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2022 BEST Robotics
Classic Competition Rules

V1.0 6 August 2022

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Section 1 General Rules

1.1 Overview

This is a student-oriented contest. The students will gain the most if they do the work. Mentors and coaches are to provide guidance only and not to make parts, detail design, nor force their will on the students.

The rules governing the BEST competition consist of the following:

1. Section 1 BEST General Rules
2. Section 2.1 Returnable Kit List
3. Section 2.2 Consumable Kit List
4. Section 3 Game Specific Rules (may supersede Generic Rules)
5. On-line Question and Answer (Q&A) system

Most questions about the game can be answered by first READING THE RULES THOROUGHLY. All questions concerning these rules (during the 8-week design and construction phase, not during the competition) must be submitted to the Game Committee in writing through the web-based interface at https://game.bestrobotics.org/qna (or through your Team Workflow page). All questions and answers will be distributed to all teams via the web. Responses to the posted questions on the web site are an extension of the rules. In the event of contradiction between the rules and the Q&A responses, the Q&A responses supersede the rules.

1.2 Safety

Safety may not and will not be compromised.

1. Safety is a priority.

2. The referees will disqualify any machine that appears to be a safety hazard.

3. Batteries, chargers, and other components of the BEST Control System Kit may not be tampered with or altered in any way.

4. Except for a power drill/driver and a soldering iron/gun (electrically powered only), no power tools (including battery operated) will be allowed in the pit area during any BEST activity. Common hand tools will be allowed. The power drill/driver may be used for drilling and/or hardware insertion/removal, but not for grinding, sawing, routing, etc. The allowed power tools can be operated only in the pit area or in the hub designated workstation area.

5. All individuals working on the machine in the pit area must wear safety gear appropriate to the activity (e.g., safety glasses should be used when soldering or drilling).

6. Any illegal tools may be confiscated for the day.

1.3 Robot Design Constraints

1.3.1 Material Constraints

Each team receives two kits: a Returnable Kit and a Consumable Kit. Each machine must be constructed using only the materials that appear on the returnable and consumable kit lists (provided in Section 2). Exceptions to this rule are described in section 1.3.2.3 **.**

The Returnable Kit List and Consumable Kit List are the official references for parts; therefore, they define the type and quantity of parts that can legally be used on the machine. The team is responsible for confirming that items in the received kits are consistent with the items on the lists and include no excess parts. Excess parts may not be used.

1.3.2 Construction Requirements

1. All robot construction is to occur after the hub Game Kickoff event has been held. There should be no part construction prior to the Game Kickoff event nor reuse of parts from previous competitions. Robot parts may be permanently marked (via scribing, drilling holes, etc.) by BEST personnel to prevent reuse.

2. There are no restrictions on the tools or machines that are used to create parts; however, there is still the expectation that students will be taught how to use these tools/machines and that they will be the ones using and operating them in the fabrication of the parts.

3. The VEX Cortex microcontroller and battery must be secured to the robot. The Cortex microcontroller must be mounted to your robot through the holes provided on its base (suggest using #8 machine screws to avoid damaging the Cortex).

1.3.2.1 Returnable Kit

1. All Returnable Kit items, including boxes and packing, **must be returned** at the conclusion of the contest in the same condition as received except as noted in item 2 below.

2. Returnable Kit equipment cannot be modified in any way, with the following exceptions:

    a. The belt stock supplied in the returnable kit may be modified as needed (e.g., cut, holes punched, etc.); however, the belt that is provided as loop may not be modified.

    b. Servo horns may be modified as desired.

c. BEST IR Sensor Kit may be assembled.

3. The Returnable Kit List specifies certain items that may not be attached to the machine (e.g., the battery chargers).

4. The motors and servos may not be opened for any reason. For example, it is illegal to change the gearing or to re-wind the armature of any motors.

5. The pulleys, bearings, and shoulder screw included in the return kit may not be modified. You may not use any glue or adhesive tape on these items.

6. Tape/adhesive/glue may not be applied to any returnable item unless specifically allowed (see Section 1.3.2.3). The adhesive portion of the supplied Velcro™ brand hook and loop fastener may not be attached to the battery or to any other returnable item.

7. Paint may not be applied to any Returnable Kit item.

8. The VEXnet Joystick, servos, VEX Cortex microcontroller, VEXnet Keys, batteries, and battery chargers may not be tampered with, modified, or adjusted in any way. The only exception is that the VEX Cortex microcontroller may be programmed as desired.

9. Teams may not put labels or rubber bands on the VEXnet Joystick, nor make internal, reversible modifications to the joysticks.

10. Wires may be soldered to the motor power lugs.

11. Only the motor controllers or the servo power adapter cables may be plugged directly into the VEX Cortex microcontroller motor ports. Motor ports 1 and 10 cannot be used (do not plug the screw terminal motor interface cables into these ports). Only the screw terminal sensor interface cables or the cables from the BEST IR Sensor Kit may be plugged directly into the VEX Cortex microcontroller digital/analog input/output ports. No other connection methods to the Cortex may be used. Soldering to the Cortex microcontroller or to any of the interfacing cables is not allowed.

12. The BEST-supplied 7.2 Volt NiMH 3000maH batteries are the only allowed source of electrical power for the functional components of your entire machine.

13. The 7.2 Volt batteries may **only** be connected to the VEX Cortex microcontroller through the supplied mating connectors. Do not attempt to connect the 7.2 Volt batteries to any other Cortex input other than the battery connector. Do not attempt to connect the 7.2 Volt batteries to any item/circuit other than the Cortex microcontroller.

14. Only one 7.2 Volt battery may be used on the machine during a match. Even if unconnected, the other battery may not be on the machine.

15. On Game Day, replacement batteries will only be provided upon proof of battery failure (e.g., a bad connection) on an exchange basis (you must turn in the faulty battery).

16. You must play all your Game Day matches using the 7.2 Volt batteries supplied by BEST. Team owned batteries (that power the robot) and team-owned battery chargers for the 7.2V batteries

are not allowed on the field or in the pit area on Game Day; however, team-owned batteries are allowed during other BEST activities.

17. You may use the provided AAA rechargeable batteries or team provided batteries in the VEX Joystick.

1.3.2.2 Consumable Kit

1. Consumable Kit parts may be modified as desired within the constraints of these rules.

2. Limited numbers of replacement parts may be available from your local hub, upon a justified request. Otherwise, lost or damaged kit material may only be replaced with identical components. Replacement parts purchased by the team must have the same:

    a. material as the kit part;

    b. treatment or grade as the kit part; and;

    c. dimensions as the kit part.

    e.g. a 1x4 may **not** be replaced with a 2x4 of the same total volume.

3. The Consumable Kit list identifies optional items that may be provided by the team and used on the machine.

4. Team supplied pennies may not be altered.

5. The only Consumable Kit items that may be used to conduct electricity are the provided wire, the snap-plug terminals or the (optional) quick-disconnect terminals (and also soldering material at the wiring connections). The only exception is that any of the Consumable Kit provided/allowed metallic materials may be used as part of a sensor circuit.

6. No package materials may be used (materials that come with kit items to protect or store them before use). Examples: The plastic film that covers the adhesive portion on the hook and loop strip; cardboard roll at the center of a tape roll.

1.3.2.3 Additional Materials, Constraints and Exceptions

1. Lubricants may be used for lubrication only. A machine may not intentionally contaminate the playing field or an opponent's machine with lubricant.

2. Paint, finish, and/or decals may be used on the robot as described. They cannot be applied to any of the returnable items. Paint or finish cannot be used to change the mechanical properties of what it is applied to. The optical properties (color and reflectivity) of the paint/finish/decals may be used in a functional manner on the robot.

3. Other non-functional decorations are only permitted if they do not aid the machine in performing the game tasks. If you can remove it or cover it up (and you may be asked to) and your machine behaves the same, it is probably non-functional. Lights can be added to the machine, but no strobe lights are allowed.

4. Video capture devices (like a GoPro or a phone) are allowed on the robot subject to the rules for decorations and with the additional rules listed below:

    a. display screen cannot exceed 6” diagonal

    b. display must be turned off or covered up

    c. non-BEST kit mounting brackets/hardware are considered to be a part of the device

    d. recommend that device be protected from possible contact with field or other robots (BEST not responsible for any damage that occurs to the device during game play)

    e. device cannot be transmitting a signal (no streaming)

    f. BEST officials may ask for the device to be removed at any time for any reason

5. Non-functional decorations may use a separate power source (e.g., 9V battery).

6. The use of markers/paint/printouts may be used to provide visual information that does not aid the team in performing the game tasks. Examples of what is allowed would be things such as labeling machine parts with a marker, placing a copy of the Cortex port use schematic on the machine, and so on.

7. You may solder electrical wire connections using your own solder except where electrical connectors are provided. Where connectors have been provided (i.e., on the VEX Cortex microcontroller, servo power adapter cables, servo extension wires, batteries and other returnable items), they must be used without soldering to the connector. Solder may be applied to connectors included in the Consumable Kit (e.g., bullet connectors or quick-disconnect connectors).

8. No welding, brazing or structural soldering is allowed.

9. Metal, rubber, and plastic items may be heated and reformed, but may not be melted and re cast.

10. Materials may not be changed chemically. The exceptions are that strings and the outer sheath of the shock cord may be singed to prevent loose ends and that kit allowed resin and hardener may be mixed to result in epoxy.

11. Residue-free “painters” tape (supplied in the Consumable Kit) may be used on any Returnable Kit items except the Joystick.

12. Thread locker may be used on Consumable Kit fasteners.

1.3.2.4 Team Custom Parts

Two Team Custom Parts (TCP) are allowed.

1. Each part can be made from any uniform (homogeneous) team supplied material.

2. Each part must be able to fit, unconstrained, into a 2” x 4” x 4” cuboid.

3. Each part must be a single continuous piece of material (when in its operational state).

4. The basic raw stock form of the chosen material must be used for the part. The starting raw stock must be rectangular or cylindrical material if the final part retains any of the original raw stock shape. Material starting shape is irrelevant for parts that are in a liquid state in the forming process or if the final part is completely carved/machined from a solid block of the material.

5. No other kit parts may be embedded in a TCP.

6. No hazardous materials are allowed (rule 1.2 item 2 still applies).

7. No welding is allowed (rule 1.3.2.3 item 8 still applies).

8. Melting is allowed (rule 1.3.2.3 item 9 is waived).

9. Chemical change is allowed (rule 1.3.2.3 item 10 is waived).

1.3.3 Size

1. At the start of each match, the machine must fit, **unconstrained**, within a cubic space that is 24 inches on a side (machine can be powered on during this check). The machine must remain within the maximum size limit, unconstrained, until the beginning of the match.

2. Once the match begins, the machine may unfold and change size through its own power.

3. There is no size requirement at the end of the match (i.e., the machine does not have to return to its initial configuration).

1.3.4 Weight

1. The weight of the machine may not exceed 24 pounds, including the battery and all parts and devices of your machine (e.g., detachable pieces, optional equipment, tethered parts, decorative items, etc.).

1.3.5 Energy Sources

1. The energy used by the machine must come solely from:

    a. electrical energy derived from the single onboard battery pack;

b. storage achieved by the deformation of the springs provided in the kit or springs created per the Team Custom Part rules;

c. a change in the altitude of the center of gravity of any part of the machine; and/or;

d. stretched items (inner tube/rubber bands/shock cord/TCP) are allowed provided that the part is attached to the machine so that it will not fly off if broken

1.3.6 Compliance

1. All machines will be inspected for compliance with the regulations before the competition. Machines must meet these regulations to qualify for the competition. The winning machines may be inspected again following the competition. Failure to comply with the regulations will result in disqualification.

2. No substitute machines are allowed. Machines may be modified between matches but must still meet all the regulations after the modifications are made. The compliance official must approve all modifications prior to the team's next match of competition.

3. Random re-checks of machines will be performed throughout the day at the discretion of the referees. Any machine found to be non-compliant will not be allowed to continue the competition until brought into compliance and may be disqualified from prior matches.

4. The machines may not leave the competition site between the time they are checked for compliance and the start of the competition without approval from the competition officials.

5. Teams that place high enough to advance to a regional/national championship are allowed to make repairs and/or functional improvements to their machine. Machines will be rechecked for compliance prior to the regional/national championship competition.

6. A machine may have multiple configurations, like different arms that can be swapped out. Each configuration must meet size and weight requirements independently and be approved through a compliance check. The sum total of all parts and materials from all of the configurations cannot exceed the quantities defined by the Returnable and Consumable Kit Lists.

1.3.7 General

1. Machines must be designed to operate by reacting only against the surfaces of the playing field (including the PVC pipes, ramps, etc.), the opponents' machines, and the air. Machines are allowed to clamp to anything in the field except another machine.

2. During a match, the machine may only be controlled through normal operation of the VEXnet system. Touching the robot (except as allowed by the Game Specific Rules) will result in penalty or disqualification as described in section 1.4.3 .

3. No external devices may be connected to the joystick during match play unless specifically provided by BEST competition personnel (things such as an auxiliary power supply or a channel shifting dongle).

4. Machines must prominently display their team number.

5. Powered tandem devices are permitted and may use an umbilical to connect the two devices. This umbilical is considered part of the machine and is subject to the same constraints as the rest of the machine.

6. All projectiles must have a frontal area greater than 10 square inches. A projectile is anything launched through the air, whether free flying or tethered. Parts that detach or fall from a machine and remain on the playing surface are not considered projectiles.

7. Gaining traction or gripping game pieces through the use of adhesives, or by abrading or breaking the surface of the field is not allowed. The friction tape (either side) from the Consumable Kit is not considered an adhesive and is allowed (actually intended) for gripping.

8. Spiked wheels are allowed only if the portion of the spike in contact with the field has at least one dimension greater than ¼ inch.

9. Strategies aimed only at destruction, damage (e.g., stabbing, cutting, etc.), over-turning, or entanglement of an opponent's machine are not in the spirit of the competition and are not allowed. Turning over an opponent's machine may or may not result in a penalty depending on the opinion of the referees. Review section 1.4.3 for a description of penalties for overly aggressive actions.

10. Machines may deploy detachable components on the field. A component is considered “detached” if it has no kit parts connecting it, directly or indirectly, to the set of kit parts that includes the battery. Such components may be used to capture, contain, manipulate game pieces, and/or block another machine. Such components may not be launched at, deliberately attached to, or otherwise deliberately used to entangle another machine. Incidental contact between any machine and such detachable components after deployment will not result in a penalty for any team. Detached components will not count as “part of the machine” unless otherwise stated.

11. Following the competition, all items provided in the Returnable Kit must be returned to the hub (local BEST organization). The rest of the machine may be retained by its respective school.

1.4 Head-to-Head Competition Rules

1.4.1 General

1. Referees have ultimate authority during the competition. No protests will be allowed.

2. On Game Day there will be individuals identified as Team Advocates to answer questions about the game or rules. Do not approach referees, scorekeepers, or other officials with questions.

3. A referee, at their discretion, may untangle machines that become entangled with part of the field, or each other, for more than 10 seconds or that may appear to be damaging the field because of the entanglement. A machine that is high-centered on an element of the field or on a game piece is not considered entangled. A machine that has tipped over is not considered entangled. A referee may ask the driver to quit attempting to free their machine if the field is at

risk of being damaged.

1.4.2 Field Colors

Specific team locations on the field (e.g., driver/spotter locations, robot starting area, allowed team maneuvering areas, team scoring areas, etc.) are designated through the following four-color scheme.

Bright Red	Bright Green
	Bright Yellow

1.4.3 Drivers and Spotters

1. During a match, only one student member of each team is allowed in the team driver's area and one student member is allowed in the team spotter's area. Adult coaches and teachers are not allowed in either of the areas during matches. Students are not allowed to stand on platforms of their own construction (or each other) to get a better view. A hub may, on a case-by-case basis, make unique provisions for special needs drivers/spotters as deemed appropriate.

2. Only one person per match is allowed to drive the machine (i.e., operate the VEXnet Joystick). Prior to the competition, each team must submit a driver list to the organizers. The minimum number of student team members on the driver list is shown in the following table:

Student team members **present** at competition	**Minimum** number of students on driver list
2-4	2
5-6	3
7-8	4
9 or more	5

Please note that the previous table reflects the minimum number of drivers required;

BEST encourages participation by as many team members as possible. Also note that the number of student team members present at the competition is used to determine the minimum number of drivers on the list.

3. The first person on the driver list is the driver for the first match; the second person on the list is the driver for the second match, etc. This rotation will continue for successive matches until the list is exhausted, at which time the rotation will start again at the top of the list. Rotation in successive phases of the competition (e.g., seeding, semi-finals, and finals) will begin where the previous phase rotation left off. If the organizers eliminate a match for any reason, the driver rotation will continue in accordance with the driver list with the driver scheduled for the eliminated match (or matches) being the first driver for the following match.

4. The spotter may be any student from the team.

5. Spotters and drivers are not allowed to handle the game pieces prior to a match.

6. During a match, spotters and drivers may not communicate with anyone through any electronic devices or other signaling technique that involves a signaling aid that is not part of the human body (e.g., signs, sticks, marked gloves, etc. are not allowed).

1.4.4 Penalties

1. A 20-second suspension may be assessed for a variety of infractions that are detailed below and in section 3.5.2 of this document. This penalty requires the driver to surrender their VEXnet Joystick to a referee for a period of 20 seconds. The referee will return the joystick to the driver upon expiration of the penalty and the machine may continue the match. Penalty decisions of the referees will be final.

2. If a driver touches their own machine before any part of it has left the starting area, a 20-second penalty will be assessed after contact ceases. Machine contact within the starting area is allowed only for the purpose of debugging a defective machine (e.g., turning on the on/off switch). If a spotter or driver otherwise touches their own or another team's machine, the machine of the individual doing the touching will be disqualified.

3. Spotters and drivers are not allowed to enter the field during a match. If a spotter or driver enters the field during a match, their machine will be disqualified.

4. If a spotter or driver leaves the designated spotter or driver area, a 20-second penalty will be assessed as described in item 1 of this section.

5. Machines that touch the ground outside the field boundary will be assessed a 20- second penalty as described in item 1 of this section. Machines that completely leave the field will be stopped for the duration of the match.

6. Damaging any portion of the field or game pieces may result in disqualification. Intentionally moving or tipping over static portions of the field is considered damaging the field and will result in disqualification.

7. Referees may instruct the driver of an aggressive machine to cease an action if the referee feels that another machine or the field may be damaged by that action. Referees will disqualify a team from a match if a major breach of the rules occurs.

8. Disqualification is on a match basis, except for non-complaint machines as noted in Section 1.3.6 . Any team that is disqualified will receive zero points for that match.

1.4.5 Match Protocol

1. There will be at least five referees during each match. The Head Referee will act as timekeeper and the other four referees will monitor each of the teams.

2. Each match will be three minutes long and will be played with a minimum of two teams or four teams, depending on the field configuration in use (2-team or 4-team). The scoring software will assign teams to a match and will determine the team's quadrant/color for each match.

3. Teams will be notified of their field and position assignment at least two minutes before the match. Teams must be in the staging area at the end of the preceding match.

4. Prior to the beginning of the match, teams must wait at the designated staging area until the beginning of the setup period. Once signaled, teams have the duration of the setup period to place their robot into a valid starting position.

5. As a guide, a maximum setup time of 30 seconds will be allowed once the team arrives at the field. If a team has not successfully placed their robot by the end of the setup period, the head referee has discretion to allow the team to continue to place their robot and assess a 20-second

penalty to be applied at the beginning of the match or whenever the team is ready to begin play.

6. At the start of each match, the machine must be placed at the designated starting area. The spotter or driver may enter the field prior to the start of the match to place the machine in its starting location and prepare it for the match. Temporary alignment marks on the field are not permitted. Additional team members may be allowed to assist in setting up the machine but must leave the field area prior to the start of the match.

7. The machine, driver and spotter must be in the designated location(s) at the start of the match to score any points during the match. The driver and spotter must remain in the designated areas during the match.

8. A maximum of 30 seconds will be allowed at the end of each match for removal of the machines. Additional team members may be allowed to assist in removing the machine.

9. At the end of the match, the driver and spotter must remain in the designated areas until referees have completed scoring of the match and indicated that robots may be removed.

10. Following the match, the referee will review the scored items with the driver; the driver will sign the scorecard indicating agreement.

1.4.6 Competition Protocol

There will be four phases to the head-to-head competition:

- a seeding phase,
- a wildcard phase,
- a semi-final phase, and
- a finals phase.

This protocol will be the same for both hub contests and championships.

Section 3 Game Specific Rules defines any tiebreakers for determining which team advances from one phase to another in the event of a tie. If no tiebreaker is identified, the default method will be 1) Engineering Notebook scores, 2) head-to-head match results, 3) Coin toss, in that order.

1.4.6.1 Field Configuration Options

There are two field configuration options for the 2022 season: two-team field or four-team field. The hub will select the configuration they desire to implement for their event.

Competition protocol will remain the same for both with the following modifications. The two team field will be color-coded such that each team area represents two colors, Blue/Red and Green/Yellow for the purposes of scheduling matches and scoring. For a two-team field

configuration, teams assigned to Blue and Green team areas will play first, followed by teams assigned to Red and Yellow team areas. A single match will be complete, and scores updated when four teams (all four colors) have competed. Schedules, scorecards, and spectator displays will be identical to a four-team configuration.

1.4.6.2 Seeding Phase

The Seeding Phase will consist of a round robin competition among all participating teams. Each team will participate in up to eight matches against randomly selected opponents. Fewer than eight matches per team may be played when time limitations exist, but no fewer than five matches. All teams will participate in the same number of matches. Match scheduling will attempt to ensure that each team plays on each quadrant of the field and that back-to-back matches are limited.

The team ranking during this phase will be based on the average of the points scored during the seeding matches excluding the teams' lowest match score. Consult Section 3 Game Specific Rules for any variation to this ranking method.

For competitions with 32 or fewer teams, the top 7 teams from the seeding phase will automatically advance to the semi-finals phase. The final team to advance into the semi-finals phase will be selected from the remaining teams during the "Wildcard Phase".

For competitions with greater than 32 teams, the top 14 teams from the seeding phase will automatically advance to the semi-finals phase. The final two teams to advance into the semi finals phase will be selected from the remaining teams during the "Wildcard Phase".

1.4.6.3 Wildcard Phase

For competitions with 32 or fewer teams, the wildcard phase will consist of a single match

between the four (4) teams with the highest BEST Engineering Notebook scores, who have not automatically advanced to the semi-final phase. The team achieving the highest score during the wildcard phase will advance to the semi-finals.

For competitions with greater than 32 teams, the wildcard phase will consist of two matches between the eight (8) teams with the highest BEST Engineering Notebook scores who have not automatically advanced to the semi-final phase. This phase will consist of 2 matches of 4 teams (as all matches are limited to 4 teams), which may be played in parallel. The two (2) teams achieving the highest scores during the wildcard phase will advance to the semi-finals.

The wildcard phase will be conducted according to the rules for the seeding phase. Each wildcard team will play in only one match during this phase.

1.4.6.4 Semi-Finals Phase

During the semi-finals phase, each team will participate in three (3) matches based on the rotation shown in Table 1 or 2. The team ranking at the end of the semi-finals will be based on the total points each team accumulated during their three matches. No scores will be dropped and the scores from all previous phases will be disregarded. Game play will be the same as previously described for the seeding phase. Only the top four (4) ranked teams from the semi finals phase will advance to the finals, regardless of the number of teams competing in the semi finals.

Table 1. Field Position Assignments for 8-team Semi-Finals

Semi-Final Match	Field Position Assignment			
	Yellow	Blue	Red	Green
1	Seed 4	Seed 6	Seed 3	Seed 2
2	Seed 7	Seed 1	Seed 5	Seed 8
3	Seed 3	Seed 7	Seed 8	Seed 4
4	Seed 6	Seed 5	Seed 2	Seed 1
5	Seed 5	Seed 3	Seed 6	Seed 7
6	Seed 8	Seed 2	Seed 1	Seed 4

Table 2. Field Position Assignments for 16-team Semi-Finals

Semi-Final Match	Field Position Assignment			
	Yellow	Blue	Red	Green
1	Seed 4	Seed 13	Seed 1	Seed 16
2	Seed 5	Seed 10	Seed 3	Seed 15

3	Seed 6	Seed 9	Seed 8	Seed 11
4	Seed 16	Seed 4	Seed 2	Seed 14
5	Seed 8	Seed 5	Seed 6	Seed 12
6	Seed 7	Seed 11	Seed 9	Seed 10
7	Seed 3	Seed 14	Seed 13	Seed 2
8	Seed 10	Seed 12	Seed 5	Seed 1
9	Seed 15	Seed 6	Seed 16	Seed 7
10	Seed 14	Seed 8	Seed 11	Seed 13
11	Seed 1	Seed 7	Seed 4	Seed 3
12	Seed 2	Seed 15	Seed 12	Seed 9

1.4.6.5 Finals Phase

The four (4) top ranked teams will participate in three (3) matches during the finals phase. Field assignments per match will rotate as shown in Table 3. The final team ranking will be based on the total points accumulated by the team during these 3 finals matches. No scores will be dropped and the scores from all previous phases will be disregarded. Game play is the same as previously described for the seeding phase. The winner is the team with the most points accumulated during the three final matches.

Table 3. Field Position Assignments for Finals

Finals Match	Field Position Assignment			
	Yellow	Blue	Red	Green
1	Semi-Final 1	Semi-Final 2	Semi-Final 3	Semi-Final 4
2	Semi-Final 4	Semi-Final 3	Semi-Final 2	Semi-Final 1
3	Semi-Final 3	Semi-Final 1	Semi-Final 4	Semi-Final 2

1.5 Other Rules

1. Student eligibility is left to each individual school.

2. All contestants on the gym floor must wear shoes appropriate to the gym floor surface as determined by the sponsoring BEST organization.

3. Each team will be provided with their own workspace in the pit area in which they may place a table with a surface area no greater than 2400 square inches if a table is not provided by the hub. Each team will have access to one electrical plug for battery charging. The exact specifications and location may vary from hub to hub.

4. Each team may bring a toolbox with basic hand-tools subject to the safety constraints listed in Section 1.2 . If a part is broken during competition and the team cannot repair it with tools or material they have, consult the sponsoring BEST organization. They will make their best effort to help the team replace the part, given local shop and/or spare material availability.

5. At least one practice day will be available preceding Game Day. Consult the sponsoring BEST organization for times and locations. Tables and electricity will be available on a shared basis and teams must provide their own tools. The same safety rules apply to practice days as they do during Game Day.

Section 2 Official Kit Contents

The official BEST Kit Lists are shown on the following pages. Refer to section 1.3.1 for details regarding Kit constraints and usage. Each machine must be constructed using only the materials (quantity, type and grade) that are on the returnable and consumable kit lists. The ONLY exceptions are described in Section 1.3.2.3 .

2.1 Returnable Kit

2022 BEST Returnable Kit List

	Qty	Item Description	Required/ Optional	Source
	1	Cortex Microcontroller	Req'd[3]	VEX Robo
	1	VEXnet Joystick	Req'd	VEX Robo
	2	VEXnet Key 2.0	Req'd	VEX Robo
	4	Motor Controller 7.2V 4A	Req'd	VEX Robo

	2	Large Motor	Req'd	VEX Robo
	2	Small Motor	Req'd	VEX Robo
	2	7.2 V 3000 mAhr NiMH battery – modified w/ PowerPoles	Req'd[1]	VEX Robotics/C r
	2	Charger Adapter (for Cortex and Battery Charger)	Req'd[2,3]	None - Hu Assy Reqd
	8	Screw Terminal Sensor Interface Cable 3-wire	Req'd[4]	VEX Robo
	4	Screw Terminal Motor Interface Cable (red and black wires)	Req'd	VEX Robo
	4	Servo Power Adapter Cable	Req'd	VEX Robo
	1	Smart Battery Charger & power cord	Req'd[2,3]	VEX Robotics/C r
	1	8-bay AAA Smart Battery Charger & power cord	Req'd[2]	VEX Robotics/C r
	6	AAA NiMH Rechargeable Batteries (installed in Joystick)	Req'd	VEX Robotics/C r
	1	USB A-A Cable	Req'd[2]	VEX Robotics/C r

	Qty	Item Description	Required/ Optional	Source
	4	Futaba 3003/3004 or HiTec HS-422/HS-425BB Servos	Req'd	various
	4	servo horn screw	Req'd	various
	5	Servo horn (radius not to exceed 1”)	Req'd	various
	2	24" servo extension cable (600 mm also allowed)	Req'd	various
	2	40" servo extension wire (36" or 1000 mm also allowed)	Req'd	various
	16	rubber grommet	Opt[5]	various
	16	brass spacer	Opt[5]	various

	16	servo mounting screw	Opt[5]	various
	1	1/4" bore, 24 tooth, (small) drive pulley	Req'd	VEX Robo
	1	1/4" bore, idler (dia. to match 24 tooth pulley)	Req'd	VEX Robo
	1	1/4" bore 120 tooth, (large) drive pulley	Req'd	VEX Robo
	1	170 tooth, 3 mm pitch, 9 mm wide HTD loop belt	Req'd	VEX Robotics/ Other
	1	3 mm pitch, 9 mm wide HTD strip belt, 3 ft long	Req'd	VEX Robotics/ Other
	1	1/4" dia. shoulder screw w/ #10-32 thread	Req'd	VEX Robotics/ Other
	1	76mm roller blade wheel (78A to 82A) w/ bearings and 6mm spacer	Req'd	VEX Robotics/ Other
	1	6mm roller blade wheel axle (any style)	Req'd	VEX Robotics/ Other
	4	R4AZZ Ball Bearing (0.25 ID x 0.75 OD x 0.28 wide)	Req'd	VEX Robotics/ Other

	Qty	Item Description	Required/ Optional	Source
	1	spare (replacement) servo horn screw	Req'd	various
	2	BEST IR Sensor Kit (1 assembled)	Req'd	BEST Robo
	3	6" servo extension cable (150mm, 8" or 200mm also allowed)	Req'd	various
	3	24" servo extension cable (600 mm also allowed)*	Req'd	various
	1	18" (or less) USB extension cable (between Cortex and VEXnet key)	Opt[5]	various
	1	VEX Programming Hardware Kit	Opt[2,5]	VEX Robo
	2	Metal wheel hubs (1.5" max dia, 0.5" max thk,	Req'd	VEX

		0.250” bore, with set screw)		Robotics/ Other
	2	window alarm sensor	Req'd	McMaster-r
	2	1/4" shaft coupler, with set screws	Req'd	ServoCity
	any	containers, bags, boxes	Req'd[2]	Hub Suppl

Notes: [1] Only one battery can be used on the robot at any given time.

[2] These items cannot be used on the robot.

[3] Cortex and battery charger may be converted (by the Hub only) to PowerPole connectors, eliminating the need for the adapters. [4] Up to (6) of the three wire sensor interface cables (VEX P/N 276-3071) may be sub’d with old style two-wire sensor cables (VEX P/N 276-1734). A total of (8) sensor interface cables are required.

[5] Teams may use these Returnable Kit optional items even if they are not supplied by their Hub.

[*] Any shroud protecting the male pins must be removed (so it can be plugged into Cortex).

2.2 Consumables Kit

2021 BEST Consumable Kit List (provided by the hub)

Type	Qty	Item Description
	1 meter	Energy Chain, P/N E2-15-20-028-0, w/ 2 each mount brackets (P/N E2.150.20
	2 ea	DryLin® N Linear Guide system, P/N NK01-27-2-450
	6 ea	igubal® Flange Mount Spherical Bearing, 1/4", P/N EFOI-04
	6 ea	igubal® Pillow Block Mount Spherical Bearing, 1/4", P/N KSTI-04
	6 ea	iglide® G300 Flanged Bushing, 1/4", P/N GFI-0405-06
	6 ea	igubal® 1/4" Rod End Bearing, 1/4"-28 Thread, P/N EBRI-04
	2 ea	DryLin® S, 1/4" diameter, hard anodized Aluminum Shaft, P/N AWI-04, 18 incl
	1 ea	1/4" thick polypropylene sheet, 12" x 24"
	1 ea	1/8" thick PVC Type 1 sheet 12" x 24"
	1 ea	0.5" thick x 2" wide 6061-T6 aluminum flat, 12" long
	1 ea	0.063" thick 5052-H32 aluminum sheet, 12" x 12"

	2 ea	0.25" diameter AISI 1018 steel round, 24" long
	4 ea	piano wire, 0.063" diameter, 12" long
	1 ea	5/16" to 3/8" thick 2' x 4' plywood, any grade
	1 ea	3/16" to 1/4" thick 2' x 4' plywood, any grade
	2 ea	1" x 4" (nominal) #2 whitewood, 2 ft long
	1 ea	1/4" dia. oak dowel, 3 ft long
	1 ea	1/2” schedule 40 PVC pipe, 5 ft long
	2 ea	3/4" schedule 40 PVC pipe, 5 ft long
	1 ea	1" schedule 40 PVC pipe, 5 ft long

	10 ea	3/4" PVC 90 degree elbow (slip)
	10 ea	3/4" PVC tee (slip)
	1 ea	PVC cement, 4 oz or 8 oz
	4 ea	2.5" x 5/8" steel ZN, corner angle bracket
	4 ea	2" x 3/8" steel ZN, flat angle bracket
	2 ea	2.5"H x 1.75"W x 0.055" narrow hinge w/removable pin
	2 ea	1.5"H x 1-3/8"W x 0.05" narrow hinge w/nonremovable pin & 4 screws
	1 ea	3/4" metal pipe hanger tape, 28 gauge, 10 ft long
	12 ft	18 gauge stranded copper wire, red insulation, single conductor
	12 ft	18 gauge stranded copper wire, black insulation, single conductor
	12 ft	CAT3 24 gauge, 4 twisted pairs of conductor wire
	16 ea	snap-plug terminals (bullet connectors), insulated, male (optional*)
	16 ea	snap-plug terminals (socket for bullet connectors), insulated, female (optional*)
	20 ea	quick-disconnect terminal, insulated, female, ~1/8" wide (optional*)
	10 ea	quick-disconnect terminal, insulated, female, ~3/16" wide (optional*)
	4 ea	sub-mini snap action switch, SPDT, 0.1 A, Omron P/N SS-01GL13PT

	2 ea	rotary potentiometer, linear, 10K ohm, 300°, panel mount, 6mm (approx.) shaft
	2 ft	heat shrink tubing, 1/4" OD expanded, 2:1 ratio, polyolefin
	10 ea	11" long x 0.18" wide nylon cable tie
	20 ea	4" long x 0.1" wide nylon cable tie
	1 ea	vinyl electrical tape, 3/4" wide, 60 ft
	1 ea	friction tape, 3/4" wide, 60 ft
	1 ea	all purpose duct tape, 2" (or 1.88") wide, 50 to 60 yd, (color optional)

	1 ea	painters tape, 1" (or 0.94") wide, 30 to 60 yd.
	1 ea	carpenters wood glue, 4 oz
	1 ea	5 minute epoxy, 0.85 oz
	1 ea	1/4"-20 threaded rod, 3 ft long, steel
	25 ea	1/4"-20 hex nut, steel
	25 ea	1/4" SAE flat washer, steel
	25 ea	1/4" medium split lock washer, steel
	6 ea	1/4-28 x 1" screw, nylon (mates with igus rod end)
	6 ea	#10-32 x 1" socket head screw, high strength (150 KSI min) steel**
	25 ea	#10-32 x 1-1/2" machine screws, steel, round/pan head, phillips **
	25 ea	#10-32 machine screw nuts, steel
	25 ea	#10 flat washer, steel
	100 ea	#8-32 x 1-1/4" machine screw, steel, round/pan head, phillips **
	100 ea	#8-32 machine screw nuts, steel
	25 ea	#8 medium split lock washer, steel (optional*)
	100 ea	#8 flat washer, steel (3/8” OD)
	10 ea	#8 flat washer, steel (3/4” OD)

	25 ea	#4-40 x 1" machine screws, round/pan head, steel **
	25 ea	#4-40 machine screw nuts, steel
	10 ea	#2-56 x 1" machine screws, round/pan head, phillips, stainless **
	10 ea	#2-56 machine screw nuts, steel
	10 ea	#2 flat washer, steel
	100 ea	#8 x 1" sheet metal screw, steel, hex head
	100 ea	#6 x 1" wood screws, steel, flat head

	25 ea	#4 x 3/4" wood screw, steel, slotted drive, round head
	5 ft	3/4" nylon sticky back hook and loop fastener
	1 ea	#18 twisted nylon or polypropylene seine twine, 225 to 250 ft long (color optiona
	4 ft	1/4" polypropylene covered shock cord (color optional)
	1 ea	bicycle inner tube (26" x 1.375" to 2.25" max)
	25 ea	#10 Rubber Band (1/16" wide x 1-1/4" long)
	25 ea	#32 Rubber Band (1/8" wide x 3" long)
	100 ea	1 1/4" long paper clips, 0.033 dia wire (No. 1 Regular)
	2 ea	Breadboard jumper male-to-female wire (between 4” and 8”)
	1 ea	VEX motor mounting kit (4 mounts + screws)

Approved Optional Items (provided by the team) [1]

Qty
10 ea
2400 sq in
2 ea

3 ea
3 ea
1 ea
3 ea
24 lb
1 ea
36 ea
1 ea
4 ea
25 ea
25 ea
1
2 ea

Notes:

* Teams may use these optional items even if they are not supplied by the hub.

** Teams may substitute shorter screws of the same type and grade.

[1] These items can be used *in addition* to the items that are supplied by the hub.

[2] PET or PETE (polyethylene terephthalate) is identified by a number 1 recycling symbol.

[3] See *Team Custom Part Guide* for further explanation and examples.

2.3 Design and Programming Software Tools

BEST Robotics provides various design tools and programming software at no cost to participating BEST teams. This currently includes:

- Sketching software – 2D sketching
- Computer-Aided Design (CAD) software – 2D & 3D Solid Modeling
- Computer-Aided Manufacturing (CAM) software – 2-axis and 3-axis tooling
- Software Development (programming) and Simulation Environments
- Mathematics, Computational and Research software
- 3D Printer Driver software
- Technical Documentation Tools

Software access instructions are provided on your BEST National Registry Team Workflow page and should remain confidential. There may be specific system requirements, internet access requirements,

account creation requirements or other stipulations for team/team member use of the software. Unless otherwise indicated, all software and software licenses should only be used by BEST participants for the purpose of competing in the BEST program.

Section 3 Game Specific Rules

3.1 Introduction

Many fulfillment firms use a robot to gather up the specific items in a warehouse and deliver them to be packed and shipped. A robot whose brain is a computer. That Robot's brain knows the location of each item and has calculated the most efficient way to retrieve items from those locations.

For the past 29 years BEST students have designed and built that type of robot. Its brain was replaced by the student's brain and its dexterity was replaced by the student's dexterity on the controls, but not this year. This year you, the student, are being replaced by a robot.

You now need to design, build, and control the robot that has replaced you. You need to make a robot

that can assemble and control another robot. Your robot must be as good and dexterous as you because it is now operating, in this BEST game, with the same limitations and restrictions you normally have. Can you do it?

3.2 Overview and Objectives

For 30 years Squeaky has been the robot mascot for BEST Robotics, Inc. Squeaky's name came from a caster wheel that was slightly burned during construction and caused a distinct squeak sound when the caster wheel rotated on the demonstration robot. Squeaky has participated in many of the past BEST games, but this year Squeaky needs your help. The field includes four tracks, each with a partially completed copy of Squeaky. Squeaky will need to have parts added to be able to collect various robot pieces that are needed to fulfill orders.

Specifically, teams are tasked with:

- Prepare for order fulfillment by moving order boxes into appropriate locations • finishing the assembly of Squeaky, also known as the Field Robot
- using the team constructed Team Robot to control the Field Robot
- using the Field Robot to collect robot parts to fulfill orders.

3.3 Game Field

The field consists of a square area that is approximately 23 ft on a side as shown in Figure 3.1. Detailed dimensions and specifications for the field are provided separately in the field drawing package. Each team has a robot starting area in a corner of the field and areas for the driver and spotter.

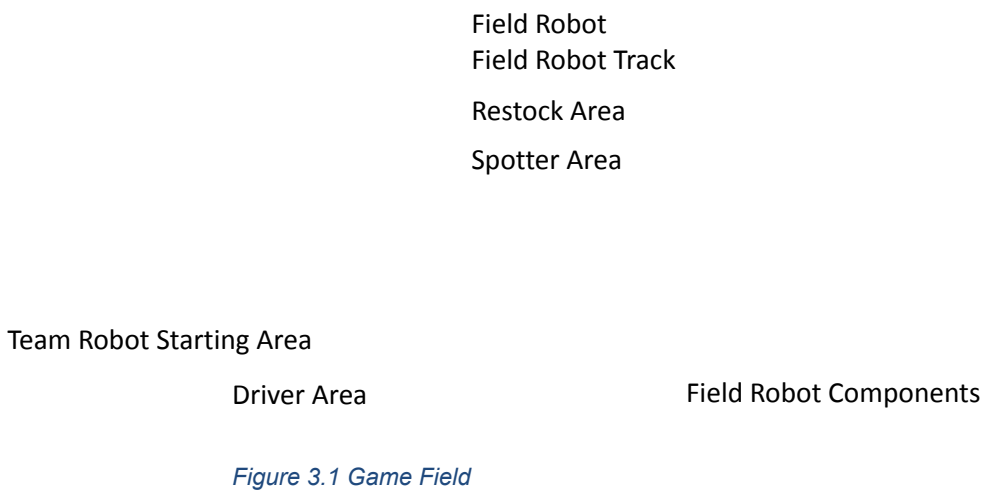


Figure 3.1 Game Field

Each team uses the track-based Field Robot to collect game pieces to fulfill orders. The track closest to a robot starting area is assigned to the team using that starting area as shown in Figure 3.2.

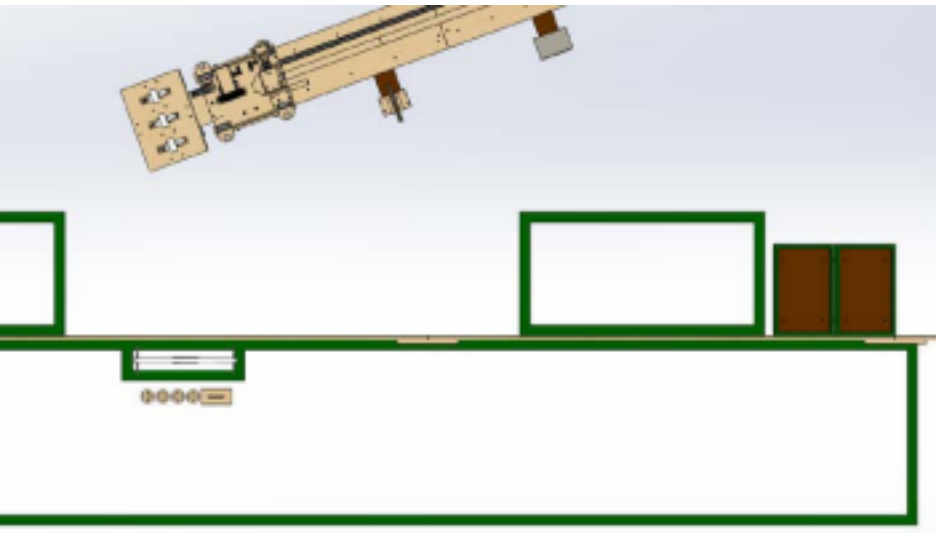


Figure 3.2 Driver and Spotter Area Detail

3.3.1 Team Robot Starting Area

Team Robot Starting Areas exist at each corner of the field. The Team Robot Starting Area is designated by colored tape and measures 24 by 24-inches from the outside edge of the tape line to the inner wall of the field boundary. Once a match starts, the Team Robot may freely enter and exit the Team Robot Starting Area.

3.3.2 Driver Area

The driver area is located adjacent to the Team Robot Starting Area and is designated by colored tape as shown in Figure 3.1 and Figure 3.2. Each driver area measures 36 by 60-inches and includes the tape border.

3.3.3 Spotter Area

The spotter area is located along the side of the field that is nearly parallel with the Field Robot track and measures 36 by 192 inches and includes the tape border. The spotter area contains the following Field Robot components that the Team Robot can install on the Field Robot:

- Four Field Robot wheels
- One Field Robot arm located in the 8 x 24-inch Field Robot Arm Area within the Spotter Area. • One Field Robot battery

Example start locations for the Field Robot wheels and Field Robot battery are shown in Figure

3.2. 3.3.4 Restock Area

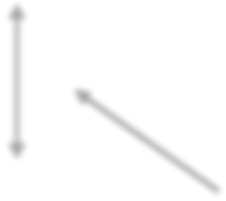
The restock area is a 24 by 48-inch area located along the field border near the spotter area (Figure 3.2). The border of the restock area is defined by the outside edges of the tape.

3.3.5 Field Robot

Figure 3.3 shows the Field Robot that starts in the designated assembly area at the end of the track. The Field Robot is constrained to the track and moves along the center track guide driven by a single 144 mm (5.7-inch) diameter drive wheel and balanced with two fixed casters. The track is elevated 3-3/4 inches above the floor. The Field Robot has an arm rotation and elevation system at the front of the robot. The arm interface includes two magnets that allow the Team Robot to attach the supplied Field Robot arm, or a team-supplied custom arm. The Field Robot has four magnetic wheel mount surfaces onto which Field Robot wheels can be installed by the Team Robot. When the Field Robot is in the assembly area, the wheel mount surfaces are oriented within ±20° of horizontally. Once the Field Robot leaves the assembly area, the wheel mounts will rotate down, and the mounting surfaces will become nearly vertical. The Field Robot has two posts onto which the Team Robot can install a Field Robot battery.

Figure 3.3 also provides the initial orientation and position of the arm and wheel mounts for the start of each match. The horizontal attachment surface of the arm interface is ~5” above the robot base when in the starting orientation. The initial rotation of the arm is as shown in Figure 3.3 within +/- 10 degrees.

Arm Interface



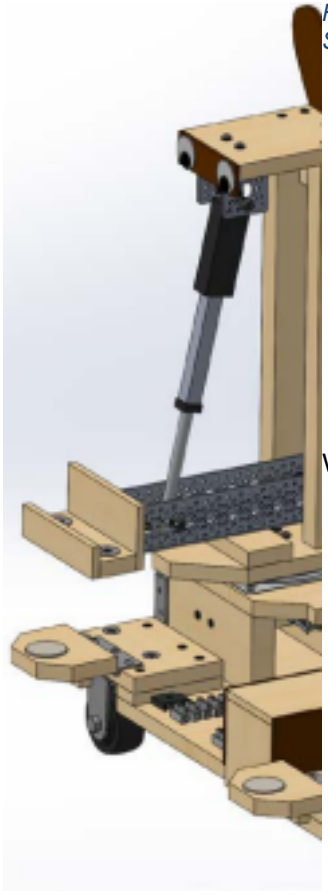


Figure 3.3 Field Robot (aka Squeaky)

A close-up view of the arm interface is shown in Figure 3.4. The interface includes two ¾-inch diameter magnets that are spaced 2-¾ inches apart (on center). The mounting surface is 1-¼ inches by 4 inches. Additional details of the arm interface can be found in the field drawing package by reviewing drawing number 22030310 and the associated component drawings.

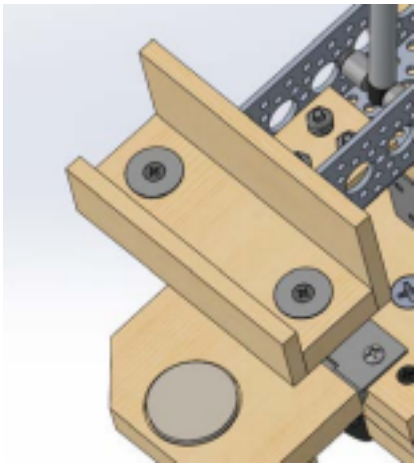


Figure 3.4 Field Robot Arm Interface

The motion of the Field Robot is controlled by the Field Robot Control described in the section that follows.

3.3.6 Field Robot Control

The control for the Field Robot is shown in Figure 3.5. The three PVC levers control each of the available movements of the Field Robot with two different speeds in each direction. The middle lever controls the drive motor that causes the Field Robot to move along the track: pushing the lever towards the track causes the Field Robot to move away from the starting area while pulling the lever back causes the field robot to move towards the starting area. The right lever controls the rotation of the Field Robot arm: pushing the lever towards the track causes the Field Robot arm to rotate clockwise (when viewed from above) while pulling the lever back causes the opposite rotation. The left lever controls the elevation (or lift) of the Field Robot arm: pushing the lever towards the track causes the Field Robot arm to lower, while pulling the lever raises the Field Robot arm. Each of the levers has two speed options: partially moving the PVC lever operates the motion in low speed while fully moving the lever to the stop operates the motion at a higher speed. The levers include a tensioning system to return the lever arm to the center (null) position when released.

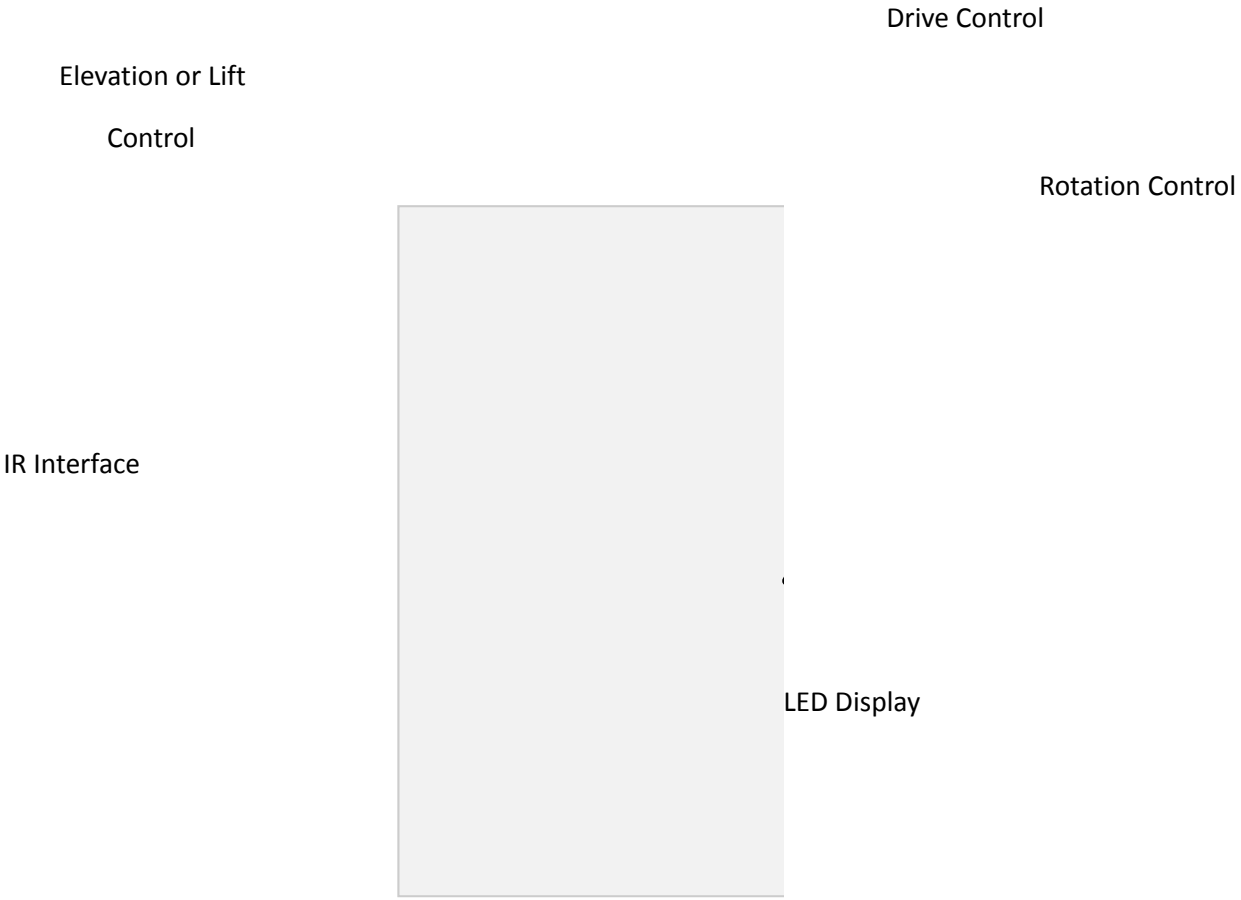


Figure 3.5 Field Robot Control

The Field Robot Control also includes an infrared (IR) receiver that can be used to change the operation of the individual controls. The IR receiver is the same as the IR receiver included in the Return Kit. The

center of the 1-inch diameter hole that exposes the IR receiver is 5-inches above the floor. The details of the IR functions are included in Section 3.3.6.1 . An LED display exists on the side of the Field Robot Control near the top and is used to display the current functionality of the levers.

3.3.6.1 Control Box Infrared Functions

The IR interface allows a Team Robot to alter the operation of the Field Robot Control. Use the BEST IR Transmitter in your kit connected to the serial port (UART1) on the Team Robot's Cortex microcontroller. Then program your robot to transmit the appropriate code(s) to cause an action. To communicate with the IR receiver in the Field Robot Control, the Cortex serial port should be opened at 600 Baud, with 8 data bits, no parity, and 1 stop bit.

Functions are available to increase, decrease, or return to nominal the speeds of the Field Robot Drive and Rotation motions. Forward and reverse motions are scaled together, e.g., a speed increase on the high-speed stick forward switch causes the same increase in speed on the high-speed stick reverse switch. The same increase or decrease in speed is applied to the slow-speed switches.

The IR interface also allows remapping of the control lever assignments so that any of the three Field Robot motions (drive, rotate, and lift) can be assigned to any of the three control levers. All three Field Robot motions are always available on the control levers and the forward/reverse operations cannot be remapped.

Table 3.1 summarizes the IR interface commands available to control the lever assignments and motor voltage scaling. Table 3.2 summarizes the available motor voltage scaling options in percentage of voltage output. Note that the speed of a motor does not linearly correlate to the output voltage.

Table 3.1 IR Codes and Resulting Action

IR Code (Hexadecimal)	Resulting Action
0xAA	Reset field. Equivalent to sending 0x3C followed by 0xA5 followed by 0x96.
0xF0	Test IR reception. Blinks the LED status display but does not change any field settings.
0x33	Set lever order (left to right) to Drive – Rotate – Lift.
0x55	Set lever order (left to right) to Drive – Lift – Rotate.
0x66	Set lever order (left to right) to Rotate – Drive – Lift.
0x5A	Set lever order (left to right) to Rotate – Lift – Drive.
0x3C	Set lever order (left to right) to Lift – Drive – Rotate. This is the reset state (default).
0xCC	Set lever order (left to right) to Lift – Rotate – Drive.

0x99	Set Drive speed range to Low.

IR Code (Hexadecimal)	Resulting Action
0xA5	Set Drive speed range to Medium. This is the reset state (default).
0xC3	Set Drive speed range to High.
0x69	Set Rotation speed range to Low.
0x96	Set Rotation speed range to Medium. This is the reset state (default).
0x0F	Set Rotation speed range to High.

Table 3.2 Motor Voltage Scaling Options

Motor	Stick Position	Motor Voltage		
		Scaled Down (Low)	Default (Medium)	Scaled Up (High)
Drive Motor	High Switch	63%	79%	95%
	Low Switch	32%	40%	48%
Rotation Motor	High Switch	67%	83%	100%
	Low Switch	33%	42%	50%
Lift Motor	High Switch	N/A	100%	N/A
	Low Switch	N/A	50%	N/A

3.3.6.2 Field Control LED Display

The Field Control LED Display gives visible feedback to the spotter about the currently programmed functionality of the Field Control levers (see Table 3.1). The LED display shows three symbols in columns left to right, one column for each of the physical control levers when viewed from the driver's perspective. The symbols displayed are

d for 'drive'; this lever controls the field robot's forward/reverse direction on the track.

L for 'lift'; this lever controls the elevation or lift of the field robot's arm.

r for 'rotate'; this lever controls the rotation left or right of the field robot's body.

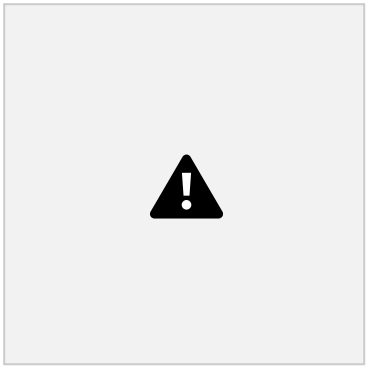
The LED display representation of the default setting (i.e., reset state) for the Field Control is show in

Figure 3.6.

Left Middle Right

Lever

Speed Setting



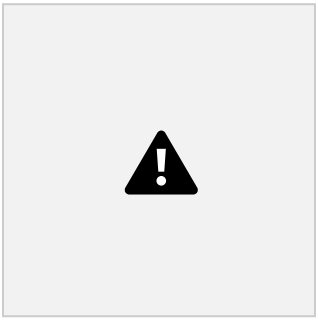
Lift rotate

drive

Figure 3.6. LED Matrix showing default Field Control setting

Additionally, above each of the lever symbols is 3-rows of dots that shows the relative speed setting for the respective levers (see Table 3.2). The default speed setting is represented by simply 2 horizontal dots. The “fast” and “slow” speed settings are represented by the relative position of the 2 dots as shown in Figure 3.7. This shows speed changes after sending IR commands 0xC3 and 0x69.

Figure 3.8 shows an example of the LED display after remapping the levers with IR command 0x5A.



Fast
Normal
Slow

drive
Lift rotate

Figure 3.7 Fast/Normal/Slow speed settings Figure 3.8 Example remapping of control levers

3.3.7 Order Boxes

Each team has access to three order boxes that are used to collect the order fulfillment game pieces. Each box measures 17-3/4 by 11-3/4 inches by 3-5/8 inches tall and sits on top of two pieces of ½ inch PVC pipe. The box that is initially located near the center of the field includes a handle that is 6-3/4 inches tall and 1-1/2 inches wide. The other two boxes are located adjacent to the Spotter Area. Both

types of boxes are shown in Figure 3.9.

Figure 3.9 Order Boxes

3.4 Game Pieces

There are two types of game pieces:

1. Field Robot Game Pieces that are installed onto the Field Robot.
2. Order Fulfillment Game Pieces that are collected to fulfill orders.

Table 3.3 provides a summary of both types of game pieces and the sections that follow include more detailed descriptions of the game pieces.

Table 3.3 Game Pieces and Starting Locations

Item	Quantity (per team)	Starting Location	Image
Field Robot Game Pieces			
Field Robot Wheel	4	Spotter Area	
Field Robot Arm	1	Spotter Area in Field Robot Arm Area	
Field Robot Battery	1	Spotter Area	
Order Fulfillment Game Pieces			

Wheel	2	Mounted Adjacent to Track	
Large Motor	2	Mounted Adjacent to Track	
Small Motor	2	Mounted Adjacent to Track	

Servo Assembly	4	Mounted Adjacent to Track	
Battery	2	Mounted Adjacent to Track	
Controller	1	Mounted Adjacent to Track	
Spool	1	End of Track	

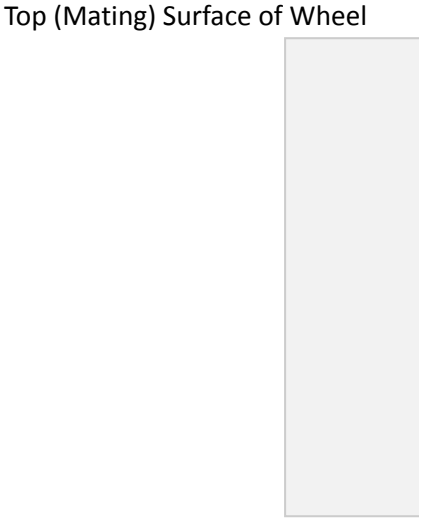
3.4.1 Field Robot Game Pieces

The Field Robot game pieces are those pieces that are installed onto the Field Robot by the Team Robot.

3.4.1.1 Field Robot Wheel

Figure 3.10 shows the Field Robot wheel that is 2-1/2-inches in diameter and approximately 1-inch thick. The wheel has a magnet captured 1/8-inch beneath the top surface of the wheel (shown in the figure). The magnet polarity is such that the top surface of the wheel will mate with the wheel mount on the robot. While both wooden parts of the wheel include a ¼-inch center hole, the holes are blocked by the interior magnet.

Figure 3.10 Field Robot Wheel



The Field Robot wheels must be within the Spotter Area and in contact with the floor at the start of the match.

3.4.1.2 Field Robot Arm

The Field Robot arm consists of a 20-inch-long piece of ½-inch, Schedule 40, PVC pipe with a piece of 6-inch long ¼-inch diameter threaded rod installed near each end. As shown in Figure 3.11, the threaded rod extends out both sides of the PVC pipe. The center of the arm includes two ¾-inch diameter washers that allow the arm to be attached to the corresponding magnets on the Field Robot arm interface.

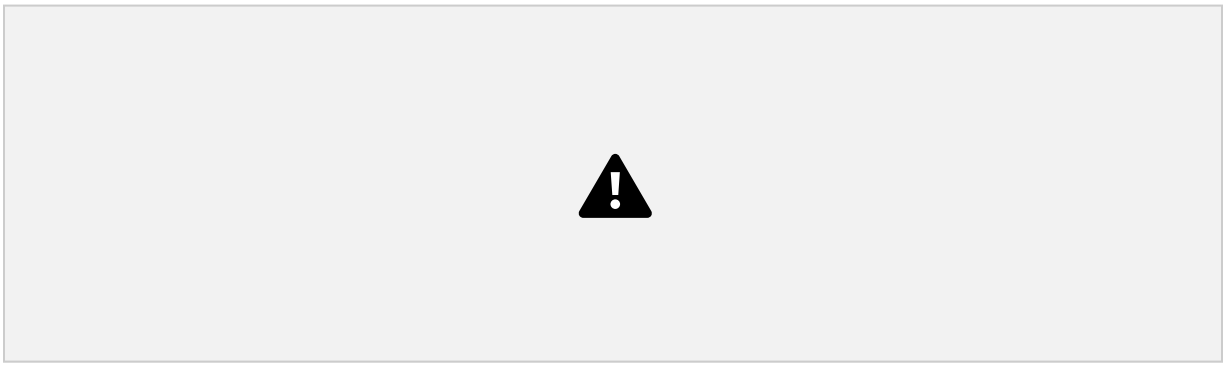


Figure 3.11 Field Robot Arm

The Field Robot arm must be inside the Field Robot Arm Area and in contact with the floor at the start of the match.

3.4.1.3 Field Robot Battery

The main portion of the Field Robot battery is 6 inches long, 3-1/2-inches wide, and 1-3/4-inches tall. A 3-inch (center-to-center) handle is mounted to the battery to simplify handling of the battery. The bottom of the battery includes two 1-inch diameter holes that allow the battery to be mounted on the corresponding studs on the Field Robot. The Field Robot Battery configuration is shown in Figure 3.12.

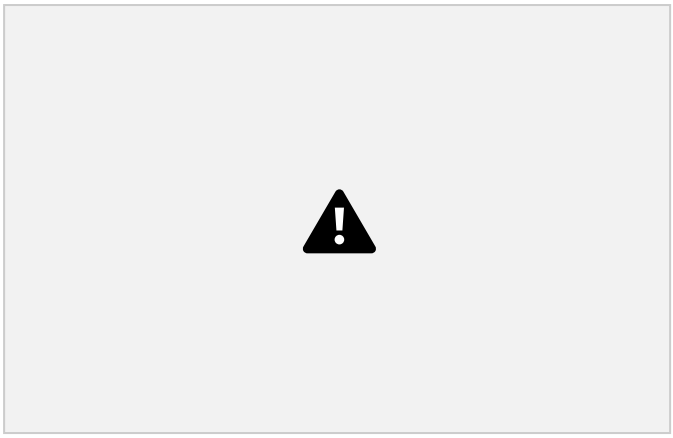


Figure 3.12 Field Robot Battery

The Field Robot battery must be within the Spotter Area and in contact with the floor at the start of the match.

3.4.2 Order Fulfillment Game Pieces

The order fulfillment game pieces are all mounted on supports attached to the Field Robot track as shown in Figure 3.13. The loop (or hole) orientation of each piece is also shown in the figure. The order fulfillment game pieces are collected by the Field Robot and placed into the order box.

Wheel Large Motors

Batteries

Controller

Figure 3.13 Initial Order Fulfillment Game Piece Positions

3.4.2.1 Order Fulfillment Wheel

The order fulfillment wheel shown in Figure 3.14 is 7-3/4-inches in diameter and approximately ¾-inches wide. The holes through the ¼-inch center portion of the wheel are 2-inch in diameter with a single center hole that is ½-inch diameter. Two wheels are initially located along the Field Robot track as

shown in Figure 3.13 on top of 5-1/2-inch-tall platforms with the rotation angle within ±20° of the angle shown.

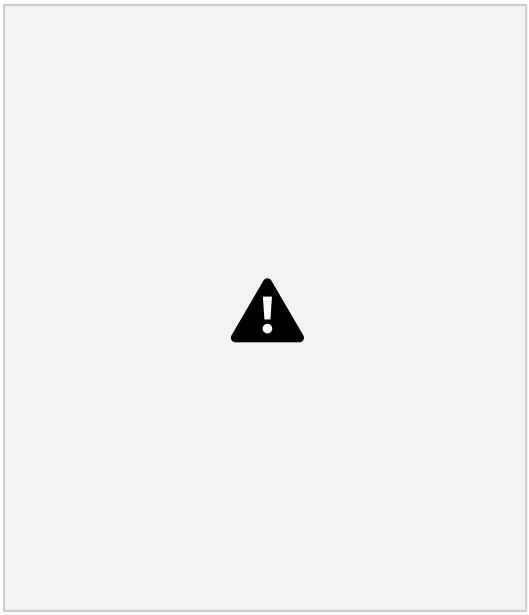


Figure 3.14 Order Fulfillment Wheel

3.4.2.2 Order Fulfillment Large Motor

The cylindrical body of the order fulfillment large motor is 2-3/8 inches in diameter and approximately 4-1/4 inches long. On one end of the motor, there is a ¼-inch shaft slightly offset from the center that extends 1-1/2 inches from the end cap. On the other end of the motor, an approximately 2-inch-wide loop extends as shown in Figure 3.15.

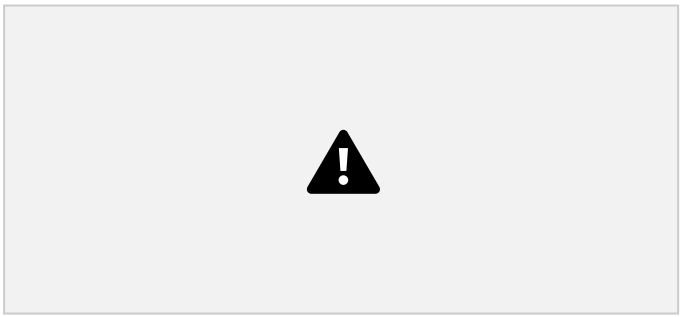


Figure 3.15 Order Fulfillment Large Motor

As shown in Figure 3.13, two large motors are initially placed on top of a 5-1/2-inch-tall platform that includes two 1-inch diameter holes through which the motor shafts are inserted. The orientation of the loop should be within ±20° of the angle shown in Figure 3.13.

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Made 2 Order Game Specific Rules V0.2 June 21, 2022

3.4.2.3 Order Fulfillment Small Motor

The order fulfillment small motor is shown in Figure 3.16. The cylindrical body of the motor is approximately 1-7/8 inches in diameter and 3-1/4 inches long. On one end of the motor, there is a ¼-inch shaft slightly offset from the center that extends just under 1-1/4 inches from the end cap. On the other end of the motor there is an approximately 2-inch-wide loop.

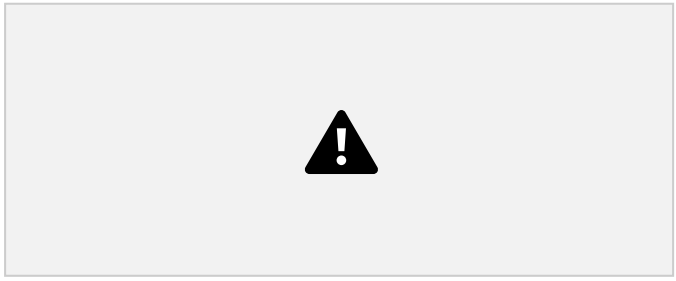


Figure 3.16 Order Fulfillment Small Motor

As shown in Figure 3.13, two small motors are initially placed on top of a 9-1/2-inch-tall platform that includes two 1-inch diameter holes through which the motor shafts are inserted. The orientation of the loop should be within ±20° of the angle shown in Figure 3.13.

3.4.2.4 Order Fulfillment Servo Assembly

The order fulfillment servo assembly, which simulates a servo attached to a shipping card, is shown in Figure 3.17. The assembly consists of an 1/8-inch-thick shipping card that is 4x6 inches in size with a 2-inch diameter hole towards one end. On the other end of the shipping card, a 1-1/2-inch-tall by 3-inch wide by 1-1/8-inch-thick servo is centered on the shipping card and extends ½-inch on both sides of the shipping card. The servo is permanently attached to the shipping card and is not separated for game play.

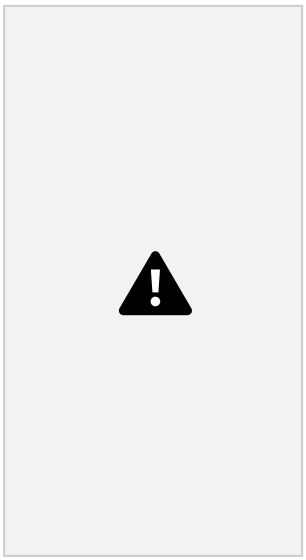


Figure 3.17 Order Fulfillment Servo Assembly

Four of the servo assemblies are initially hanging from pegs with centers that are 13-inches above the floor. Two servo assemblies are located on each side of the support structure as shown in Figure 3.13.

3.4.2.5 Order Fulfillment Battery

The body of the battery shown in Figure 3.18 is 5-1/2-inches long and approximately 1-11/16-wide. The loop on the end of the battery is roughly 2-inches across. Two batteries are initially positioned on top of the 14-1/2-inch-tall mount as shown in Figure 3.13.

Figure 3.18 Order Fulfillment Battery

When positioned on the support platform, the loop side of each battery body overhangs the track side of the support platform by ½ inch ±¼ inch and is oriented nominally as shown in Figure 3.13.

3.4.2.6 Order Fulfillment Controller

Figure 3.19 shows the order fulfillment controller that is approximately 6x4x2-inches in size and is constructed from a cardboard box. The initial position of the controller is on top of a 7-inch-tall mount as shown in Figure 3.13.

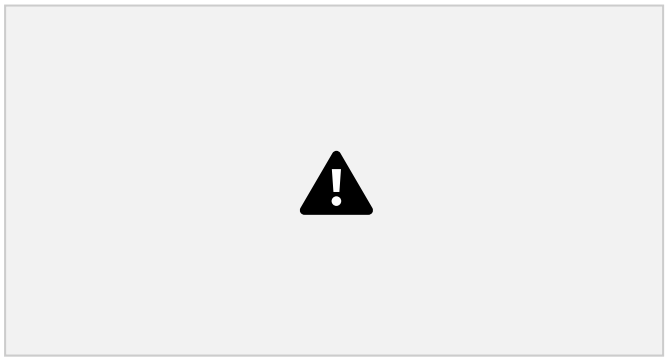


Figure 3.19 Order Fulfillment Controller

3.4.2.7 Order Fulfillment Spool

Figure 3.20 shows the order fulfillment spool that is initially located at the end of the Field Robot track as shown in Figure 3.13. The plastic spool is approximately 3-1/4-inches in diameter and 3-1/4 inches tall

and includes a piece of foam around the inner spool surface. The center opening of the spool is just over 9/16-inch in diameter.

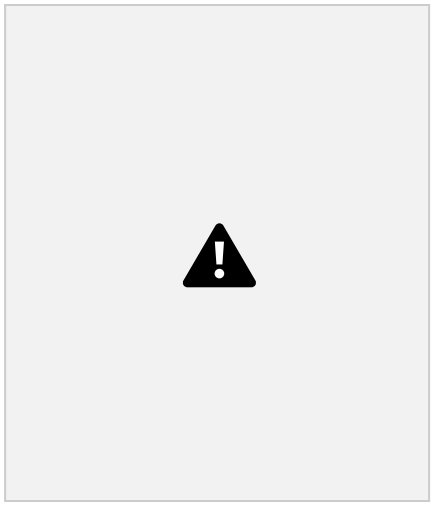


Figure 3.20 Order Fulfillment Spool

The initial position of the spool is centered on the 3-1/2-inch-wide support and the center axis of the spool is aligned with the inside edge of the support.

3.5 Interaction Rules

3.5.1 Interaction with Other Robots, the Field, and Game Pieces

a. The Team Robot operates the Field Robot Control by moving the control levers and interacting with the control through the IR system.
b. A Team Robot may return their Field Robot game pieces (wheels, battery, arm) to the Team Robot Starting Area if they are not successfully installed on the Field Robot or have become uninstalled from the Field Robot.
c. Incidental contact between the Team Robot and the team's own fulfillment game piece in its initial position or a scoring position within an order box will nullify the game piece; the game

piece can no longer be scored or used for any other purpose.

Violation of any of the restrictions described in rules that follow (d through i) will result in a **disqualification** for the current match.

d. The Team Robot must remain fully inside the Robot Starting Area and in the 24” x 24” x 24” starting configuration until the match begins.

e. Team Robots may drive anywhere on the surface of the field, but access to the following areas is limited:

i. The Team Robot Starting Area of another team may be driven through as long as no game pieces are present in that area and the owning team’s Team Robot is not currently in the Team Robot Starting Area. At the discretion of the referee, a team may be disqualified for interfering with another team’s Team Robot Starting Area.

ii. A Team Robot may not enter another team’s Restock Area and may not remove any game pieces from another team’s Restock Area.

iii. The area that extends in the track direction between the end of the Field Robot track and the adjacent track is an order box area that is owned by the team as shown in Figure 3.21. The owning team is the only team that can place an order box in this area and once an order box has been placed in this area, no other team may drive through the area.

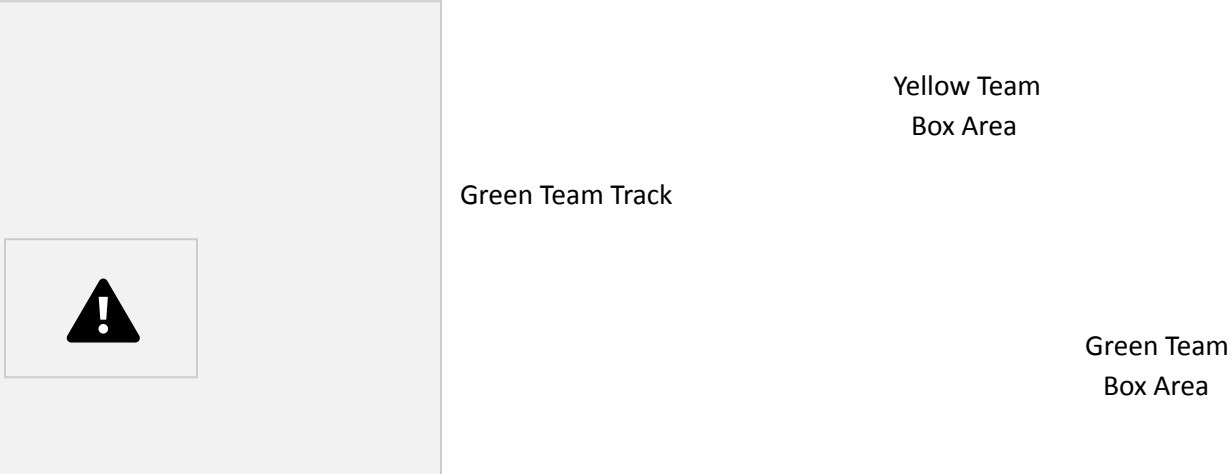
iv. The area between the Field Robot Control and the field border is owned by the team that is designated to use that Field Robot Control (Figure 3.21). Other teams may drive through this area but may not interfere with another team’s ability to operate the Field Robot Control. At the discretion of the referee, a team may be disqualified for interfering with another team in this area.

f. Team Robots may not handle or interfere with another team’s order boxes.

g. Team Robots may not interfere with the operation of any Field Robot including their own Field Robot.

h. Only Field Robots may place Order Fulfillment Game Pieces into an order box. i. Team robots may not handle Order Fulfillment Game Pieces unless those pieces are no longer in their starting location, no longer in control of a Field Robot, are not in contact with an order box, and are in contact with the floor. Order Fulfillment Game Pieces that satisfy ALL these conditions are considered eligible for restocking.

j. The Team Robot or any objects manipulated by the Team Robot, may not intentionally break the outer planes of the Field Robot Control box openings. This includes openings for the levers, infrared sensor, tuning potentiometer or reset switch.



Green Team
Control Area

Figure 3.21 Special Team Areas

3.5.2 Driver and Spotter Rules

The following rules apply to the driver and spotter. All rules are cumulative and must all be satisfied.

a. The spotter may load the Field Robot game pieces (Arm, Wheels, Battery) onto the Team Robot when the Team Robot is inside the Robot Starting Area.

b. The spotter may touch the field or Team Robot inside the Robot Starting Area only during interactions with the Team Robot.
c. The spotter may rearrange the Field Robot wheels and Field Robot battery within the spotter area prior to the start of the match but the pieces may not leave the spotter area and must be in contact with the floor at the start of the match. These pieces may not be placed into the Robot Starting Area (or on the Team Robot) prior to the start of the match.
d. The spotter may bring one 3” x 5” card, unrestricted in content, to the field for reference during the match.

Any violation of the following rules (e through j) will result in a **disqualification** for the current match.

e. The driver may not touch any part of the field, any game piece, or the Team Robot during the match.
f. Other than debugging a non-functioning machine, the spotter may not manipulate the Team Robot in any way after the match starts. Specifically, the spotter may not manipulate (move parts, reposition components) the Team Robot to complete the process of loading Field Robot game pieces onto the Team Robot.
g. The spotter may not touch the field outside of the Team Robot Starting Area, or any game piece that does not start in the spotter area.
h. Throwing or tossing of game pieces is not allowed.
i. The spotter may not extend or otherwise manipulate the configuration of the team-built arm. j. The Team Robot may not run any autonomous (or time delay) program during the period that the spotter is interacting with the Team Robot in the Team Robot Starting Area.

Any violation of the following rules (k through q) will result in a **20 second penalty** during the current match.

k. The driver must keep their feet within the Driver’s Area during the match.
l. The spotter must keep their feet within the Spotter’s Area during the match. m. The spotter may only interact with the Team Robot when any part of the Team Robot is inside the Robot Starting Area.
n. The spotter may not be touching the Team Robot or any part of the field when the driver is touching the joystick.
o. The driver must maintain “hands off” the joystick while the spotter is loading game pieces onto the Team Robot.
p. The joystick must be placed on a “hands free” surface or on the floor before the spotter touches the Team Robot and remain there during periods of interaction with the Team Robot. “Hands

free” means no touching the joystick during this time.

q. The Team Robot is considered inside the Team Robot Starting Area when any part of the Team Robot has broken the plane of the Team Robot Starting Area.

3.6 Game Play

The primary objectives are to:

- Prepare to fulfill orders by moving the order boxes into locations reachable by the Field Robot. • Complete the construction of the Field Robot.
- Operate the Field Robot to fulfill one or more orders by placing order fulfillment game pieces into order boxes.
- Return any dropped order fulfillment game pieces to the Restocking Area.

3.6.1 General Rules

3.6.1.1 Order Boxes

The two different types of order boxes shown in Figure 3.9 are treated the same for the purposes of scoring. Teams may place the order box at any location with the following limitations:

a. An order box may not be placed within 18-inches of another team’s track, except when placed at the end of their own team’s track.

b. An order box may not be placed in another team’s Robot Starting Area or Restock Area. c. An order box may not be placed within another team’s Box Area as identified in Figure 3.21. d. Once an order fulfillment game piece has been placed into an order box, the Team Robot may no longer move the order box. Incidental (i.e., not intentional) contact between the field robot and an order box that causes it to move is allowed regardless of the contents of the order box.

3.6.1.2 Team-Built Arm

Teams may use a single team-built arm in place of the Field Robot arm that is provided as part of the field. The team-built arm effectively replaces the field-provided Field Robot arm for a match and is scored the same as if the field supplied Field Robot arm was used.

a. The team-built arm must be constructed from kit materials.

b. The combined materials used for the team-built arm and Team Robot must not exceed the materials available in the kit

c. Team-built arms may not contain any springs or other stored energy sources other than that resulting from gravity and a change in elevation.

d. The team-built arm must fit within an 8 x 8 x 24-inch space at the start of the match and must be placed in the Field Robot Arm Area at the start of the match.

e. The team-built arm must maintain its initial configuration (shape) until the Team Robot leaves

the Team Robot Starting Area.

f. Teams may construct more than one team-built arm; only one team-built arm is allowed at the field during a match, replacing the field-provided arm.

g. All team-built arm(s) collectively count against the 24 lb maximum robot weight. The field provided arm does not count against the robot weight.

3.6.2 Scoring Actions

The sections that follow define the scoring requirements. The point values for these actions are provided in Section 3.7 .

3.6.2.1 Install Field Robot Game Pieces

The Field Robot Game Pieces may only be installed while the 11x16 inch base of the Field Robot (Drawing 22030101) is completely within the Field Robot assembly area. Once the Field Robot moves along the track, the base of the Field Robot is no longer completely within the Field Robot assembly area.

However, the Field Robot Control may be used to rotate and/or elevate the Field Robot arm interface to aid in the installation of the Field Robot arm while the base of the Field Robot remains in the Field Robot assembly area.

At the end of the match, game pieces that are installed per the requirements that follow will be scored.

a. A Field Robot wheel is installed when it is magnetically attached to the wheel flap. b. The Field Robot battery is installed when the battery has been placed onto both battery posts and the side of the battery opposite the handle (bottom) is completely in contact with the base of the robot.

c. The Field Robot arm is installed when the arm is supported only by the arm interface. When a team-built arm is substituted for the Field Robot arm, the same installation requirements exist.

3.6.2.2 Order Box Placement

An order box that is placed with both PVC pieces of the order box in contact with the floor and any portion of the order box within 6 ¼ inches of the track will score the order box placement points. Order boxes can be placed as close to the track as desired by the team.

3.6.2.3 Order Fulfillment Game Pieces in an Order Box

a. An order fulfillment game piece scores when it is completely supported by the order box. b. The order fulfillment game piece may be in contact with or on top of other order fulfillment game pieces that are also supported by the order box and still score.

c. An order fulfillment game piece does not have to be completely inside the order box to score. d. An order box does not have to be in scoring position as defined in Section 3.6.2.2 for the order fulfillment game pieces inside the box to score.

3.6.2.4 Order Fulfillment Game Pieces in Restock Area

a. Order fulfillment game pieces that meet the restock eligibility requirements given in Section 3.5.1 score when they are resting on the floor completely inside the Restock Area at the end of the match.
b. Only the Team Robot can move game pieces to the Restock Area.

3.6.3 Fulfillment Order Types

a. There are six different order types as specified in Table 3.7 that can be fulfilled by placing the indicated order fulfillment game pieces into an order box.
b. A single order box can only hold one type of order and pieces beyond those required for the order will invalidate the order but the entire contents of the box will still be scored as individual pieces.

3.7 Scoring Values

a. All points are determined at the end of the match.
b. Game pieces are scored based on their final location at the end of the match. c. Any game piece that the Field Robot, Team Robot, or spotter is touching at the end of the match does not score.
d. Penalties are assessed by referees in real-time during the match.

3.7.1 Scoring Summary

Table 3.5 through Table 3.6 summarize the points awarded for order boxes, field robot game pieces, and order fulfillment game pieces.

a. To score order box placement points, any portion of the Order Box must be within 6 ¼ ” of the edge of the plywood track surface.

b. Each order fulfillment game piece that is resting on the floor inside the restock area will score 10 points.

c. A wire spool **resting on the floor** and not inside the restock area will score 15 points.

d. Each order fulfillment piece inside an order box will score as shown in Table 3.6.

Table 3.4 Scoring Summary for Order Boxes

Game Piece	Per Quadrant Count	Points for Box within 6 ¼ “ of the Team’s Track	Total Points Available
Order Box (No handle)	2	5	10
Order Box (with handle)	1	10	10

Table 3.5 Scoring Summary for Field Robot Game Pieces

Game Piece	Per Quadrant Count	Points for Installation on Field Robot	Total Points Available
Wheel	4	10	40
Battery	1	10	10
Arm	1	25	25

Table 3.6 Scoring Summary for Order Fulfillment Game Pieces

Game Piece	Per Quadrant Count	Points Inside an Order Box	Total Points Available
Wheel	2	30	60
Large Motor	2	30	60
Small Motor	2	30	60
Battery	2	30	60
Servo	4	20	80
Controller	1	30	30
Spool	1	20	20

3.7.2 Bonuses

3.7.2.1 Fulfilled Orders Bonus

There are 6 types of orders that can be fulfilled by your team for additional points. Each order requires a unique quantity of fulfillment items inside an order box. To be considered a valid fulfilled order, only those items/quantities specified in Table 3.7 may be in the order box.

Table 3.7 Scoring Summary for Fulfilled Orders

Order Fulfillment Game Piece	**Per Quadrant Count**	**Order Type**					
		Full Robot	**Spares**	**Arm Build**	**Upgrade**	**Expansion**	**Drive**
Wheel	2	2	1				2
Large Motor	2	2	1				2
Small Motor	2	1	1	1		1	
Battery	2	1	1		1	1	
Servo	4	2	1	2	2	2	
Controller	1	1	1		1		
Points for a Fulfilled Order		100 pts	50 pts	20 pts	25 pts	25 pts	25 pts

3.7.2.2 Field Robot Assembly Bonus

a. A point multiplier is applied to the fulfillment game pieces inside an order box when one of the Field Robot Assembly configurations indicated in Table 3.8 has been satisfied.

b. Table 3.9 shows the point values of fulfillment game pieces inside an order box when the Field Robot Assembly bonus multiplier is applied.

Table 3.8 Field Robot Assembly Bonus Multipliers

Field Robot Assembly Component	Assembly Config 1	Assembly Config 2	Assembly Config 3
Wheel	2	2	4
Arm	1	1	1
Battery		1	1

Fulfillment Piece Bonus Multiplier	1.2x	1.3x	1.4x

Table 3.9 Fulfillment Game Piece Point Values With Each Bonus Multiplier

Fulfillment Game Piece	Points for Game Piece Inside an Order Box			
	Points without Bonus (For Reference)	Points With Assembly Config 1 Multiplier (1.2)	Points With Assembly Config 2 Multiplier (1.3)	Points With Assembly Config 3 Multiplier (1.4)
Wire Spool	20	24	26	28
Wheel	30	36	39	42
Large Motor	30	36	39	42
Small Motor	30	36	39	42
Servo Board	20	24	26	28
Battery	30	36	39	42
Controller	30	36	39	42

3.7.3 Scoring Definitions

Inside, In, Within – within the imaginary infinite vertical planes defined by the innermost sides of a container/area or the outer edge of a tape line defining the boundaries of an area.

Resting on - touching such that the entire weight of the object is supported by what it rests on.

3.8 Appendix: BEST IR Sensor Kit Communications Coding

Refer to the BEST IR Sensor documentation at https://www.bestrobotics.org/IR_Kit/

Section 4 Awards and Judging

4.1 Head-to-Head Competition / Robot Performance Judging

The head-to-head competition / robot performance results for a team are dependent on the following criteria:

- The Student Participation Survey must be completed by all students on the team roster prior to competing in any head-to-head, classroom or virtual competition. Refer to the BEST National Registry Team Workflow for due dates. Completion of the survey will be verified at the Robot Compliance Check.
- An Engineering Notebook must be submitted by the participating team prior to competing.
- All team members (students, teachers, mentors) must individually register in the BEST National Registry prior to competing on Game Day.
- A participating team must be compliant with the General Rules (constraints, etc.) and successfully pass the Robot Compliance Check prior to competing

Any team that does not meet these criteria may be eliminated from consideration of awards and/or advancement.

The Final head-to-head competition ranking is determined through robot performance using the Game Specific scoring rubric defined in Section 3 .

- For BEST Classic Competition, this will consist of the head-to-head competition results (all phases executed)

4.2 The BEST Award

The BEST Award is presented to the team that best embodies the concept of *Boosting Engineering, Science, and Technology.* This concept recognizes that inclusiveness, diversity of participation, exposure to and use of the engineering process, sportsmanship, teamwork, creativity, positive attitude and enthusiasm, and school and community involvement play significant roles in a team's competitive experience and contribute to student success in the competition beyond winning an award.

In accordance with the BEST philosophy, **materials submitted by teams must be the work of students.** The involvement of student peers in auxiliary roles to support a school's official BEST team – i.e., journalists, photographers, artists, musicians – is encouraged.

Space constraints at each regional championship site will determine the number of teams that can compete for the BEST Award at the championship (check with the specific guidelines published by each regional championship). For a team to be eligible to compete for the BEST Award at any of the regional championships, the team: (1) must have placed in the top 3 teams in the BEST Award judging at their

local hub competition, and (2) must agree to compete in all five of the BEST Award component categories at the regional championship.

4.2.1 Judging Evaluation and Criteria

Evaluation of competitors will be based on the criteria outlined here. An evaluation score of 100 possible points will be composed of the following components:

Component I - Engineering Notebook (required for ALL teams)

Component II - Marketing Presentation (required for BEST Award consideration)

Component III – Team Exhibit and Interviews (required for BEST Award consideration)

Component IV - Spirit and Sportsmanship (required for BEST Award consideration)

Component V - Robot Performance (required for BEST Award consideration)

Judged Components Point Value
Engineering Notebook 30 points Marketing Presentation 25 points Team Exhibit and Interviews 20 points Spirit and Sportsmanship 10 points Robot Performance 15 points

Total 100 points

Refer to Section 5 for details on each of the Judged Components.

Refer to the ***2022 Awards and Judging – Hub Logistics*** document for the specific judging scenario at your local hub. Championship events will always judge all components; teams that advance to a championship as eligible to compete for the BEST Award must compete in all five components.

4.2.2 Judging Procedure

- A distinguished team of judges from private and public sectors with technical and non-technical expertise will evaluate teams. Judges will serve on a rotation schedule.

- As each team completes a component, it will be assigned a component score that is the average of individual scores of the judges reviewing it.

- The organizing hub/championship may choose to drop the lowest judges' score for any judged component at their discretion.

- Teams should know in advance that scores among many teams frequently differ by only fractions of a point.

4.2.3 Judging Results

- Each team will be provided with a copy of its score sheets within 3 days following their local competition.

- Teams advancing to a championship can use judges' comments to make improvements as they wish subject to the schedule restrictions of the championship (e.g., Engineering notebook due dates).

4.2.4 BEST Award Recognition

The teams ranked first, second, and third in the BEST Award judging will receive trophies superior to the teams finishing first through third in the Head-to-Head robot competition.

4.3 Simulink Design Award

The "BEST Simulink Design Award" sponsored by MathWorks is an award open to all teams participating in the competition. The award is presented to one team in each of the 3 BEST championship regions (South's, Texas, and Denver) that best applies the Simulink in the programming of their robot based on the judging criteria below and their robot's performance in the competition. Any team using MathWorks MATLAB/Simulink to design their software (i.e., robot program) is eligible.

4.3.1 Applying for the Award

To apply for the award, teams are required to submit their best Simulink model and a short video describing their program design using Simulink. The entries must be submitted before 11 PM (local time) two weeks before their respective regional championship. See the ***2022 Awards and Judging – Hub Logistics*** document and the BEST Robotics website for more information on deadlines.

Information that teams need to provide when submitting their entry:

- Name of School
- BEST Hub (know which hub you belong to)
- Team Contact
- Team Contact Email Address (**important:** all entries are tied to the email address)
- # Students on the Team
- Simulink Model File (.slx file)

- Link to YouTube Video (3 minutes maximum)
- Brief Description (256 chars) of how the team used Simulink to program their robot

A PASSCODE may be required to submit your entry. Contact your Hub or refer to your Team Workflow page on the BEST National Registry to get the PASSCODE.

4.3.2 Simulink Design Award Guidelines

- Only one entry per team is allowed.
- All teams can participate for the award within their region. There will 1 winner per region. •

Every entry should include the following items:

  - 1 Simulink model file (*.slx)
  - 1 video link (use YouTube only)

- The Robot program must be created using Simulink. Submissions of programs designed using other software will not be accepted. The submitted Simulink file should not be a pre-built example model or the default program. It should be your own program or a modification of the existing examples or default program.
- The video should be no more than 3 minutes in length and include at least a 1.5 minute overview about the program design (e.g. a screencast of the Simulink model with voice over).
- Multiple submissions may be made by a team prior to the submission deadline always using the same email address during submission. Only the last submitted entry will be scored.
- Final submissions for this award must be uploaded at https://www.bestrobotics.org/simulink_award/ before the stated deadlines.

4.3.3 Simulink Design Award Evaluation

The award will be given to one team from each region and be based on the judging criteria and robot performance in the competition. The following criteria will be used for judging each entry using a maximum 100pt scale. The Simulink model is worth up to 70 points and the video is worth up to 30 points.

Simulink Model		**Possible Points**
Creativity	Innovative, creative, and original work	10
Functionality	Error-free and designed to achieve the game tasks	10
Software Design Practices	Best practices like commenting, block naming, etc.	15
Difficulty and Mastery	Level of Simulink knowledge demonstrated in executing the tasks	20
Readability	Clean, organized, and easy to comprehend	15
	TOTAL	**70**

(YouTube) Video		Possible Points
Creativity	Interesting, innovative, and informative	5
Quality of the video	Video making process and technical execution	10
Concept	Engaging, coherent and appropriate	10
Clarity	Message is clear and well-communicated	4
Adherence to Guidelines	Video length and content on Simulink usage	1
	TOTAL	**30**
	Total Possible Points	**100**

4.3.4 Simulink Design Award Recognition

The winning teams will be awarded the following:

- Cash award
- Trophy with inscription 'BEST Simulink Design Award – by MathWorks', and
- a MathWorks hat for each team member

The winning teams from each region will be recognized on the BEST website (www.bestrobotics.org) and their regional championship website.

4.4 Robot Critical Design Review

The intent of the Robot Critical Design Review (CDR) is for students to explain their design in detail, including design features/functionality, the requirements and strategies that influenced certain design features, the methods and results of each design discipline, and design risk assessment. Judges ask questions, provide feedback on areas to improve, proposed alternative solutions to investigate, etc., to ensure the team's success.

4.4.1 Robot CDR Guidelines

The CDR is a multi-disciplined technical review, conducted at both system-level and component-level, to ensure that an initial product baseline is established and that all customer requirements have been addressed to satisfaction.

- Each team will present a Critical Design Review (CDR) of their robot design to a panel of judges. •

The format and content of the review is determined by the team.

- The goal of the CDR is to ensure that the final design will meet the application requirements. The application requirements consist of the rules for robot construction and the game play objectives.

- The CDR consists of explaining the details of the design and game strategy and presenting how it will satisfy the objectives.
- Judges are expected to ask questions during the review that will require detailed knowledge about specific functionality or components of the robot and every design discipline involved. Students presenting the CDR should be capable of answering with specific details. Judges may ask questions at any time during the review.
- Judges will use the CDR to provide feedback to teams on their design, including requirements that were overlooked, additional analysis that may be beneficial, and generally how to improve their design.
- The review will take no more than 25 minutes. Judges will have 5 minutes for conferencing following the review, if needed, to complete the evaluation.
- At least 3 students will actively participate as presenters in the CDR.
- The CDR will review results from the following design disciplines:
    - Systems, Mechanical, Electrical, Software, Test, Human Factors, Risk Assessment
- The CDR will provide a detailed review of:
    - Requirements
    - Functionality Overview
    - Design Specifications (Component and System)
    - Risk and Lessons Learned

4.4.2 Robot CDR Evaluation

The Robot Critical Design Review may be judged as an independent award. Its score will not influence the BEST Award Score. Robot CDRs will be evaluated considering the following:

- ***Requirements***
    - Did the team present requirements (and strategies) that influenced their design specifications?
    - Did the team present both stated and derived requirements?
    - Did the team present how the requirements influenced their design?

- ***Functionality***
    - Did the team describe the functionality of the robot in detail? Including how each of the robot's tasks will be performed.
    - Did the team present block diagrams of major robot components?
    - Did the team discuss any prototyping or modeling that was performed (either successful or unsuccessful)?

- ***Research***
    - Did the team present any research performed regarding technical solutions (e.g., drive mechanisms, lift mechanisms, etc.)?

- ***Design Specifications (component and system)***
    - Did the team present component and system-level specifications? (e.g., capabilities and

technical specs)
        - e.g., weight, dimensions, speed, lift, structural integrity, power, processing, accuracy, etc.
    - Did the team use diagrams, tables, graphs, equations, calculations, simulations, and/or explanations to show "how" they arrived at specifications?

- ***Multi-discipline review***
    - Were multiple design disciplines represented in the review? Systems, mechanical, electrical, software, test, human factors, etc.

- ***Risk Assessment***
    - Did the team review known risks in their design, including alternate or back-up plans if the mission objectives are not able to be accomplished?

- ***Innovation***
    - Were innovative design elements or processes used?

- ***Lessons Learned***
    - Did the team share lessons learned?

4.5 Skills Challenges

Skills challenges may be offered at the hub's discretion for any competition format. Check your hub's ***2022 Awards and Judging – Hub Logistics*** document to see which skills challenges are offered. Because these skills challenges are optional, the rules, instructions, and evaluation criteria for each of the challenges are provided in separate rules documents.

- Robot Modeling Challenge
- Engineering Drawings Challenge
- Website Design Challenge
- Video Design Challenge
- Mathworks BEST IQ Challenge (National Level)

4.6 Additional Awards

Refer to Section 7 for details on additional awards provided at the Hub and Championship levels.

Section 5 BEST Award Components

5.1 Engineering Notebook (30 Points)

• The Engineering Notebook will be worth 30 points towards the BEST Award.

5.1.1 Notebook Requirements

• ALL participating teams are required to submit an Engineering Notebook at both the local competition and the regional championship following the requirements stated herein. All notebooks will be evaluated on a 30-point scale.

• For competitions having 32 or fewer total teams, the notebook scores of all teams will be used to determine which 4 teams earn a chance to participate in the single "wildcard" match. The winning wildcard team will be one of eight total teams that advance to the semifinals phase.

• For competitions having greater than 32 total teams, the notebook scores of all teams will be used to determine which 8 teams earn a chance to participate in one of the two "wildcard" matches. The two winning wildcard teams will be two of sixteen total teams that advance to the semifinals phase.

• The purpose of the notebook is to document the process the team used to design, build, and test their robot.

• The notebook must be delivered in electronic format (PDF only).

• Please see the ***2022 Awards and Judging – Hub Logistics*** document for information on when and how the notebook is to be submitted.

• The notebook must meet the following specifications:

  • The title page must identify the school, team name, teacher contact, and team number

  • 35 typed **single-sided** pages or less (note that the title page and Table of Contents page(s) will not be counted as part of the 35 pages)

  • The document should be formatted as standard, 8 ½" x 11" paper, double-spaced, 1" margins, and Times New Roman (preferred) or similar business-style font no smaller than 12 pt. Single spacing is acceptable in tables and outlines.

  • Teams may include a supplemental appendix of no more than 40 total pages of information. The appendix may include support documentation such as drawings, photos, organization charts, minutes of team meetings, test results, etc. *This material should directly support the process described in the primary document and NOT reflect activities related to community or promotional efforts, spirit development, or team building.*

5.1.2 Notebook Evaluation

• The notebook will be judged on the documentation of the team's:

  • ***Implementation of the Engineering Design Process***

    o Evidence that the engineering process was effectively used.

  • ***Research Paper***

    o Correlation between the current year's game theme and how related technological practices or scientific research is being used at a company/industry/research lab in the team's state or region; Any information related to the game theme, such as history, famous inventor(s), or major milestones; Analysis of the game theme/problem and the related technology's impact on the human experience, our needs, adaptations, and progress with solutions throughout history; Creativity in linking the game theme to

appropriately related science/technology content; Proper use of grammar and composition throughout the paper; citations of sources used to gather information for the paper

- The research paper must be a minimum of 2 pages and maximum of 5 pages (of the allotted 35 pages), including citations.

• ***Brainstorming Approaches***

- How well organized and productive was the brainstorming approach used? How well was the brainstorming approach documented?

• ***Analytical Evaluation of Design Alternatives***

- Use of analytical and mathematical skills in deciding upon and implementing design alternatives

• ***Offensive and Defensive Evaluation***

- Analysis of the gaming strategies and design elements used to achieve specific team goals

• ***Software Development Process***

- Evidence that a software development process was effectively used including
  - Project scope/requirements/specification ("what" the robot should do without stating how)
  - Design ("how" the software will achieve the scope/requirement/specification)
  - Implementation (tools, methods and techniques used in your programming)
  - Test/Verification (methods used to verify correct operation of the robot program)
  - Deployment (source code management, release, download frequency, etc.)
- Evidence that software design methods/techniques were explored and utilized.

• ***Safety***

- Evidence that safety training took place and safe practices were followed to prevent students' misuse of tools and other devices/equipment that may result in personal injury or damage to property

• ***Support Documentation***

- Team organization, team minutes, test results, CAD/other drawings, photos, etc. that support the main document

• ***Overall Quality and Completeness of Notebook***

- Organization, appearance, adherence to specifications, quality of content

5.2 Marketing Presentation (25 Points)

• The Marketing Presentation will be worth 25 points towards the BEST Award.

5.2.1 Purpose and Context

• The purpose of the Marketing Presentation is for students to learn how to address the needs of a potential client, share product and brand information and navigate the business environment.

• The Team's Role: To create a company that designs and manufactures robots (the product). • The

Judge's Role: To serve as the client who is looking to purchase a robot(s) to solve a problem(s).

- The Problem: Refer to the Game Specific Rules and research the real-world relevance of the game premise in today's industry.

The context for the presentation is as follows:

Your team is a business pitching your latest invention/product to a group of decision makers at BEST Inc. headquarters in response to a Request For Proposal (RFP). Your goal is to inform, persuade, and build trust between your company and your potential client.

Your company's brand promise will establish a shared understanding of the client's problem and how your product delivers the solution. The only details about the engineering team and the manufacturing process that need to be included are those that highlight the unique characteristics or how the characteristics differentiate your product from a competitor. Storytelling should be an important tool to add personality to your brand and create a stronger connection with your client.

BEST Inc. is very involved in community outreach. Share how your team, as a potential vendor embraces the same social responsibility.

To close the meeting, propose a formalized offer for the client.

5.2.2 Marketing Presentation Guidelines

- A minimum of 4 and maximum of 8 students may participate in the room for the presentation. Each student present must have an active role in the presentation.
- Participating teams will sign up for a presentation time to occur at a time designated by the local hub or championship.
- Only students may participate in the presentation/discussion, including setting-up and dismantling the presentations. Teachers, parents, mentors, and other loving adults are not permitted to watch the presentation.
- The only printed or other materials that teams may give to the judges are a brochure and business cards. No gifts for the judges please.
- Robots and models may be used during the presentation for demonstration purposes.
- Teams should represent diversity in grades, gender, race, ethnicity, and abilities. Teams are encouraged to share and demonstrate how their efforts are inclusive.

- Videotaping/photographing the presentation by students will be allowed; however, the person(s) handling recording devices will be counted in the maximum students allowed and therefore s/he will need to contribute to the presentation beyond capturing footage or images.
- The presentation format is the prerogative of the team.
- The team must provide any equipment it wishes to use or check with the local hub or championship for information about what equipment can be provided. See the ***2022 Awards and Judging – Hub Logistics*** for details of equipment provided at your hub/championship event.

5.2.3 Marketing Presentation Logistics

- There will be a check-in station in the general area of the presentation rooms where teams should check in prior to their time slot.

- The presentation/meeting will last for no more than twenty-five (25) minutes including any setup/breakdown. Teams are expected to begin with formal presentation.
- The meeting may become conversational with judges beginning to ask questions after ten (10) minutes of uninterrupted presentation by the team. The team may instigate a conversational format at any time, if desired. This is to encourage a business meeting atmosphere.
- Teams should use the judges' questions as cues and adapt their conversation. Be prepared to go off script and have a dialog exchange with the judges.
- At least five (5) minutes will be scheduled between presentation sessions to allow breaks for judges, rotations, and additional time to confer without the team present.
- The local hub or championship will provide event-specific information (times, locations, etc.). Refer to the ***2022 Awards and Judging – Hub Logistics*** document for these additional details.

5.2.4 Marketing Presentation Evaluation

Presentations will be evaluated with consideration of:

- ***Company Overview***
  - The team introduced themselves and explained their roles within the company.
  - The team expressed a mission statement for their company stating the company's purpose for being, encapsulating culture, values, and ethics.
  - The team created a consistent brand and brand promise – the value or experience customers can expect to receive every time they interact with the company.
  - The team created a strong visual identity based on the brand and mission statement. • The team defined their public image through their publicity, social responsibility, and community awareness activities.
  - The team explained their budgets and expenses, including any funding sources (sponsors or in kind contributors, fundraising events, etc.).
  - The team included their company sustainability and 1-year company outlook including employee development, recruitment, and training.

- ***Product Features***
  - The team clearly defined the problem and the customer priorities.
  - The team explained their product's features and how the product's benefits solve the client's problem.
  - The team clearly defined how the product is unique, desirable and produces a benefit(s) to the client.
  - The team identified factors that differentiate their brand and product from the competition. • The team used visual aids to effectively enhance the presentation.
- ***Business Offer***
  - The team explained the product's acquisition cost and manufacturing cost.
  - The team proposed their delivery and aftermarket support including warranty and training for the client's workforce to operate and/or maintain the product.
  - The team proposed a formal offer to the client (judges).
- ***Business Professionalism***
  - The team met the 4-8 participant guidelines and was dressed professionally, or theme based. •

The presentation was understandable, well organized, and prepared.
- The team was conversational and engaged in discussion.
- The team included testimonials to support research or success stories.
- The presentation was creative and interesting.

5.3 Team Exhibit and Interview (20 Points)

- The Team Exhibit and Interview will be worth 20 points towards the BEST Award.
- The purpose of the Team Exhibit is for students to display a visual story of the team's company, product, outcomes, and impact including communicating the company brand, student learning and community outreach.
- The purpose of the Interview is to
    - strengthen students' communication skills (as listeners and speakers),
    - validate their knowledge and understanding of the work done by the entire team,
    - spotlight community outreach and publicity activities, and
    - communicate/share their experience and lessons learned.

5.3.1 Team Exhibit and Interview Guidelines

- Hubs hosting a Classic competition may choose to implement Physical or Virtual Team Exhibits. Refer to the ***2022 Awards and Judging – Hub Logistics*** document for details on which format your hub will implement.
- Championships may choose to implement Physical Team Exhibits or Virtual Team Exhibits, or both; the championship Team Exhibit format will be communicated following your hub kickoff.

5.3.1.1 Virtual Team Exhibits

- Virtual Team Exhibits will be implemented using a dedicated WordPress website for the team.
- The Virtual Team Exhibit must use the system provided through the BEST National Registry Team Workflow page.
- Only those themes and widgets available through the virtual exhibit template can be use. •

Native html coding is allowed.

- Primary exhibit content should be placed on the front page.
- Pages other than the HOME page are allowed for additional content. The virtual exhibit should not exceed 3 additional pages.

5.3.1.2 Physical Team Exhibits

- Refer to the ***2022 Awards and Judging – Hub Logistics*** document for standard table size at your local hub competition and availability. At championships, each team may be provided with a standard six-foot long table (approximately 29 inches wide) upon request. Skirting for the table will not be provided.

- An 8’ X 8’ X 8’ exhibit space will be allocated per team at your local hub and the championships. All exhibit content must remain within the defined exhibit area.
- All exhibits must display the national BEST Robotics logo in plain view
- Teams are encouraged to use recycled, upcycled and repurposed items and to avoid using expensive store-bought display boards and structures. Consideration is given to creative and hand-made exhibit props.
- Each team should bring one extension cord and one power strip for any electrical needs. Refer to the ***2022 Awards and Judging – Hub Logistics*** document for possible electricity and electrical limitations at your local hub competition.
- Any audio-visual equipment and extra extension cords will be the responsibility of the team. •

Each team is responsible for the security of its own material.

- Each team is responsible for breakdown of its team materials and clean-up of its exhibit area following the awards ceremony on Game Day.
- All material should be clearly marked with the appropriate identification and contact information.
- Refer to the ***2022 Awards and Judging – Hub Logistics*** document concerning when and where team exhibits can be set up at your hub or championship competition.
- Candy and other food and drink items are not permitted at exhibits as complimentary handouts. Refer to the ***2022 Awards and Judging – Hub Logistics*** document concerning specific rules for your hub or championship competition.

5.3.1.3 Student Interviews

- During the scheduled interview time, at least one student representative from the team must be present who is able to respond to informal questions asked about the exhibit. In addition, students should be aware that judges may ask questions concerning robot design and construction. These questions will be part of the interview evaluation of the team.
- Teams should expect to be evaluated by two to four different judges during a single interview period.
- In addition to the scheduled interviews at a Classic competition, the judges may also interview team members in the pit area and in the seating area at any time.

5.3.2 Exhibit and Interview Evaluation

Exhibits (6 points) will be evaluated on:

- Creativity – The team demonstrated creativity in incorporating the game theme into the design and presentation of this exhibit. The exhibit is unique, and the game/industry theme is very prominent.
- Technology - The exhibit effectively balances the use of print, models, multi-media, graphics, and other technology.
- Aesthetics – The exhibit is cohesive, engaging, and interactive. Information is logically arranged.

The area is neat, clean, and well-organized.

- Compliance – The team, hub and national logos and branding are clearly visible. All sponsors are clearly displayed. The team adhered to all specifications set forth by the Hub/Championship. The students showed evidence that they were the primary designers and builders of their product (robot), team exhibit and all related materials.

Student Interviews (14 points) will be evaluated on:

- Company Elevator Speech and Branding
  - The team clearly defines what benefits the product (robot) delivers.
  - The team explains their outreach and social responsibility.
  - The team conveys the company's brand through tone and language.
  - The brand promise (the service/reputation your company offers the customer) is evident throughout the exhibit and in the student interviews. The team effectively explains how the product illustrates the company brand.
- Knowledge and Experience with BEST
  - Knowledge – Students easily and thoroughly answer technical questions about the product (robot), team exhibit, and related materials. They show a deep understanding of the design and construction of the robot and exhibit; adult contributions are mentioned purely in an advisory capacity.
  - Learning – The students clearly express an understanding of the game theme/problem and their own learning experience. They clearly articulate lessons learned through experience. It is evident that they understand the game/industry theme well.

  - Enthusiasm – Students describe with obvious enthusiasm and positivity their experience in BEST and show a clear understanding of the organization's mission. Students communicate the impact of the BEST Robotics program on his/her path toward STEM or career choice through testimonials.
- Outreach
  - Sharing – The team demonstrates sharing of information and/or technology resources, and mentoring of other schools, including other BEST teams. There is clear evidence of support (through testimonials or storytelling) to other schools with information, technology, or encouragement.
  - Publicity/Demonstrations – Students effectively communicate their publicity methods (print materials, media/press), media platforms used, and specific presentations/demonstrations to other schools and community groups about BEST to generate excitement.
  - Inclusion – There is evidence of team diversity and that recruitment efforts include multiple grade levels and students from a cross-section of the school population. Specific efforts to promote inclusiveness are clearly identified.
  - Advocacy – Students communicate any fundraising and/or sponsorship efforts they implemented. They describe clear strategies for recruiting sponsors, team fundraisers, and how any funds raised were allocated to support the team (in a team budget that is available for review). The students present and demonstrate strong evidence of executing these efforts.

5.4 Spirit and Sportsmanship (10 Points)

• Spirit and Sportsmanship will be worth 10 points towards the BEST Award.

5.4.1 Spirit and Sportsmanship Guidelines

• Judges will evaluate this category on Game Day

• Judges will observe the spirit promoted by the team during their head-to-head competition matches as well as the team's conduct throughout the day in the seating area, team exhibit area, game floor, and pit area

5.4.2 Spirit and Sportsmanship Evaluation

• Spirit includes the vigor and enthusiasm displayed by team representatives

• Teams can use posters, props, t-shirts, cheerleaders, musicians, mascots, costumes, and lower frequency noisemakers to increase the level of spirit (Check the ***2022 Awards and Judging – Hub Logistics*** document to determine noise-maker restrictions for your local hub competition)

• Community involvement: number of team supporters present at competition (other than students)

• Sportsmanship includes outward displays of sportsmanship (e.g., helping other teams in need), grace in winning and losing, and conduct and attitude considered befitting participation in sports

• Overall team sportsmanship is also demonstrated by students (not mentors) making the majority of robot adjustments and repairs during the competition

5.5 Robot Performance (15 Points)

• The *Robot Performance* component will determine the final 15% of possible BEST Award points.

• Robot Performance points will be awarded based on the total game points earned throughout the seeding phase of the head-to-head competition (for BEST Classic competitions), according to the following scale:

- Team finishes in top 20% of all teams competing at hub 15 Points
- Team finishes in top 40% of all teams competing at hub 12 Points
- Team finishes in top 60% of all teams competing at hub 9 Points
- Team finishes in top 80% of all teams competing at hub 6 Points
- Team finishes in top 100% of all teams competing at hub 3 Points
- Team is unable to score any points during the competition 0 Points

• Up to 15 Robot Performance points will be possible

5.6 BEST Robotics Brand Usage Guidelines for Teams

Although BEST Robotics does not require teams to design websites or tee shirts or maintain a certain level of presence on social media, students are encouraged to explore options and we support their creativity. BEST Robotics also wants to ensure that our brand is presented in a clear and consistent manner across our footprint. Therefore, we ask students to follow these guidelines:

- Include the BEST Robotics national logo on all digital and printed materials.
- Team websites should include
    - On the homepage - the national logo and a link to national website

- Storytelling from students (video or quote with pictures)
- Testimonials from community leader (video or quote with pictures)

• Tee shirts should include the national logo, set apart from other sponsors or positioned above all other sponsors

• All social media posts during or about your team's outreach activities should include the hashtag: #BESTRobotics and tag @BESTRobotics.

Section 6 Advancement to Championship

The total number of teams a hub will be allowed to send to a championship is determined by the championship. Traditionally this number is related to the number of teams competing at the hub, the total number of teams in the region, and the maximum number of teams that the championship venue can accommodate.

If a championship is offered, the advancing teams will be selected using the following priority order:

1. BEST Award 1st Place
2. Game Head-to-Head/Time Trials 1st Place
3. BEST Award 2nd Place
4. Game Head-to-Head/Time Trials 2nd Place
5. BEST Award 3rd Place
6. Game Head-to-Head/Time Trials 3rd Place
7. BEST Award 4th Place
8. Game Head-to-Head/Time Trials 4th Place
9. BEST Award 5th Place
10. BEST Award 6th Place
11. BEST Award 7th Place
12. etc.……

The list above is intended to illustrate the qualification order, not necessarily the exact number of teams advancing from each hub. In 2021, hubs will have the option of foregoing any playoff phases (wildcard, semifinals, finals) and ranking Game head-to-head place based on seeding phase or dedicated time trials alone.

Exception to the qualification order:

A hub has the option to advance a Game winner OR a BEST Award winner at their discretion IF the hub is limited in the number of advancing teams that can participate in the BEST Award at the championship, and IF a BEST winner also places as a Game winner.

For example, if a championship allows four advancing teams per hub, BUT only two advancing teams can participate in the BEST Award, AND a Game winner is also a BEST Award winner at the hub level, a hub could be forced to advance a 3rd place BEST Award team that cannot compete in the BEST Award at the Regional level. In such a case, the hub can opt to send the 3rd place Game winner instead of the 3rd place BEST Award winner.

Section 7 Standard Awards

7.1 Hub-Level Awards

The following summarizes all hub level awards. Awards distributed may be dependent upon the competition; see the Competition Specific Awards section for details on which awards will be given at each BEST hub competition. Optional awards are given at the hub's discretion.

BEST Award

Awarded to the team that best embodies the concept of ***Boosting Engineering, Science and Technology***. Winning the BEST Award is considered the highest achievement any team in the competition can accomplish. First, second, and third place finishes will be awarded.

Head-to-Head Competition Award or Robot Performance Award

Awarded to the teams whose machines finish first, second, and third in the head-to-head robotics competition or Robot Performance Time Trials. A fourth place "finalist" may also be awarded.

Most Robust Machine

Awarded to the team whose machine requires the least maintenance during and between matches and is generally the sturdiest machine in the competition.

Founders Award for Creative Design

Awarded to the team that makes best use of the engineering process in consideration of offensive and defensive capabilities in machine design. Awarded in recognition of BEST founders Steve Marum and Ted Mahler.

BEST Critical Design Review Award

Awarded to the team presenting the best overall Robot Critical Design Review to the judges that

includes technical discussion of robot design features/functionality, requirements and strategies that influenced feature design, and the methods and results of each design discipline (mechanical, electrical, software, test, human factors, logistics, etc.).

Skills Challenges Awards

Awards are offered for multiple Skills Challenges categories. Awarded to the team with the highest cumulative score in the skill category as determined by the rubric or scoring method for that skill. The skills categories awards are:

- BEST Robot Modeling Award

- BEST Engineering Drawings Award
- BEST Website Design Award
- BEST Video Design Award
- BEST Engineering Notebook Award (at Hub's discretion)
- BEST Marketing Presentation Award (at Hub's discretion)
- BEST Team Exhibit Award (at Hub's discretion)

7.1.2 Classic Competition Specific Awards

7.1.2.1 Classic Competition

The following awards will be given at all BEST Classic Competitions, when multiple teams compete in a head-to-head fashion:

- Required awards:
  - BEST Award (1st – 3rd place)
  - Head-to-Head Competition Award (1st-4th place)
  - Founder's Award for Creative Design
  - Most Robust Design Award
- Optional awards (at hub discretion):
  - BEST Critical Design Review Award
  - Any Skills Challenge Awards

7.2 Regional Championship Awards

The following awards will be given at all BEST regional championships:

BEST Award

Awarded to the team that best embodies the concept of ***Boosting Engineering, Science and Technology***. Winning the BEST Award is considered the highest achievement any team in the competition can accomplish. First, second, and third place finishes will be awarded.

Head-to-Head Robotics Competition Award or Robot Performance Award

Awarded to the teams whose machines finish first, second, and third in the head-to-head robotics competition or Robot Performance Time Trials. A fourth place "finalist" award may also be awarded.

Founders Award for Creative Design

Awarded to the team that makes best use of the engineering process in consideration of offensive and defensive capabilities in machine design; awarded in recognition of BEST founders Steve Marum and Ted Mahler.

Most Robust Design

Awarded to the team whose machine requires the least maintenance during and between matches and is generally the sturdiest machine in the competition.

BEST Simulink Design Award

Awarded to one team in each of the 3 BEST regions (Denver, South's, Texas) that best applies MATLAB/Simulink based on the specified judging criteria and their robot's performance in the competition.

7.3 National Level Awards

The following awards will be provided at the national level, considering all participating

students: • BEST IQ Challenge (1^{st} – 3^{rd} place)