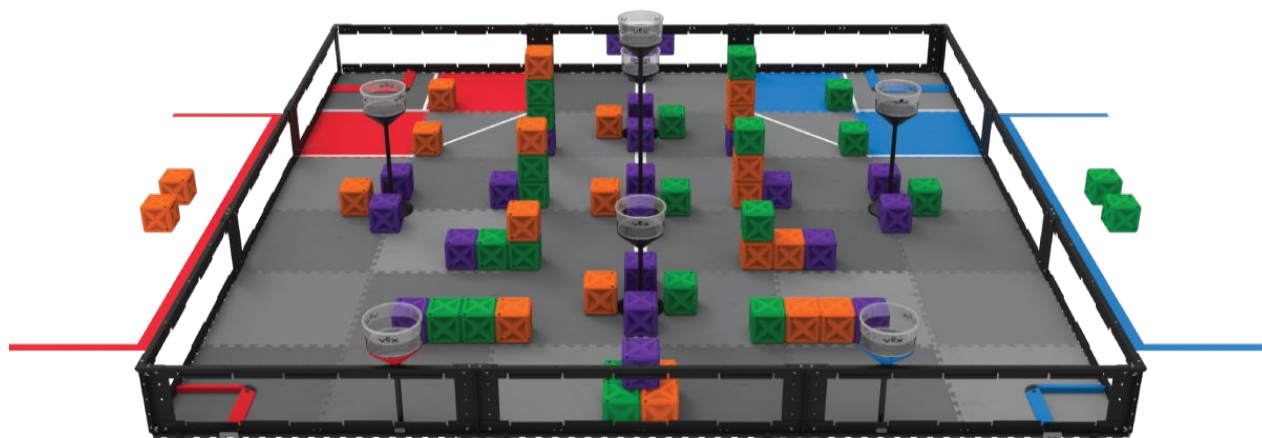
Figure 1: Initial setup configuration. Exact Cube placement on the field will be reveled at the SkillsUSA NLSC Orientation Meeting.

Game Definitions

Alliance Station – The designated region where the Drive Team Members must remain for the duration of the Match. Drivers for each Robot will be in their own Alliance Station and may choose which Robot starts from the red side and which Robot starts from the blue side.

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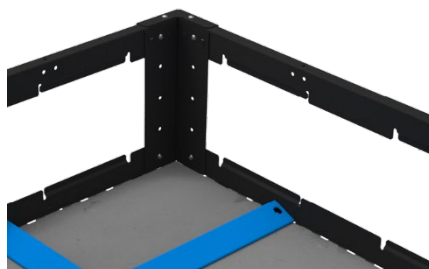

Figure 2: Close-up of a Goal Zone, depicting the Barrier.

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 Zones.
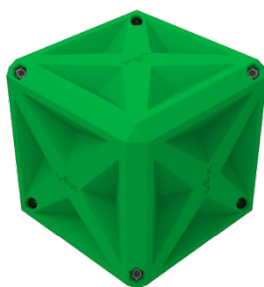

Figure 3: A Cube.

Drive Team Member – Either of the two (2) Students allowed in the Alliance Stations during a Match from the Team. Only Drive Team Members are allowed to touch the controls at any time during the Match or interact with the Robot as per <G5>. Adults and/or Mentors and/or Coaches of the Team are not allowed to be Drive Team Members.

Driving Skills Match – A Driving Skills Match consists of a sixty-second (1:00) Driver Controlled Period plus an Overtime Period. There is no Autonomous Period. Teams can elect to end their run early, however this will count as an official run.

Entanglement – A Robot status. A Robot is Entangled if it has grabbed, hooked, or attached to a Field Element.

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.
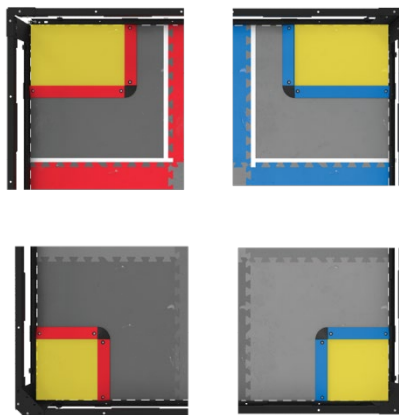
Figure 4: Close-ups of the four (4) Goal Zones.

Match – Either a Driving Skills Match including its Overtime Period or a Programming Skills Match including its Overtime Period.

Match Affecting – A rule violation status determined by the head referee. A rule violation is Match Affecting if it changes the score of the match.

Match Load – One of two (2) purple Cubes that may be placed on the field according to <SkillsUSA6>.

Outer Protected Zone - The 2-dimensional area of foam tiles bound by the field perimeter and tape lines where only Base Cubes can be Scored. The tape lines are not part of the Outer Protected Zone.

Figure 5: Close-up of the blue Outer Protected Zone where only Base Cubes can be Scored

Placed - A purple Cube status. A purple Cube is considered Placed in a Tower at the end of the sixty-second portion of the match (ie. before the Overtime Period) if any part of it is breaking the plane defined by a given Tower's Placing Line. Each Placed Cube gives the team an additional five seconds (0:05) of Overtime. Only purple Cubes may be used for Placing.

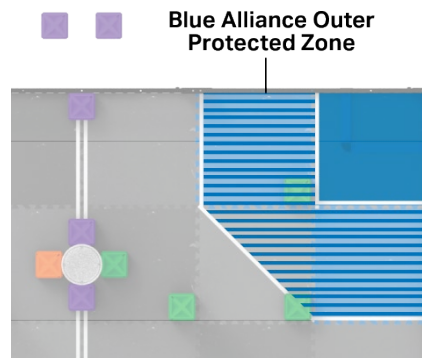> Note 1: Only one (1) Cube can be Placed in each Tower. If multiple Cubes meet the definition of Placed for a single Tower, then neither one is considered Placed.
> Note 2: If no purple Cubes are Placed, then there is no Overtime Period and the Match will end at the end of the sixty-seconds.
> Note 3: The maximum time of the Overtime Period is thirty-five seconds (0:35).
> Note 4: The Score for the Match will be recorded after the Overtime Period even if the Team's overall Score decreases during the Overtime Period.
> Note 5: Cubes Placed or removed from Towers during the Overtime Period have no effect on the duration of the Overtime Period.

Figure 6: A Cube that is Placed.

Figure 7: A Cube that is not Placed.

Figure 8: Neither Cube is Placed because they are not purple. Furthermore, the top Cube is not Placed because it is not below the Placing Line.

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

Preload – The Cube, one (1) that must be used in accordance with <SG1> prior to the start of the Match. The Robot starting in the red Alliance Station will use the orange Cubes. The Robot starting in the blue Alliance Station will use the green Cubes.

Programming Skills Match – A Programming Skills Match consists of a sixty-second (1:00) Autonomous Period plus and Overtime Period. There is no Driver Controlled Period. Teams can elect to end their run early, however this will count as an official run.

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 or Outer Protected Zone if it is not contacting a Robot 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 or fully within the Outer Protected Zone.
    2. Level or "flush" with the foam tile(s).
- **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 within the Goal Zone, ie. a Cube cannot be a Stacked Cube in the Outer Protected Zone.
    2. Not contacting the top of the field perimeter wall.
    3. Not contacting the Top Surface of any Cubes which are not Scored.

Figure 10: An example of a Goal Zone with Cubes that are Scored (green checkmark) and not Scored (red "X"). These Cubes are not Scored because the Robot is making contact with a Cube, and the Cube above is not on a Scored Cube.
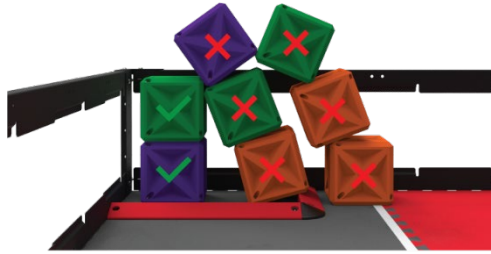
Figure 11: An example of a Goal Zone with Cubes that are Scored (green checkmark) and not Scored (red "X"). These Cubes are not Scored because they are contacting Top Surfaces of Cubes which are not Scored.
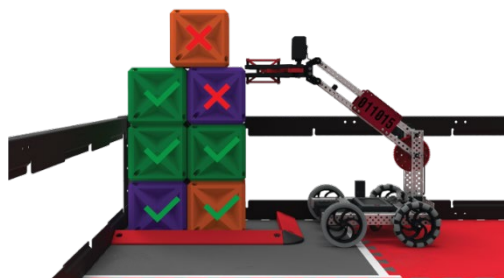

Figure 12: An example of a Goal Zone with Cubes that are Scored (green checkmark) and not Scored (red "X"). These Cubes are not Scored because they are contacting Top Surfaces of Cubes which are not Scored.
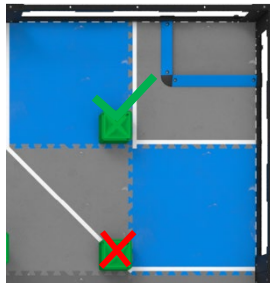
*Figure 13: An example of an Outer Protected Zone with a Cube that is Scored (green checkmark) and not Scored (red "X").
The Cube not Scored is because it is not fully within the Outer Protected Zone because it is touching the tape line.*

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.
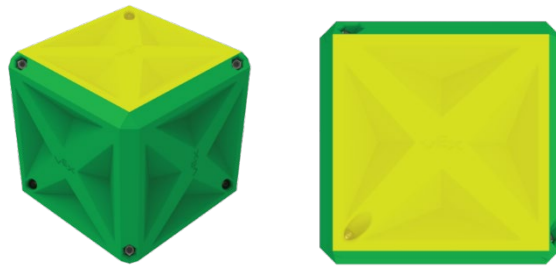
Figure 14: Close-up of a Cube, depicting the Top Surface in yellow.

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

Figure 15: Close-up of a Tower. All Towers are used for the same purpose of Placing Cubes. The color on the base of the Tower does not have any meaning in this game.

Scoring

Scoring Cubes in red Goal Zones

- Base or Stacked Cubes that are orange or purple are worth five (5) points

- Base or Stacked Cubes that are green are worth negative five (-5) points

Scoring Cubes in blue Goal Zones

- Base or Stacked Cubes that are green or purple are worth five (5) points
- Base or Stacked Cubes that are orange are worth negative five (-5) points

Scoring Cubes in the red Outer Protected Zone

- Base Cubes that are orange or purple are worth two (2) points
- Base Cubes that are green are worth negative two (-2) points

Scoring Cubes in the blue Outer Protected Zone

- Base Cubes that are green or purple are worth two (2) points
- Base Cubes that are orange are worth negative two (-2) points

Safety Rules

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

<S2> Stay inside the field. 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 is NOT to penalize Robots for having mechanisms that inadvertently cross the field perimeter 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 including Mobile Robotics Technology. 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.

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-roboticscompetition/ .

<G2> VRC is a student-centered program. Adults may assist Students in urgent situations when preparing for events, 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. During the competitive events, Adults may not touch or program the Robot for any reason.

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

<G4> Robots begin the Match in the starting cube. At the beginning of a Match, one Robot must be smaller than a volume of 24" long by 24" wide by 24" tall. The second Robot must be smaller than a volume of 15" long by 15" wide by 15" 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 <RE4> 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 two (2) Drive Team Members. No Drive Team Member may fulfill this role for more than one Team in a given competition season.

<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 1:** 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 <RE12> and <G9>.
>
> **Note 3:** The Drivers for one Robot will start in the red Alliance Station and the Drivers for the second Robot will start in the blue Alliance Station. They may choose to switch sides for the Overtime Period but may never have more than one Robot Drive Team Member in the same Alliance Station during any point in the Match. (ie. One driver stands in the red Alliance Station and the other driver stands in the blue Alliance Station.)

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

<G8> N/A

<G9> Hands out of the field. Drive Team Members may only touch the Team's controls at specified times during a Match. Drive Team Members are prohibited from making intentional contact with any Game Object, Field Element, or Robot during a Match.

Drive Team Members are not permitted to break the plane of the field perimeter at any time during the Match.

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 Programming Challenge Match, Drive Team Members are not permitted to interact with the Robots 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 result in a Disqualification.

<G11> N/A

<G12> N/A

<G13> N/A

<G14> N/A

<G15> N/A

<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.

<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.

> **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> N/A

<G22> N/A

VRC Tower Takeover Specific Game Rules

<SG1>Starting a Match. Prior to the start of each Match, the Robots must be placed such that they are:
1. Contacting the field perimeter wall on the side that coincides with their Alliance's Goal Zone and Alliance Station.
2. Contacting a foam field tile
3. Not contacting a Tower.
4. Not contacting any Cubes other than the Preload.
5. Contacting a Preload
   a. The Preload must be contacting exactly one (1) Robot
   b. The Preload must be fully within the field perimeter.
6. Not contacting a Goal Zone or a Barrier.
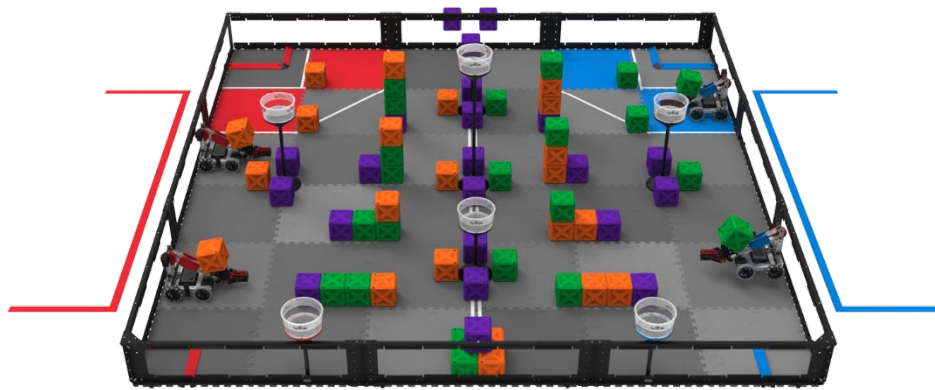
Figure 15: *Four examples of Robots in valid starting positions.*

<SG2> N/A

<SG3> N/A

<SG4> N/A

<SG5> N/A

<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.

<SG7> N/A

Game Rules Specific only to SkillsUSA

<SkillsUSA1> This manual will be updated for NLSC. Rules in this manual are subject to change for NLSC and will be announced when teams arrive at the Championship for the Orientation Meeting. Teams should be prepared for the following changes which may or may not occur. No other rules will be changed.

1. Outer Protection Zone location.
2. The starting position of all Cubes.
3. Scoring values of Scored Cubes (including which colors should be scored in each Zone).
4. The amount of additional time given for Placed Cubes.
5. The colors of Placed Cubes changing from purple to orange or green.

<SkillsUSA2> Only Placed Cubes are looked at before the Overtime Period. Scores are calculated at the end of the Match per <G18>. However, the amount of Overtime is calculated at the end of the sixty-second (1:00) period and before Overtime after all Cubes, Field Elements, and Robots come to rest.

<SkillsUSA3> Place your Robot before Overtime. Teams will be given no more than thirty-seconds (0:30) to pick up their Robot and place it in a legal starting position <SG1> using an additional Pre-load. Teams can choose to stay on the same side as they started the Match, or switch sides at this point. Once ready, the Head Referee will count down and start the Overtime Period. If Teams take longer than the thirty second (0:30) grace period after the sixty-seconds (1:00), the Head Referee will start the

Overtime Period and the Team will not be permitted to start their Robot until they have their Robot in a legal starting position <SG1>.

<SkillsUSA4> **The Cubes do not get reset before the Overtime Period**. After the sixty-second period (1:00), the Cubes may not be moved from their current locations on the field until the start of the Overtime Period, ie. do not reset the field. Any Cubes contacting the Robot must be removed from the Robot and may not be returned to the field, ie. those Cubes are now "out of play."

<SkillsUSA5> **The Cubes in the Towers can be used to Score during the Overtime Period**. The Placed Cubes in Towers do not need to stay in the Towers during the Overtime Period. Teams are permitted to use Robot actions to remove the Cubes from the Towers to Scored locations on the field.

> Note: This can be done at any point in the match legally. But teams will want to have Cubes Placed in Towers at the end of the sixty-seconds, then Scored in Zones at the end of the Overtime Period.

<SkillsUSA6> **The Match Loads can be placed anywhere**. If the Team has earned an Overtime Period by Placing Cubes in Towers, the Team will be given two (2) purple Cubes as Match Loads and can place these before the start of the Overtime Period, anywhere on the field in a non-Scored location and not touching the Robot.

<SkillsUSA7> **Work safe.** At no time may a team member take off his or her safety glasses while working on a Robot or in the Alliance Station at the field. This includes all of practice time.

<SkillsUSA8> **No Power Tools.** Teams may not use power tools in the competition or pit areas. Hand tools are the only acceptable means of cutting and bending materials.

ROBOT EQUIPMENT

Competitors will be required to purchase their own robot kits for competition. All equipment found in the VEX EDR product line found here is permitted with the following limits.

<RE1> **Two Robots per Team.** Only two (2) Robots will be allowed to compete per Team. Though it is expected that Teams will make changes to their Robots at the competition, a Team is limited to only two (2) Robots. As such, a legal Robot 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.

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 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 third Robot and are no longer legal.

1. Teams may not compete with two Robots while additional Robots are being modified or assembled.
2. Teams may not switch back and forth between multiple Robots during a competition and must remain with their two Robots. This includes using a different pair of Robots for Driving Skills and Programming Skills.
3. 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.

\<RE2\> 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 the Orientation meeting.

\<RE3\> Robots must be safe. Mechanisms and components that could potentially damage playing field components such as the field perimeter or Field Elements are not permitted.

\<RE4\> Robots must fit in a sizing box. At the beginning of any Match, one Robot must be smaller than a volume of 24" long by 24" wide by 24" tall. The second Robot must be smaller than a volume of 15" long by 15" wide by 15" tall.
1. Robots may expand beyond their starting size constraints after the start of a Match.
2. 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.

\<RE5\> 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 pro-viding 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.

\<RE6\> 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.

\<RE7\> Certain non-VEX EDR components are allowed. Robots are allowed the following additional "non-VEX" components:
1. Any material strictly used as a color filter or a color marker for a VEX Light Sensor.
2. 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.
3. 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).
4. Hot glue when used to secure cable connections
5. An unlimited amount of 1/8" (or local metric equivalent), braided, nylon rope
6. 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.

\<RE8\> 3D Printed Parts. An unlimited amount of plastic 3D printed parts may be used on the Robot using PLA, PETG and/or ABS. These parts must be documented in the Engineering Notebook and explained why they are chosen including how they were printed.

Note: Using a 3D printer to make molds for casting or injection molding is not legal and not within the spirit of this rule.

\<RE9\> A limited amount of tape is allowed. Robots may use a small amount of tape when used for the following purposes:
1. For the sole purpose of securing any connection between the ends of two (2) VEX cables.
2. For labeling wires and motors.
3. For covering the back of License Plates (i.e. the "wrong color").

4. For the purposes of preventing leaks on the threaded portions of pneumatic fittings. This is the only acceptable use of Teflon tape.
5. 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.
6. In any other application that would be considered a "non-functional decoration" per <R12>.

<RE10> 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.

<RE11> Robots have one microcontroller. Each Robot must use ONLY one (1) VEX EDR Microcontroller.
1. Examples of VEX EDR Microcontrollers are the VEX ARM® Cortex®-based Microcontroller (276- 2194) and the V5 Robot Brain (276-4810).
2. Any other microcontrollers or processing devices are not allowed. 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.

<RE12> Robots use VEXnet. Robots must ONLY utilize the VEXnet system for all Robot communication.
1. VEX 75Mhz Crystal Radios are prohibited.
2. Electronics from the VEXpro, VEX RCR, VEXplorer, VEX IQ, or VEX Robotics by HEXBUG product line are prohibited.
3. 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.
4. 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.

<RE13> 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 <RE22>.
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 <RE22>.
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.*

<RE14> 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.)

1. 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.
2. Teams may not "Y" off of a Motor Controller 29 (276-2193).

<RE15> Electrical power comes from VEX batteries only. The only allowable source(s) of electrical power are as follows:

1. If using a VEX ARM® Cortex®-based Microcontroller, Robots may use (1) VEX 7.2V Robot Battery Pack of any type.
   a. 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.
   b. 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.
   c. Teams must connect a charged 9V backup battery to their VEXnet system using the VEXnet Backup Battery Holder (276-2243).
   d. VEXnet Joysticks must only be powered by AAA batteries.
2. If using a V5 Robot Brain, Robots may use (1) V5 Robot Battery (276-4811).
   a. There are no legal power expanders for the V5 Robot Battery.
   b. V5 Robot Batteries may only be charged by the V5 Robot Battery Charger (276-4812).
   c. V5 Wireless Controllers may only be powered by their internal rechargeable battery. 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.

Component	VEX ARM® Cortex®-based Microcontroller			V5 Robot Brain		
	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

<RE16> One controller per Robot. No more than one (1) VEX wireless remote may control a single Robot during the tournament.

1. No modification of these transmitters is allowed of ANY kind.
2. No other methods of controlling the Robot (light, sound, etc.) are permissible. i. Using sensor feedback to augment driver control (such as motor encoders or the Vision Sensor) is acceptable.

<RE17> 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.

1. 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.
2. Teams are advised to use the latest official VEXos firmware updates, found at www.vexedr.com. Custom firmware modifications are not permitted.
3. Teams may change or replace the gears in the "2-Wire 393" or "2-Wire 269" motors with the corresponding official VEX Replacement Gears
4. Teams may change or replace the gear cartridge in the V5 Smart Motor with other official replacement gear cartridges

<RE18> 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.

1. Physical modifications to electrical components such as a legal microcontroller or radio is prohibited unless otherwise explicitly permitted, per <RE17>.
2. 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.
3. Metallurgical modifications that change fundamental material properties, such as heat treating, are not permitted.
4. Teams may cut pneumatic tubing to a desired length.
5. Teams are permitted to fuse/melt the end of the 1/8" nylon rope to prevent fraying.
6. Welding, soldering, brazing, gluing, or attaching in any way that is not provided within the VEX EDR platform is NOT permitted.
7. 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.

<RE19> 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.

<RE20> 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.

<RE21> 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.

<RE22> 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.

<RE23> Programing using any language. Teams may program the robots in any programming language that suits their needs. Teams will not be judged on which language is chosen, but rather, will be judged on how the robot performs. Some programming options can be found here.

DESIGN PROCESS

Judges must use the Design Rubric to evaluate the teams' design process. A record of all teams submitting notebooks shall be kept by the Judge Advisor. Notebooks shall be collected during the orientation meeting and brought to the Judges' room for evaluation. The Rubric comes in two (2) pages. The first page is for the Engineering Notebook, and the second page is for the Design Interview.

Engineering Notebooks

The Engineering Notebook is a way for teams to document how the VEX Robotics Competition experience has helped them to better understand the engineering design process while also practicing a variety of critical life skills including project management, time management, brainstorming, and teamwork. Bound notebooks are preferred by Judges and are given a 3-point bonus on the Design Rubric.

Each notebook is created through a concerted effort by a team to document their design decisions.

Engineering is an iterative process whereby students recognize and define a problem, brainstorm and work through various stages of the design process, test their designs, continue to improve their designs, and continue the process until a solution has been identified. During this process, students will come across obstacles, encounter instances of success and failure, and learn many lessons. It is this iterative process that students should document in their Engineering Notebook.

The Engineering Notebook is an opportunity to document everything a team does throughout the design process. Students should include a number of items in their Engineering Notebook including:

- A table of contents
- Team meeting notes as they relate to the design process
- Design concepts, sketches and pictures
- Notes from competitions regarding observations that should be considered in the next iteration of their design
- Programming improvements or significant modifications
- CAD drawings of their Robot and/or specific elements of their Robot.
- Team members' observations and thoughts on their design
- Team organization practices as they relate to their design process
- Other documentation that a team finds useful as related to their robot's design

The team should also document their project management practices including their use of personnel, financial, and time resources.

A bound quad-ruled notebook is the preferred format. The team number should be on the cover. The notebook should never be edited. Pages should never be removed from the notebook even if they contain errors. The notebook should be written in ink with errors crossed out using a single line. Pages should be numbered, and entries should be dated in chronological order with each page signed or initialed by the students. Additional materials such as examples of computer code or CAD drawings should be glued or taped into the notebook.

The question of what is a 'bound' Engineering Notebook often arises. To be considered bound, a notebook must have been bound prior to any entries being made in it.

Judges will not accept electronic notebooks on laptops, thumb drives, or cloud-based servers.

Design Interview

All teams will be interviewed by Judges who will ask them questions about their robot and design process. Teams should bring their robot with them to the interview. Judges will fill out page 2 of the Design Rubric and give teams a score based on the responses of the team members. Teams are not to prepare a slide presentation such as Power Point for this interview and should be prepared to talk about their robot without any written notes such as cards or written outlines.

Appendix A contains the Design Award Rubric and Design Interview Rubric.

Programming Interview

All teams will be interviewed by Judges who will ask questions about the coding and programming process. Teams should bring their robot, laptop and programming cable with them to the interview. Judges will use the following interview process rubric to determine the knowledge of the programmer and quality of the written code.

Appendix B contains the Programming Interview questions.

Appendix C contains the Programming Interview Scorecard.

Safety Points

All teams are expected to be safe in the competition area. Students will start with 90-points in Safety and will be deducted 10-points for every instance of a safety violation. The minimum score is zero.

Students will be notified immediately upon each instance of a safety violation. Examples of Safety violations are as follows.

- General horseplay (running, throwing objects, pushing others)
- Not wearing shoes (except when walking on foam tiles)
- Not wearing safety glasses while working on Robot
- Not wearing safety glasses while standing in the Alliance Station
- Using teeth as a tool (other than eating)
- Leaving equipment in aisles (creating trip hazards)

TEAM RANKING

Teams will be given a total score based on the Professional Development Test, Engineering Notebook (Page 1 of the Design Rubric), CAD drawings, the Design Interview (Page 2 of the Design Rubric), the Programming Interview, the team's highest Programming Skills Score, the team's highest Driving Skills Score, and the Team's Safety Score. Teams are ranked by the sum of their weighted scores in these categories.

All teams will be given the same number of Robot Skills Matches to be determined by the Competition Organizer. At SkillsUSA NLSC, each team will get three (3) chances for Programming Skills and three (3) chances for Driving Skills. Only the highest Programming Skills score and the highest Driving Skills score will be used to determine rankings.

In the case of ties, the tie will be broken by looking at the following in order.

1. Engineering Notebook Score
2. Team's highest Programming Skills Score
3. Team's highest Driving Skills Score

Appendix F contains the Mobile Robotics Technology Overall Scorecard.

Design Award Rubric – Page 1 *Engineering Notebook Review*

Directions: Write the points in each row for the criterion that best describes the performance of the Engineering Notebook on each topic. Total the points.

Team Number _____

	Topic	Criteria			Points
		Expert (4-5 points)	Proficient (2-3 points)	Emerging (0-1 points)	
Engineering Design Process	Identify game and robot design challenges and goals	<u>Identifies</u> the game challenge or robot design challenge <u>in detail at the start of each design</u> process cycle with words and pictures. States the goals for accomplishing the challenge.	Identifies the challenge at the start of each design cycle. <u>Lacking details in words</u>, pictures, or goals.	<u>Does not identify the challenge</u> at the start of each design cycle.	
	Brainstorm and diagram or prototype solutions	<u>Lists three or more possible solutions</u> to the challenge with labeled diagrams. Citations provided for ideas that came from outside sources such as online videos or other teams.	<u>Lists one or two possible solutions</u> to the challenge. No citations provided for ideas that came from outside sources.	<u>Does not list any</u> solutions to the challenge.	
	Select the best solution and plan	Explains why the solution was selected through testing and/or a decision matrix. <u>Fully describes the plan</u> to implement the solution.	Explains why the solution was selected. <u>Mentions the plan</u>.	<u>Does not explain</u> why the solution was selected or does not mention the plan.	
	Build and program the solution	Records the steps to build and program the solution. Includes enough detail that the reader <u>could recreate the solution following the steps in the Notebook</u>.	Records the key steps to build and program the solution. <u>Lacks sufficient detail to recreate the solution</u>.	<u>Does not record the key steps</u> to build and program the solution.	
	Test solution	<u>Records all the steps</u> to test the solution, including test results.	<u>Records the key steps</u> to test the solution.	<u>Does not record the steps</u> to test the solution.	
	Repeat design process	Shows that the <u>design process is repeated multiple times</u> to improve performance on an individual design goal or overall robot or game performance.	Shows that the <u>design process is not often repeated</u> for individual design goals or overall robot or game performance.	<u>Does not show that the design process is repeated</u>.	
	Usefulness and repeatability	<u>Records the entire design and development process</u> in such great clarity and detail that the reader could recreate the project's history and build the current robot from the notebook.	Records the design and development process completely but <u>lacks sufficient detail</u> to fully recreate the entire project or robot.	Does not record the design and development process or <u>lacks sufficient detail</u> to understand the design process.	
	Record of team and project management	Provides a <u>complete record of team and project assignments</u>; notes from team meetings including goals, decisions, and accomplishments; name or initials of author; each page numbered and dated. Design cycles are easily identified. Includes Table of Contents and/or Index so anyone can easily locate needed information.	Records <u>most of the information listed</u> at the left. Organized so that team members can locate most of the needed information.	<u>Does not record most of the information</u> listed at the left. Not organized; needed information difficult to locate.	
	Notebook construction	Five (5) points if notebook is bound. Notebook must have been <u>bound before any entries</u> were made in it.	Zero points for any other notebook construction.	Zero points for any other notebook construction.	

Describe a few of the best features of the Engineering Notebook:

Total points for Engineering Notebook:

CAD Drawings

(Keep separate from Engineering Notebook Score)

1 point = Made an attempt to have a CAD drawing, but it is not accurate

2-3 points = Have basic elements of CAD drawings

4-5 points = Have detailed CAD drawings for entire Robot including some early iterations of design

CAD Score_____

Design Award Rubric – Page 2 *Team Interview with Judges*

Directions: Write the points in each row for the criterion that best describes the team's performance on each topic during interview. Total the points below.

Team Number _____

Topic	Criteria			Points
	Expert (4-5 points)	Proficient (2-3 points)	Emerging (0-1 points)	
Design process and Engineering Notebook	Students clearly explain all aspects of the design process and how they recorded their use of the design process in the Notebook.	Students can explain most aspects of the design process and how they recorded their use of the process.	Students can explain only limited aspects of the design process and how they recorded their use of the process.	
Game strategies and robot designs	Students can describe three or more game strategies and robot designs that were considered; students can fully explain how and why the current game strategy and robot design were chosen.	Students can describe two game strategies and robot designs that were considered; students can explain how and why the current game strategy or robot design were chosen.	Students can describe only their current game strategy and design, or they cannot explain how and why the current game strategy or robot design were chosen.	
Project and team management	Students can explain how team progress was tracked against an overall project timeline, and how students were assigned to tasks based on their skills and availability; students can explain management of material resources.	Students can explain how team progress was monitored, or how students were assigned to tasks, or management of material resources.	Students cannot explain how team progress was monitored or how students were assigned to tasks or how material resources were managed.	
Teamwork and communication	Students can explain how multiple team members contributed to the robot design and game strategy. All students answer questions independently.	Students can explain how most team members contributed to the robot design and game strategy. Students support each other as needed to answer questions.	Only one team member answered questions or contributed to the robot design process.	
Respect and courtesy	Students answer respectfully and courteously. Students make sure each team member contributes. Students wait to speak until others have finished.	Students answer respectfully and courteously. Some students attempt to contribute but are interrupted by other students.	Students do not answer respectfully and courteously. Students interrupt each other or the Judges.	
Describe a few of the best features of the team interview:			**Total points for Design Interview (30 Max):**	

Professional Dress

(Add this to the Design Interview Score)

As the students walk into the interview, check to see if their shirts are fully tucked in.

Add 5 points if BOTH students have their shirts fully tucked in.

Professional Dress Score_____

(5 or 0)

Mobile Robotics Programming Interview Process

This interview is comprised of 3 sections. For each section please read all instructions and questions before assessing the team.

Please pay attention to the students' Professional Dress as they walk into the interview. There is a point value evaluation on the Programming Interview Scorecard for this category.

Section 1: General Programming Information (Maximum 15 pts)

For this section you will be asking the team general information about their program. This section will make sure teams have come prepared for their interview.

1. Did the team bring a laptop with their code?

No (0 pts)		Yes (5 pts)	

2. Did the team bring their robot?

No (0 pts)		Yes (5 pts)	

3. Ask the team, what programming software are they using. Does it match the code that was brought to the interview?

No (0 pts)		Yes (5 pts)	

Section 2: Program Design and Fluency (Maximum 60 pts)

In this section you will ask the team to walk you through their code. Ask the team to start at the very beginning and explain the program until the robot stops. Read all questions beforehand because you will need to assess the program after the walk through is complete. The following questions are for the judge and should not be asked to the team.

4. Did the program include comments?

1 pt	2 pt	5 pt	9 pt	10 pt
Program did not contain comments.	Program contained comments but lacked in depth. The comments were only useful for the programmer.			Program contained in depth comments for their entire code base. Comments were articulate and meaningful.

5. Did the program use variables instead of hard coding numbers? (eg. when they set the speed of the motor, is it a number or a variable)?

1 pt	2 pt	5 pt	9 pt	10 pt
Program did not include any variables.	Program contained a mix of variables and hard coded values. Variable may not be organized.			The program used variables for all or most opportunities. Variables were organized and named in a meaningful way.

6. Did the program contain advanced programing structures like loops and if else statements?

1 pt	2 pt	5 pt	9 pt	10 pt
Program did not contain any loops or if else statements.	The program only had a few loops or if/else structure. Some parts of the code were reused in loops but others were programed linearly.			The program contained many loops and if/else structures.

7. Did the program contain functions that were used throughout their code?

1 pt	2 pt	5 pt	9 pt	10 pt
Program did not contain any functions.	The program used some functions but missed opportunities to make a function.			The program had multiple functions and was used to reuse code wherever possible in their program.

8. Is the code formatted in an organized manner?

1 pt	2 pt	5 pt	9 pt	10 pt
Program did not follow any kind of format. Code was not properly indented or spaced in a neat fashion.	Most or some of the code was formatted. There are areas where code could have been formatted a little better.			The entire code base is formatted and spaced.

9. How did the team conduct the walkthrough of their code?

1 pt	2 pt	5 pt	9 pt	10 pt
The team showed zero or minimal knowledge of their program. They were not able to articulate what their program does or where it starts.	Team was able to walk you through the program. Students read the comments verbatim and were not able to explain more than what was already written in the program. The team was unsure about how some of the code worked in some sections.			The team was able to explain all parts of their program. The team used proper terminology when talking about their program. The team was able to explain their code without having to read the comments verbatim.

Section 3: Smart Programming (Maximum 15 pts)

In this section you will be asking the team specific questions about their program. The judge will assess the team on how well they answer each question.

10. Ask the team how many sensors are on their robot that they programed.

1 pt	2 pt	3 pt	4 pt	5 pt
Team uses one or less sensors on their robot.	The team uses a moderate amount of sensors (2 - 3).			Team used a large amount of sensors (4+).

11. Find a sensor on the team's robot or one they mentioned in the question above. An example could be an Encoder in the Smart Motor. Ask the team to show you where in their code that they use this sensor. Is the team able to explain and show you how they used the sensor?

1 pt	2 pt	5 pt	9 pt	10 pt
Team did not use any sensors or could not find how they used the sensor in their code.	The team struggled to find where they used the sensor in their code, and/or was only able to explain how they used the sensor by reading comments in that section. The team did not fully understand what data was being collected by the sensor and how it was used by the program.			Teams were able to quickly find the sensor in their program. They were able to explain in great detail how the program uses the data from the sensor.

Programming Interview Scorecard

Team Number _____

Total Score _____

_____ 1. Laptop (5)

_____ 2. Robot (5)

_____ 3. Software Match (5)

_____ 4. Comments (10)

_____ 5. Variables (10)

_____ 6. Programming Structure (10)

_____ 7. Functions (10)

_____ 8. Format (10)

_____ 9. Walkthrough (10)

_____ 10. Number of Sensors (5)

_____ 11. Code for Sensor (10)

_____ **Subtotal (90)**

_____ Professional Dress: 5 points per student if shirt is fully tucked in as they walk into interview. (10)

_____ **Total Score: Copy this number to the top of sheet (100)**

Programming Skills Matches

REC Foundation

(1-minute matches)

Team Number _____

Highest Score _____

Trial 1

Red Goal Zones		**Red Outer Protected Zone**	
Orange or Purple Cubes	_____ x 5 = _____	Orange or Purple Cubes	_____ x 2 = _____
Green Cubes	_____ x −5 = _____	Green Cubes	_____ x −2 = _____
Blue Goal Zones		**Blue Outer Protected Zone**	
Green or Purple Cubes	_____ x 5 = _____	Green or Purple Cubes	_____ x 2 = _____
Orange Cubes	_____ x −5 = _____	Orange Cubes	_____ x −2 = _____

Trial 1 Total Score _____ (maximum of 100 points)

Trial 2

Red Goal Zones		**Red Outer Protected Zone**	
Orange or Purple Cubes	_____ x 5 = _____	Orange or Purple Cubes	_____ x 2 = _____
Green Cubes	_____ x −5 = _____	Green Cubes	_____ x −2 = _____
Blue Goal Zones		**Blue Outer Protected Zone**	
Green or Purple Cubes	_____ x 5 = _____	Green or Purple Cubes	_____ x 2 = _____
Orange Cubes	_____ x −5 = _____	Orange Cubes	_____ x −2 = _____

Trial 2 Total Score _____ (maximum of 100 points)

Trial 3

Red Goal Zones		**Red Outer Protected Zone**	
Orange or Purple Cubes	_____ x 5 = _____	Orange or Purple Cubes	_____ x 2 = _____
Green Cubes	_____ x −5 = _____	Green Cubes	_____ x −2 = _____
Blue Goal Zones		**Blue Outer Protected Zone**	
Green or Purple Cubes	_____ x 5 = _____	Green or Purple Cubes	_____ x 2 = _____
Orange Cubes	_____ x −5 = _____	Orange Cubes	_____ x −2 = _____

Trial 3 Total Score _____ (maximum of 100 points)

Driving Skills Matches

(1-minute matches)

REC Foundation

Team Number _____

Highest Score _____

Trial 1

Red Goal Zones

Orange or Purple Cubes   _____ x 5 = _____

Green Cubes   _____ x −5 = _____

Blue Goal Zones

Green or Purple Cubes   _____ x 5 = _____

Orange Cubes   _____ x −5 = _____

Red Outer Protected Zone

Orange or Purple Cubes   _____ x 2 = _____

Green Cubes   _____ x −2 = _____

Blue Outer Protected Zone

Green or Purple Cubes   _____ x 2 = _____

Orange Cubes   _____ x −2 = _____

Trial 1 Total Score _____ (maximum of 150 points)

Trial 2

Red Goal Zones

Orange or Purple Cubes   _____ x 5 = _____

Green Cubes   _____ x −5 = _____

Blue Goal Zones

Green or Purple Cubes   _____ x 5 = _____

Orange Cubes   _____ x −5 = _____

Red Outer Protected Zone

Orange or Purple Cubes   _____ x 2 = _____

Green Cubes   _____ x −2 = _____

Blue Outer Protected Zone

Green or Purple Cubes   _____ x 2 = _____

Orange Cubes   _____ x −2 = _____

Trial 2 Total Score _____ (maximum of 150 points)

Trial 3

Red Goal Zones

Orange or Purple Cubes   _____ x 5 = _____

Green Cubes   _____ x −5 = _____

Blue Goal Zones

Green or Purple Cubes   _____ x 5 = _____

Orange Cubes   _____ x −5 = _____

Red Outer Protected Zone

Orange or Purple Cubes   _____ x 2 = _____

Green Cubes   _____ x −2 = _____

Blue Outer Protected Zone

Green or Purple Cubes   _____ x 2 = _____

Orange Cubes   _____ x −2 = _____

Trial 3 Total Score _____ (maximum of 150 points)

Team Number _____

Mobile Robotics Technology Overall Scorecard

Scoring Category	Max Score (Raw x Weight)	Raw Score	Weight	Total Score
Professional Development Test	25 x 1 = 25		1	
Engineering Notebook	45 x 4 = 180		4	
CAD Drawings	5 x 5 = 25		5	
Design Interview	30 x 6 = 180		6	
Programming Interview	100 x 2 = 200		2	
Highest Programming Skills Score	100 x 1.5 = 150		1.5	
Highest Driving Skills Score	150 x 1 = 150		1	
Safety Points	90 x 1 = 90		1	
Total Points	**1000**	**N/A**	**N/A**	

Used for tiebreaking purposes only:

_____ Engineering Notebook Score

_____ Team's highest Programming Skills Score

_____ Team's highest Driving Skills Score