



ROBOTICS EDUCATION & COMPETITION FOUNDATION

Presents:

Mobile Robotics Technology Game Manual – Junior Edition Middle School Teams

2019-2020

Adapted from VEX IQ Challenge
Squared Away 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 VIQC Squared Away Robot Skills Challenge.

ELIGIBILITY

Open to a team of two active SkillsUSA members who must be or have been enrolled in a middle-school exploratory course that prepares for future study in a career and technical education.

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 4 ft. x 8 ft. VEX IQ Challenge field set up as illustrated in the figures throughout. These matches consist of Driving Skills Matches, which will be entirely driver controlled, and Programming Skills Matches, which will be autonomous with limited human interaction.

The object of the game is to attain the highest score by Scoring Balls in or on Cubes and Scoring Cubes in Corner Goals or on Platforms.

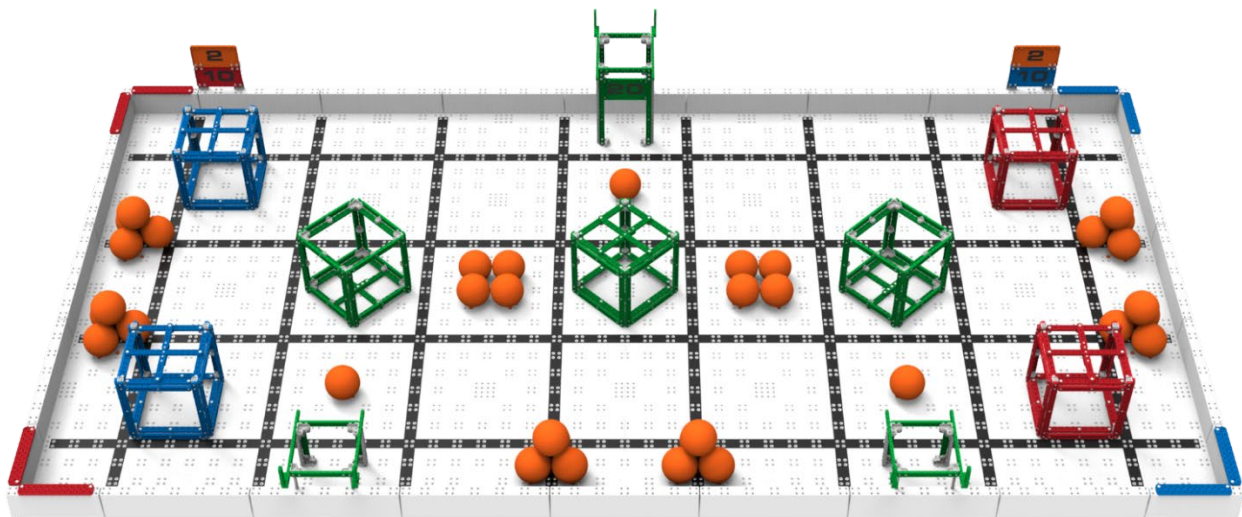


Figure 1: Initial setup configuration. Exact Cube and Ball placement on the field will be revealed at the SkillsUSA NLSC Orientation Meeting.

Each VEX IQ Challenge Squared Away Match includes the following:

- Thirty-five (35) Balls
 - Two (2) red Cubes
 - Two (2) blue Cubes
 - Three (3) green Cubes
- Four (4) Corner Goals
 - Two (2) red Corner Goals
 - Two (2) blue Corner Goals
- Three (3) green Platforms

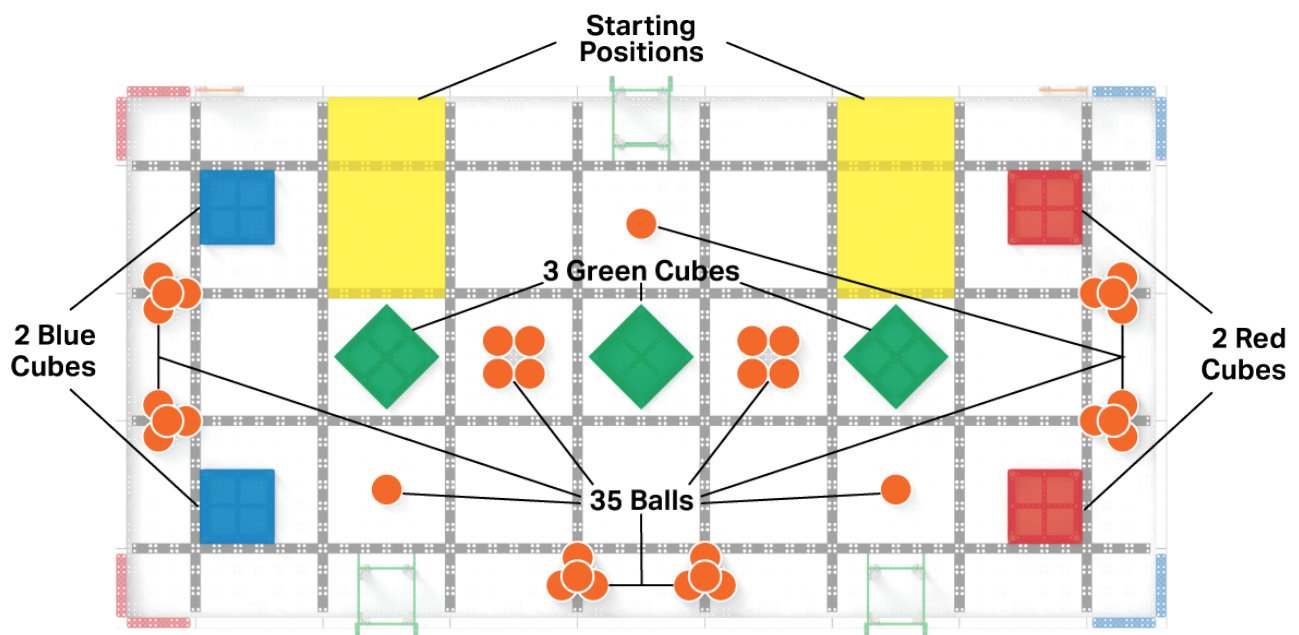


Figure 2: Overhead view of the Field. The Starting Positions, Cubes, and Balls are all highlighted.

Game Definitions

Autonomous - A Robot that is operating and reacting only to sensor inputs and to commands pre-programmed by the Students into the Robot control system. The Robot is operating without input from a VEX IQ Controller.

Ball – An orange spherical shaped plastic object with diameter of approximately 3" (76.2mm).

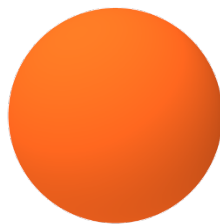


Figure 3: A Ball.

Corner Goal – One of the four 6" square goals located in the corners of the Floor that are used to Score Cubes. The inside edges of the black lines surrounding the Corner Goal mark the outer edges of the goal. The Corner Goal is defined as this portion of the Floor, not the 3-dimensional volume above it. The field perimeter and black lines are not considered part of the Corner Goal.

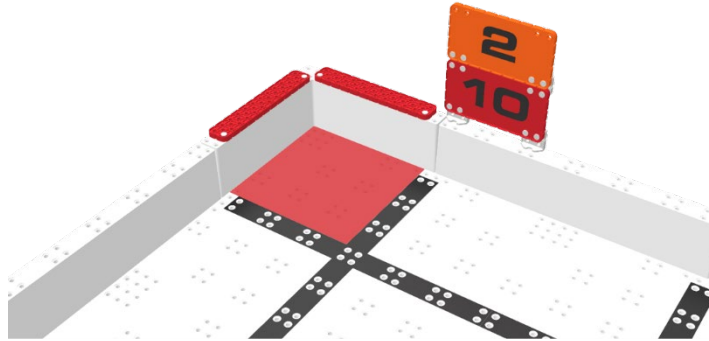


Figure 4: A red Corner Goal.

Cube – A red, green, or blue cube-shaped object built out of VEX IQ parts with dimensions of approximately 7" (177.8mm).

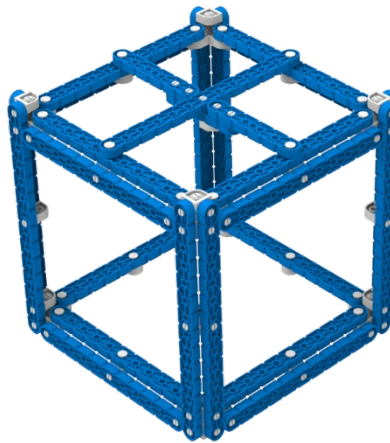


Figure 5: A blue Cube.

Disablement - A penalty applied to a Team for a rule violation. During Disablement, a Team is no longer allowed to operate their Robot, and the Drivers will be asked to place their VEX IQ Controller on the ground. A Disablement is not the same as a Disqualification.

Disqualification - A penalty applied to a Team for a rule violation. If a Team is Disqualified in a Match, the Head Referee should notify the Team of their violation at the end of the Match. At the Head Referee's discretion, repeated violations and Disqualifications for a single Team may lead to its Disqualification for the entire event.

Driver - A Student Team member who stands in the Driver Station and is responsible for operating and controlling that Team's Robot. Up to two Team members may fulfill this role in a given Match.

Driver Controlled - A Robot operating under the control of a Driver.

Driver Station - The region behind the Field, where the Drivers must remain during the Match unless legally interacting with their Robot.

Field - The entire playing field, including the field perimeter and field tiles.

Field Element - The field perimeter, Floors, Platforms, and any other supporting structures or VEX IQ elements attached to the Field.

Floor - The interior part of the playing field that is within the field perimeter.

Game Object - A Cube or a Ball.

Match - A Driving Skills Match or a Programming Skills Match.

Driving Skills Match - A Driver Controlled period that is **two minutes (2:00)** long with only one (1) Robot on the Field.

Programming Skills Match - An Autonomous period that is **two minutes (2:00)** long with only one (1) Robot on the Field.

Skills Match - A Driving Skills Match or Programming Skills Match.

Platform - One of three (3) green and white structures built out of VEX IQ parts, approximately 5" (127.0mm) or 9.5" (241.3mm) tall, that are used for Scoring Cubes.

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

Scored - A Game Object is Scored if it satisfies one of the following conditions and is not touching a Robot.

1. **A Ball is Scored inside of a Cube** if it meets the following criteria:
 - a. The Ball is at least partially within the three-dimensional volume defined by the outer edges of the Cube's structure.
 - b. The Ball is not contacting the Floor "outside" of the Cube. The portion of the Floor which is "outside" of the Cube is roughly defined as a vertical projection of the Cube onto the Floor beneath the Cube, regardless of the Cube's orientation.

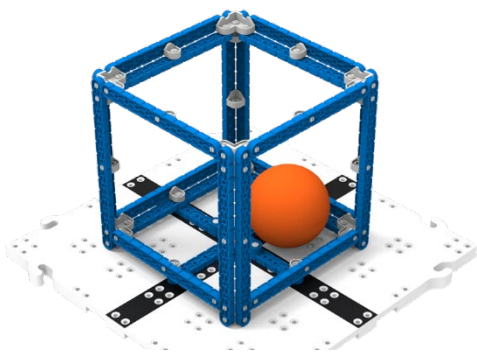


Figure 6: A Ball Scored inside of a Cube.

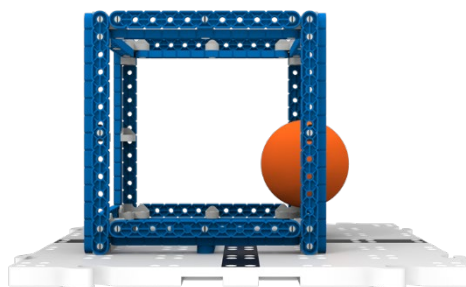


Figure 7: A Ball Scored inside of a Cube.

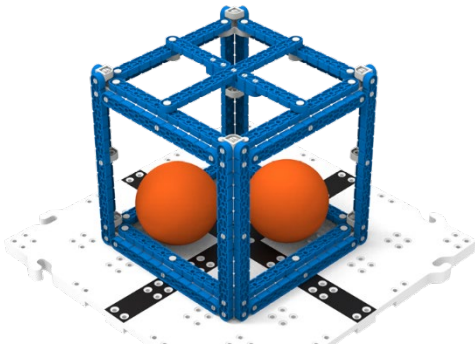


Figure 8: Two Balls Scored inside a Cube.

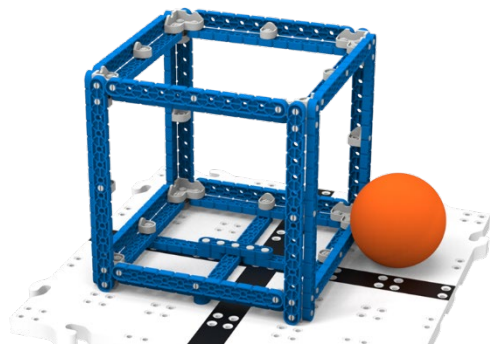


Figure 9: A Ball that is touching the Floor outside a Cube and is therefore not Scored.

2. **A Ball is Scored on top of a Cube** if it meets the following criteria:
 - a. The Ball is at least partially above the side of the Cube with cross-beams.
 - i. The side of the Cube with cross-beams is the side which is furthest away from (and roughly parallel to) the Floor.
 - b. The Ball is not contacting the Floor.
 - c. The Ball is at least partially within the three-dimensional area defined by the infinite vertical projection of a Cube when it is placed normal to the Floor.

Note: If a Ball meets the criteria for both “inside” and “on top of” a Cube (i.e. criteria 1 and 2), then it counts as being on top of a Cube (i.e. criteria 2).

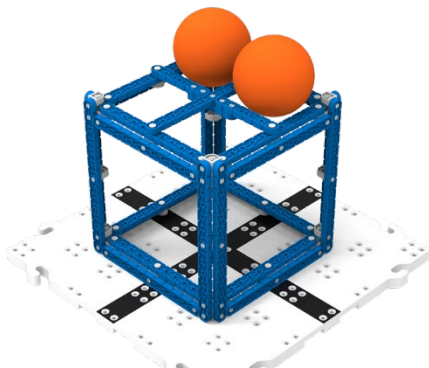


Figure 10: Two Balls Scored on top of a Cube.

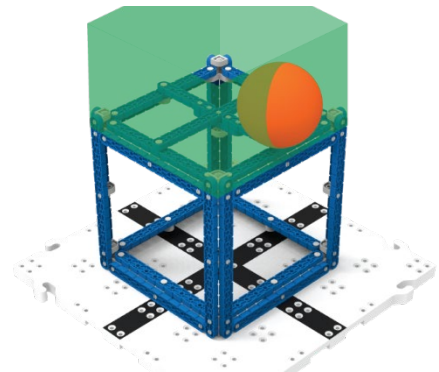


Figure 11: A Ball partially within the infinite vertical projection of a Cube, therefore is Scored on top of a Cube.

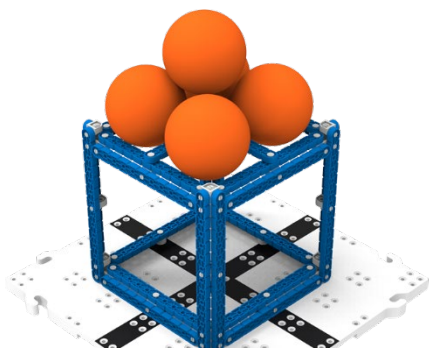


Figure 12: Five Balls Scored on top of a Cube.

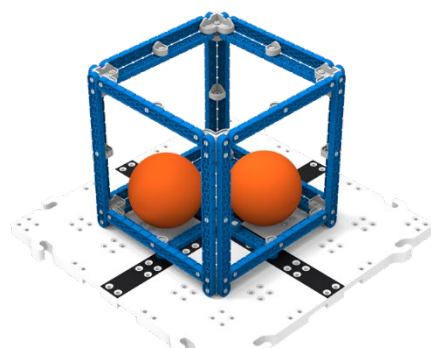


Figure 13: These two Balls are not Scored on top because the cross-beams are not furthest away from the floor, but the Balls are Scored inside a Cube.

3. **A Cube is Scored in a Corner Goal** if any part of it is contacting a Corner Goal of the same color as the Cube. See the definition of Corner Goal for specific details.

Note: A maximum of one (1) Cube may count for points per Corner Goal.

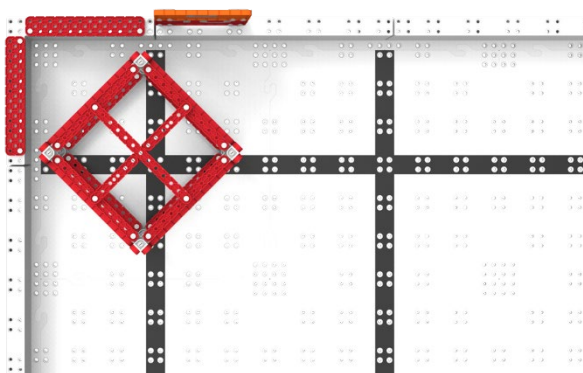


Figure 14: A red Cube Scored in a Corner Goal.

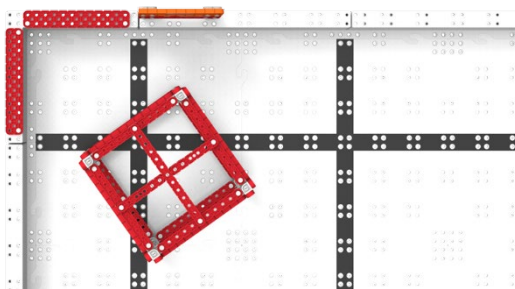


Figure 15: A Cube Scored in a Corner Goal..

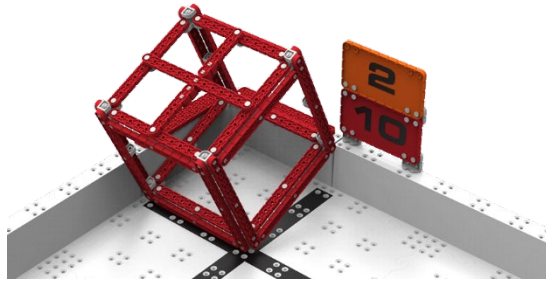


Figure 16: A Cube that is not touching the Corner Goal, therefore is not Scored.

4. **A Cube is Scored on a Platform** if it meets the following criteria:
- The Cube is contacting the Platform (including its supporting structures).
 - The Cube is not contacting the Floor.
 - The Cube is not contacting the Field Perimeter.
 - The Cube matches the color of the Platform (i.e. is a green Cube).

Note: A maximum of one (1) Cube may count for points per Platform.

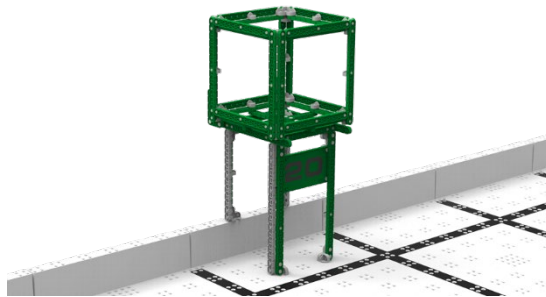


Figure 17: A Cube Scored on a Platform.

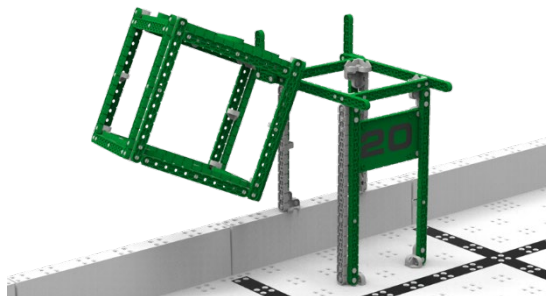


Figure 18: A Cube contacting a Platform and not contacting the Floor or the Field Perimeter, therefore is Scored.

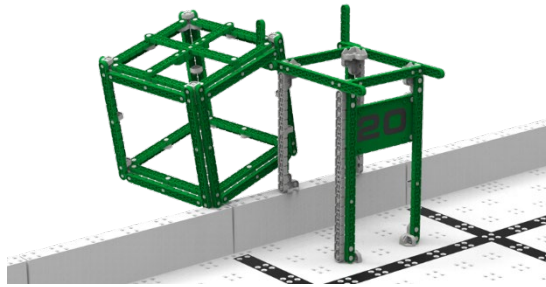


Figure 19: A Cube contacting the Field Perimeter, therefore is not Scored.

Starting Position - The two (2) designated 11" x 19" (279mm x 482.6mm) spots on the field where Robots must start the Match. Starting Positions are bounded by the inner edges of the long black lines, outer edge of the short black line, and the inner edge of the field perimeter.

Student - Anyone eligible to play in the Junior Mobile Robotics Technology Competition for SkillsUSA.

Scoring

- A Ball that is Scored in a Cube is worth one (1) point.
- A Ball that is Scored on a Cube is worth two (2) points.
- A Cube that is Scored in a Corner Goal is worth ten (10) points.
- A Cube that is Scored on a Platform is worth twenty (20) points.

Safety Rules

<S1> Stay safe, don't damage the Field. If, at any time, the Robot operation or Team actions are deemed unsafe or have damaged any Field Elements or Scoring Objects, the offending team may be *Disabled* and/or *Disqualified* at the *Head Referee's* discretion. The *Robot* will require re-inspection before it may again take the *Field*.

General Game Rules

<G1> Treat everyone with respect. All Students and adults associated with a Team are expected to conduct themselves in a respectful and positive manner while participating in the VEX IQ Challenge. If Team members are disrespectful or uncivil to staff, volunteers, or fellow Teams at an event, the Team may be Disqualified from their current or upcoming Match. Judges may also consider team conduct and ethics when determining awards.

In all aspects of the VEX IQ Challenge program, the Students make the decisions and do the work with adult mentorship. The VEX community prides itself on being a positive learning environment where no one is bullied, harassed, or berated. Teams avoid placing unnecessary stress upon Students and/or event volunteers; instead, challenging situations are viewed as teachable moments to model positive behaviors and good sportsmanship.

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 http://link.roboticseducation.org/recf_codeofconduct.

<G2> VEX IQ 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 the VEX IQ Challenge. 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. Violation of this rule could be considered a violation of <G1> and/or the REC Foundation Code of Conduct.

During the hours of competition, Adults may not assist Students in any way, including offering advice on how to program, build or drive the Robot.

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

<G4> Pre-match setup. At the beginning of a Match, each Robot must meet the following criteria:

- Only be contacting the Floor and/or the inside surface of the Field Perimeter.
- Fit within an 11" x 19" (279.4mm x 482.6mm) area, bounded by the Starting Position.
- Be no taller than 15" from the Floor.

Note: Robots may start in either Starting Position.

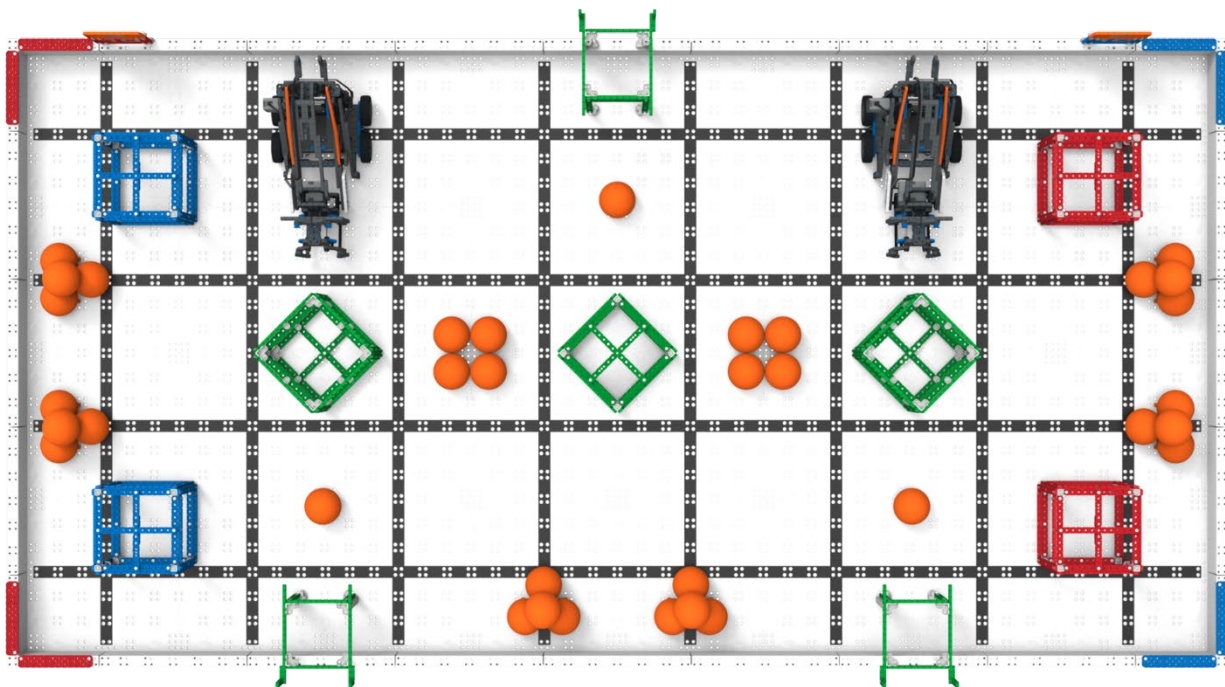


Figure 20: Two Robots in legal Match starting configurations.

<G5> Expansion is limited during a Match. During the Match, Robots may not expand beyond the following restrictions:

- a. Horizontally, beyond an 11" x 19" (279.4mm x 482.6mm) area.
- b. Vertically, beyond the 15" (381mm) high starting requirement.

Violations of this rule will result in a warning for minor offenses that do not affect the Match. Major and/or score affecting offenses will result in a Disqualification. Teams who receive multiple warnings, or who are unable to easily remedy the violation, may also receive a Disqualification at the Head Referee's discretion.

<G6> Two Drivers per Team. Each Team shall include two Drivers. No Driver may fulfill this role for more than one Team at any given event.

<G7> Drivers switch Controllers midway through the Match. In a Driving Skills Match, no Driver shall operate a Robot for more than sixty-five (1:05) seconds. The two Drivers must switch their controller between sixty-five (1:05) seconds and fifty-five (0:55) seconds remaining in the Match. The second Driver may not touch his/her Team's controls until the controller is passed to him/her. Once the controller is passed, the first Driver may no longer touch his/her Team's controls.

Note: If only one Driver is present the Driver must cease Robot operation after sixty-five (1:05) seconds.

Violations of this rule will result in a warning for minor offenses that do not affect the Match. Score affecting offenses will result in a Disqualification. Teams who receive multiple warnings may also receive a Disqualification at the Head Referee's discretion.

<G8> Drivers drive your Robot and stay in the Driver Station. During a Match, Robots may only be operated by that Team's Drivers. Drivers must remain in their Driver Station, except when legally interacting with their Robot as per <G16>. Drivers are not allowed to use any communication devices during their Match. Devices with communication features turned off (e.g. a phone in airplane mode) are allowed.

<G9> Hands out of the Field. Drivers are prohibited from making intentional contact with any Field Element, Game Object, or Robot during a Match, except for the allowances in <G16>.

Violations of this rule will result in a warning for minor offenses that do not affect the Match. Score affecting offenses will result in a Disqualification. Teams who receive multiple warnings may also receive a Disqualification at the Head Referee's discretion.

Note: Accidental contact may result in a warning, Disqualification, or Disablement at the Head Referee's discretion.

<G10> Keep Game Objects in the Field. Game Objects that leave the Field during a Match will not be returned. "Leaving the Field" means that a Game Object is outside of the vertical projection of the Field Perimeter and no longer in contact with the Field, Field Elements, other Game Objects, or Robots.

<G11> When it's over, it's over. Scores will be calculated for all Matches immediately after the Match is complete, and once all Robots and Game Objects on the Field come to rest.

- a. Head Referees or other event staff are not allowed to review any videos or pictures from the Match.
- b. If there is a concern regarding the score of a Match, only the Drivers from that Match, not an adult, may share their questions with the Head Referee.
- c. This rule's intent is for Driver inputs and Robot motion to cease at the end of the Match. A pre-programmed routine which causes Robot motion to continue after the end of the Match would violate the spirit of this rule. Any scoring which takes place after the Match due to Robots continuing to move will not count.

<G12> Keep your Robot together. Robots may not intentionally detach parts or leave mechanisms on the Field during any Match. If an intentionally detached component or mechanism affects gameplay, the Team may be Disqualified at the Head Referee's discretion.

Note: Parts that become unintentionally detached from the Robot are no longer considered to be part of the Robot and can be either left on the Field or collected by a Driver (utilizing <G16>).

<G13> Don't damage the Field or Game Objects. Robots may not grasp, grapple, or attach to any Field Elements, including the Platforms. 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.

While Robots are permitted to grasp, grapple, or attach to Game Objects, Robots which cause damage to Game Objects would be considered in violation of this rule and/or <S1>.

The intent of this rule is to prevent Robots from unintentionally damaging the Field or Game Objects. Minor violations of this rule that do not affect the Match will result in a warning. Score affecting offenses will result in a Disqualification. Teams that receive multiple warnings may also receive a Disqualification at the Head Referee's discretion.

<G14> Let go of Game Objects after the Match is over. Robots must be designed to permit easy removal of Cubes and Balls from their Robot without requiring that the Robot have power or remote control after the Match is over.

<G15> Be prepared for minor field variance. Field tolerances may vary by as much as ± 1 " unless otherwise specified. Teams must design Robots accordingly.

<G16> Replays are allowed, but rare. Match replays are at the discretion of the Event Partner and Head Referee and will only be issued in the most extreme circumstances.

<G17> Handling the Robot mid-match is allowed under certain circumstances. If a Robot goes completely outside the playing Field, gets stuck, tips over, or otherwise requires assistance, the Team's Drivers may retrieve & reset the Robot. To do so, they must:

- a. Signal the Head Referee by placing their VEX IQ Controller on the ground.
- b. Move the Robot to any legal Starting Position.
- c. Any Game Object being controlled by the Robot while being handled must be removed from the Robot and gently placed in a non-Scored position by the Team.
- d. Any Game Objects in the Starting Position may be moved out of the Starting Position and gently placed into a non-Scored position by the Team.

This rule is intended so Teams can fix damaged Robots or help get their Robots "out of trouble." It is not intended for Teams to use as part of a strategy to gain an advantage during a Match, including via moving Game Objects per parts 3 and 4 above. If a Head Referee sees Teams strategically exploiting this rule, they may be Disqualified from said Match.

<G18> Handling the Robot mid-match is allowed during Programming Skills Matches. A Team may handle their Robot as many times as desired during a Programming Skills Match.

- a. Upon handling the Robot, it must be immediately brought back to any legal Starting Position.
 - i. Driver may reset or adjust the Robot as desired from this position, including pressing buttons on the Robot Brain or activating sensors.
- b. Any Game Objects being controlled by the Robot while being handled must be removed from the Robot and gently placed in a non-Scored position by the Team.
- c. Any Game Object in the Starting Position may be moved out of the Starting Position and gently placed into a non-Scored position by the Team.
- d. During a Programming Skills Match, Drivers may move freely around the Field, and are not restricted to the Driver Station when not handling their Robot.
 - i. The rest of <G7>, which states that Drivers are not allowed to use any communication devices during their Match, still applies.

An intent of this exception is to permit Drivers who wish to “stage” Robot handling during a Programming Skills Match to do so without excessive running back and forth to the Driver Station.

<G19> Starting a Programming Skills Match. Drivers must start a Robot’s Programming Skills Match routine by pressing a button on the Robot Brain or manually activating a sensor. Because there is no VEX IQ Controller handoff, only one (1) Driver is required for Programming Skills Matches (although Teams may still have two (2) if desired).

- a. Pre-Match sensor calibration is considered part of the standard pre-Match setup time, i.e. the time when Teams would typically be turning on the Robot, moving any mechanisms to their desired legal start position, etc.

ROBOT EQUIPMENT

<R1> Robots must pass inspection. The Team’s Robot must pass inspection before being allowed to participate in any Matches. Noncompliance with any Robot design or construction rule may result in Disqualification of the Robot at an event.

- a. If significant changes are made to a Robot, it must be re-inspected before it will be allowed to participate in a Match.
- b. If a Robot has multiple functional configurations, all possible configurations must be inspected before being used in competition.
- c. Teams may be requested to submit to random inspections by event personnel during the event. Refusal to submit will result in Disqualification.
- d. Referees or inspectors may decide that a Robot is in violation of the rules. In this case, the Team in violation will be Disqualified and the Robot will be barred from the Field until it passes re-inspection.

<R2> One Robot per Team. Only one (1) Robot will be allowed to participate per Team in the Jr. Mobile Robotics Technology Competition. Though it is expected that Teams will make changes to their Robot at the event, a Team is limited to only one (1) Robot, and a given Robot may only be used by (1) Team. The VEX IQ system is intended to be a mobile robotics design platform. As such, a VEX IQ Challenge Robot, for the purposes of the VEX IQ Challenge, has the following subsystems:

Subsystem 1: Mobile robotic base including wheels, tracks, 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 VEX IQ legal battery, a VEX IQ control system, and associated Smart Motors for the mobile robotic base.

Subsystem 3: Additional mechanisms (and associated Smart Motors) that allow manipulation of Game Objects or navigation of Field obstacles.

Given the above definitions, a minimum Robot for use in Robot Skills Challenges must consist of subsystem 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 participate with one Robot while a second is being modified or assembled.
- b. Teams may not switch between multiple Robots. This includes using different Robots for Robot Skills Challenge Matches, Qualifying Matches, and/or Finals Matches.
- c. Multiple Teams may not use the same Robot during a competition or season. 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.
- 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.

- 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> N/A

<R4> Robots must fit in the sizing box. At the start of each Match, the Robot must be able to satisfy the following constraints:

- a. Only be contacting the Floor and/or the Field Perimeter.
- b. Fit within an 11" x 19" (279.4mm x 482.6mm) area, bounded by the Starting Position.
- c. Be no taller than 15" from the Floor.

This rule works in conjunction with <G4>. <R4> is an "inspection rule", meaning that a Robot may not pass inspection if it cannot satisfy these constraints. However, <G4> is a "game rule", meaning that even if a Robot passed <R4> in inspection (i.e. it is theoretically capable of satisfying the constraints), Head Referees will still be watching for it before each Match.

<R5> Max Robot size is 11" x 19". Robots must be demonstrably able to comply with the expansion rules set forth by <G5>.

- a. A Robot may not expand beyond an 11" x 19" horizontal area any at any point during the Match. This limit includes the full range of motion by any appendages. For example, an arm that extends out of these constraints while operating during the Match would make the Robot illegal.



Figure 21: A Robot which starts the Match with the legal size constraints.

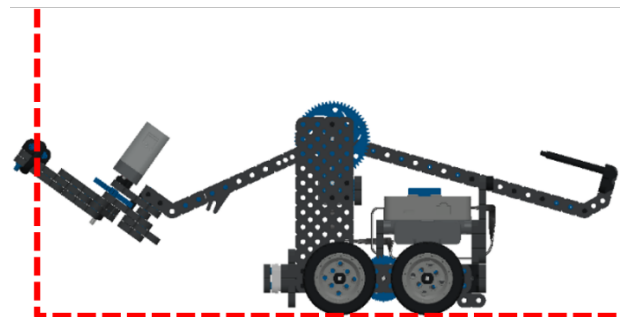


Figure 22: The Robot from Figure 21 which has expanded outside of the legal size constraints.

Note: The 11" x 19" horizontal limit is not restricted to the same configuration or relative position to the Robot as it was at the beginning of the Match, in its 11" x 19" Starting Position. For example, a Robot with mechanisms that can extend out of opposite sides of the Robot would be legal, so long as the Robot never exceeds 11" x 19" at any point during the Match. Teams who have the potential to violate this rule should be prepared to demonstrate how they will limit this motion during a Match.

- b. A Robot may not expand beyond a 15" (381mm) vertical limit at any point during the Match.

<R6> Robot starting configuration is the same as inspection configuration. The starting configuration of a Robot at the beginning of a Match must be the same as the Robot configuration that was inspected for compliance, and within the maximum allowed size.

- a. Teams using more than one Robot configuration at the beginning of Matches must tell the inspector(s) and have the Robot inspected in its largest configuration(s).
- b. A Team may NOT have its Robot inspected in one configuration and then place it in an uninspected configuration at the start of a Match.

<R7> VEX IQ parts only. Robots may be built ONLY from official robotic components from the VEX IQ product line, unless otherwise specifically noted within these rules.

- a. Official VEX IQ products are ONLY available from VEX Robotics & official VEX Resellers. To determine whether a product is “official” or not, consult www.vexiq.com.
- b. If an inspector or other event official questions whether something is an official VEX IQ component, the Team will be required to provide documentation to an Inspector that proves the component’s source. Such types of documentation could include receipts, part numbers, or other printed documentation.
- c. Only the VEX IQ components specifically designed for use in Robot construction are allowed. Using additional components outside their typical purpose is against the intent of the rule (i.e. please don’t try using VEX IQ apparel, team or event support materials, packaging, Field Elements, or other non-robot products on a VEX IQ Challenge Robot).
- d. Products from the VEX EDR or VEXpro product line cannot be used for Robot construction. Products from the VEX EDR product line that are also cross-listed as part of the VEX IQ product line are legal. A “cross-listed” product is one which can be found in both the VEX IQ and VEX EDR sections of the VEX Robotics website.
- e. Official components from the VEX IQ product line that have been discontinued are still legal for Robot use. If using a discontinued part, Teams must be cognizant of <R7a>.
- f. 3D printed components, such as replicas of legal VEX IQ parts or custom designs, are not legal for Robot use.

<R8> N/A

<R9> N/A

<R10> One Brain per Robot. Robots are limited to one (1) VEX IQ Robot Brain.

- a. Robot Brains, microcontrollers, or other electronic components that are part of the VEX Robotics by HEXBUG, VEX EDR, or VEXpro product lines are not allowed.
 - i. The Robot AA Battery Holder (228-3493) is the only exception to this rule, per <R12>.
- b. Robots must use one (1) VEX IQ 900 MHz radio, VEX IQ 2.4 GHz radio, or VEX IQ Smart Radio in conjunction with their VEX IQ Robot Brain.
- c. The only legal method of driving the Robot during Driving Skills Matches is the VEX IQ Controller.

<R11> Six motors per Robot. Robots may use up to six (6) VEX IQ Smart Motors.

- a. Additional motors cannot be used on the Robot (even ones that aren’t connected).

<R12> One battery pack per Robot. The only allowable sources of electrical power for a VEX IQ Challenge Robot is one (1) VEX IQ Robot Battery or six (6) AA batteries via the Robot AA Battery Holder (228-3493).

- a. Additional batteries cannot be used on the Robot (even ones that aren’t connected).
- b. Teams are permitted to have an external power source (such as a rechargeable battery pack) plugged into their VEX IQ Controller during a Match, provided that this power source is connected safely.

<R13> Parts may NOT be modified.

- a. Examples of modifications include, but are not limited to, bending, cutting, sanding, gluing, or melting.

<R14> Robots may not be dangerous. The following types of mechanisms and components are NOT allowed:

- a. Those that could potentially damage Field Elements or Game Objects.
- b. Those that could potentially damage other Robots.
- c. Those that pose an unnecessary risk of entanglement.

<R15> N/A

<R16> N/A

<R17> **Keep the Robot up to date.** Teams should make sure that their VEX IQ firmware (VEXos) is up to date. Teams can download the latest version of VEXos at www.vexiq.com/vexos.

<R18> **Teams will Re-Build from Kits for SkillsUSA NLSC.** Teams will not be permitted to bring any Robotic components to SkillsUSA NLSC. Each team will be provided the following kits and will be given time to build their Robot using only their Engineering Notebook for notes and assembly instructions that they have prepared. Only parts found in these kits will be permitted and teams must adhere to all rules including size constraints.

- a. VEX IQ Super Kit (228-2500)
- b. VEX IQ Foundation Add-On Kit (228-2531)
- c. VEX IQ Competition Add-On Kit (228-3600)

Note: These kits will be new and will require the teams to update all Firmware as part of the competition. Failure for Students to be able to update the Firmware and link the controller to the brain may result in Teams being unable to drive or program their Robot.

<R19> **Teams may use any programming language.** Teams must come to competition with a laptop for programming their Robot. The laptop must have the programming software already installed and licensed. Some programming software options can be found here.

<https://www.vexrobotics.com/vexiq/resources/programming>

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. Teams should not be able to insert entries between other entries. Leaving blank pages between entries defeats the purpose of being bound.

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)

- Using teeth as a tool (other than eating)
- Leaving equipment in aisles (creating trip hazards)

Note: Eye protection is not required in Junior Mobile Robotics Technology.

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 process cycle</u> 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, pictures, or goals.</u> | <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 solutions</u> to the challenge. | |
| | Select the best solution and plan | Explains why the solution was selected through testing and/or a decision matrix. Fully describes <u>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 could recreate the solution following the steps in the Notebook. | 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</u> multiple times 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 most of the information listed 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 <u>clearly explain all aspects of the design process</u> and how they recorded their use of the design process in the Notebook. | Students <u>can explain most aspects of the design process</u> and how they recorded their use of the process. | Students <u>can explain only limited aspects of the design process</u> and how they recorded their use of the process. | |
| Game strategies and robot designs | Students can describe <u>three or more game strategies</u> 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 <u>two game strategies</u> and robot designs that were considered; students can explain how and why the current game strategy or robot design were chosen. | Students can describe <u>only their current game strategy</u> 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 <u>how team progress was tracked against an overall project timeline</u> , and how students were assigned to tasks based on their skills and availability; students can explain management of material resources. | Students can explain <u>how team progress was monitored</u> , or how students were assigned to tasks, or management of material resources. | Students <u>cannot explain how team progress was monitored</u> or how students were assigned to tasks or how material resources were managed. | |
| Teamwork and communication | Students can explain how <u>multiple team members contributed</u> to the robot design and game strategy. All students answer questions independently. | Students can explain how <u>most team members contributed</u> to the robot design and game strategy. Students support each other as needed to answer questions. | Only <u>one team member answered</u> questions or contributed to the robot design process. | |
| Respect and courtesy | Students answer respectfully and courteously. Students <u>make sure each team member contributes</u> . Students wait to speak until others have finished. | Students answer respectfully and courteously. Some <u>students attempt to contribute</u> but are interrupted by other students. | Students <u>do not answer respectfully</u> 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 programming 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 programmed 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 programmed.

| 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

(2-minute matches)



Team Number _____

Highest Score _____

Trial 1

Number of Balls Scored

Inside of a Cube _____ x 1 = _____

On top of a Cube _____ x 2 = _____

Number of Cubes Scored

In Corner Goals _____ x 10 = _____

On Platforms _____ x 20 = _____

Trial 1 Total Score _____ (maximum of 100 points)

Trial 2

Number of Balls Scored

Inside of a Cube _____ x 1 = _____

On top of a Cube _____ x 2 = _____

Number of Cubes Scored

In Corner Goals _____ x 10 = _____

On Platforms _____ x 20 = _____

Trial 2 Total Score _____ (maximum of 100 points)

Trial 3

Number of Balls Scored

Inside of a Cube _____ x 1 = _____

On top of a Cube _____ x 2 = _____

Number of Cubes Scored

In Corner Goals _____ x 10 = _____

On Platforms _____ x 20 = _____

Trial 3 Total Score _____ (maximum of 100 points)

Driving Skills Matches

(2-minute matches)



Team Number _____

Highest Score _____

Trial 1

Number of Balls Scored

Inside of a Cube _____ x 1 = _____

On top of a Cube _____ x 2 = _____

Number of Cubes Scored

In Corner Goals _____ x 10 = _____

On Platforms _____ x 20 = _____

Trial 1 Total Score _____ (maximum of 150 points)

Trial 2

Number of Balls Scored

Inside of a Cube _____ x 1 = _____

On top of a Cube _____ x 2 = _____

Number of Cubes Scored

In Corner Goals _____ x 10 = _____

On Platforms _____ x 20 = _____

Trial 2 Total Score _____ (maximum of 150 points)

Trial 3

Number of Balls Scored

Inside of a Cube _____ x 1 = _____

On top of a Cube _____ x 2 = _____

Number of Cubes Scored

In Corner Goals _____ x 10 = _____

On Platforms _____ x 20 = _____

Trial 3 Total Score _____ (maximum of 150 points)

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