

3. ROBOT DESIGN, CONSTRUCTION & OPERATION

3.1 Safety Rules

(see complete list of rules in Appendix A)

- S1. Safety first. Due to the nature of the event in which electrical equipment, springs and tools are used, safety will not be compromised.
- S2. Safety glasses must be worn by all team members in the driver stations and player stations during matches, and in the pit area when working on robots. They are also highly recommended if your neighbor(s) in the pit are working on their robot.
- S3. Any robot which causes a safety hazard during a match will be disabled.
- S4. If at any time the referees determine that a robot is likely to cause safety hazards in future matches, the robot must be modified to the referees' satisfaction or it will not be allowed to compete.
- S5. No energy stored in a rubber band may be used to launch any projectile. This does not apply to the latex tubing provided in the Kit. However, the inner tubes are the only projectiles the latex tubing may be used to launch.
- S6. Projectiles must have a frontal area greater than or equal to 10 square inches and be shaped to avoid eye injury.
- S7. **Do not tamper with the power supply, batteries, chargers, speed controllers, joysticks, or any other control system component except as noted in the control system rules.** Tampering could result in failure or malfunction of the control system, and lead to a safety hazard or damage to the robot.
- S8. Remove batteries from the robot while making adjustments to your robot. Due to the strength of the motors in the Kit, it is important to keep fingers away from the gears while your robot is connected to a power supply.
- S9. The batteries may deliver more than 100 Amperes. Do not let the wires come into contact with any metal surfaces. Route wires carefully to avoid damage and short circuits, which may cause serious burns, fire, and/or permanent destruction of the batteries.

3.2 Design & Operation Rules

(see complete list of rules in Appendix A)

- M1. The energy used by the robots in The Competition must come solely from:
 - electrical energy derived from the onboard battery packs
 - storage achieved by deformation of springs or the latex tubing provided in the Kit
 - compressed air (or vacuum) stored in the air accumulator

- a change in the altitude of the device's center of gravity.
 - storage achieved by deformation of springs purchased from Small Parts, Inc. (SPI) Latex tubing from SPI may not be used as a spring.
- M2. Robots must sit, unconstrained, inside a 36" square footprint and be no more than 48" high at the start of a match. The weight of the robot, including batteries and control system, may not exceed 120.0 pounds.
- Size \leq 36" long x 36" wide x 48" high; Weight \leq 120.0 pounds**
- Keep in mind that these are maximum dimensions. It is recommended that robots be designed for slightly smaller dimensions and weights in order to allow a degree of tolerance for oversized/overweight mechanisms and differences in measurement between the team and the official inspection. Many teams have discovered the hard way that reducing size and weight while preserving functionality is no easy task after the robot has been constructed.*
- Also, many shippers such as UPS will not ship packages as large as a full robot. Many teams have found it helpful to make ease of disassembly and reassembly one of the design goals.*
- M3. All robots will be weighed and measured during the practice day at each Competition event and may be re-inspected anytime during an event. If modifications to your robot are necessary to meet the above requirements, they must be completed before seeding matches begin.
- M4. **Teams are expected to design and build robots to withstand vigorous amounts of interaction with other robots.** (See also rules T6-8.)
- M5. Until the controls are enabled at the beginning of each match, robots and any appendages, extensions or projectiles must remain unconstrained within the 36"x36"x48" starting size. Once a match begins, robots may extend beyond that limit under their own power.
- M6. Robots must be designed to operate by reacting against the surface of the playing field, the innermost face of the 4x4 field border, the goal, the tubes, the other robots, and the air. (See Section 2.2 for Field Diagrams.)
- M7. **Robots must display their team company and school names and/or logos. The judges, referees, and announcers must be able to easily identify them by name. In addition, team numbers must be displayed on at least two opposite sides (180 degrees apart) of the robot. Numbers should be at least 3 inches high and clearly visible from a distance of not less than 50 feet.**
- M8. During a match, robots may be manipulated only by the normal operation of the wireless programmable control system.
- M9. Gaining traction by using adhesives or by damaging the surface of the playing field or the tubes is not allowed. (See also Rules T9-10.)
- M10. During any Competition event, any mechanism which will alter the operation of the robot may not be added or removed after the first match of the seeding rounds unless mandated by the judges for rule compliance reasons. However, mechanisms existing on the robot may be reconfigured

between matches. Also, the control system may be reprogrammed as described in the control system rules between matches.

- M11. No substitute robots are permitted; however, functionally identical replacement parts are allowed.
- M12. Only items listed under the PNEUMATICS section of the Kit list may be used to store, generate, or transmit compressed air or vacuum, with the following exceptions:
- Suction cups may be fabricated from legal Kit parts, as defined in rule K1 below.
 - Pneumatic fittings from Small Parts, Inc. may be used.

Custom-made pneumatic fittings, air cylinders, pumps, air accumulators, and so forth are not allowed, even if they are created from components included in the kits. Also, valves, syringes, tubing, and so forth from SPI or outside sources may not be used for pneumatics.

3.3 Control System Rules

(see complete list of rules in Appendix A)

- C1. The control system is provided to allow wireless control of the robots. The Transmitter box, Receiver box, servos, speed controllers, RNETs, antennas, batteries, battery chargers, power supply and joysticks may not be tampered with, modified, adjusted or marked in any way, with the following exceptions:
- the dip switches on the Transmitter and Receiver may be set for custom operation.
 - the user programmable code in the Receiver may be customized.
 - the speed controllers may be calibrated as described in the Tekin REBEL Owner's Manual.
 - The connectors on the ends of the 12 AWG wires on the Tekin REBEL Speed Controllers must be removed. Do not remove the connector on the 24 AWG, 3 wire PWM cable.

Tampering includes drilling, cutting, machining, gluing, rewiring, etc. All items listed in Rule C1 must be mounted without alteration. Do not write on or otherwise mark control system components.

- C2. Do not attach tape, stick-on hook & loop fasteners, glue, or other adhesives to control system components. We will re-use many of these components, and these items can be difficult to remove. Instead, use clamps, straps, or existing holes for mounting. The only exceptions to this rule are:
- Tape may be used to secure the position of the trimmers on the Joysticks in order to prevent accidental changes in calibration.
 - Stick-on hook & loop fasteners may be used to attach the speed controllers.

For mounting control system components, use mechanical fasteners, such as cable ties, straps, or brackets. Do not use tape, stick-on hook & loop fasteners, glue, or other adhesives.

- C3. The black/almond project box is intended to serve as a mounting point for the rocker switches and potentiometers and to enclose the associated wiring. You may modify the project box in any manner to accommodate your needs. It may not be used on the vehicle.
- C4. **Only the wire supplied in the Kit may be used to conduct electricity.** Additional wire is not permitted.
- C5. Electrical devices may only be wired as described in Section 4. Some important facts are listed here in Section 3.3.
- C6. The 12 gauge wire must be used for connections from the batteries to the speed controllers, from the speed controllers to any motors, and from the batteries to the Receiver box.
- C7. The 16 gauge jacketed cable must be used for any device connected to a relay output.
- C8. The 22 and 24 gauge wire may only be used for connecting sensors (limit switches, reed switches, rocker switches, air pressure switches, potentiometers) to inputs or for extending the PWM cables.
- C9. **Relay outputs may not power more than one device per output.** (The double-solenoid valve is considered one device, because the diodes may be used to route power to only one solenoid at a time.)
- C10. **Only the Receiver, speed controllers, and muffin fan may be connected directly to the battery outputs.**
- C11. The battery contacts inside the Skil drill shells must be used to draw power from the batteries. If the handle part of a drill shell is cut away from the main body, the wire side of the contacts must be insulated with heat shrink tubing or electrical tape to prevent short circuits.
- It is strongly recommended that the contacts be used in conjunction with the handle of the drill shell and the battery clip at the end, as they are designed to hold the battery snugly yet allow for easy changeover of batteries.*
- C12. The Skil drill motors may be powered only by the Tekin speed controllers.
Do not connect the drill motors to the relay outputs.
- C13. No more than one motor may be powered by each Tekin speed controller.
- C14. The Delco seat motors and Delphi tape drives may be powered by the Tekin speed controllers or the relay outputs.
- C15. Two 0.1 μ F capacitors, included with each speed controller, must be installed on each motor connected to a speed controller, as described in the Tekin REBEL Owner's Manual.

- C16. One 20A circuit breaker (provided in the Kit) must be installed in series with each drill motor. The circuit breaker must be accessible for inspection at each Competition event.
- C17. One 30A circuit breaker (provided in the Kit) must be installed in series with the positive terminal on each battery contact, such that all battery output flows through this breaker before being distributed to the Receiver, speed controllers, fan, or other battery. The circuit breaker must be accessible for inspection at each Competition event.
- C18. Only the 9 volt power supply included with the Kit should be used to power the Transmitter box. Use of an alternate power supply could damage the Transmitter box or RNet and is therefore prohibited.
- C19. Do not connect 12 volt power or ground wires to the relay outputs. Doing so will cause a short circuit and may damage the Receiver.
- C20. Do not connect power or other outputs to the sensor port on the Receiver. Power for sensors is available from the sensor port.
- C21. Any sensors used on the robot must be connected directly to the sensor port on the Receiver, and may not be wired in series with the motors, pumps, or valves.
- C22. R Nets may not be used in the Pit Area at any Competition event. A tether must be used for bench testing.
- C23. If the control system is damaged due to improper wiring or misuse, FIRST will charge for repair or replacement of the affected items. (*See Section 3.7 for details.*)
- C24. Robots must only be operated with both batteries present and wired in parallel.
- Operating a robot with only one battery can permanently destroy the battery. Don't do it!**
- C25. All wires distributing power with a constant polarity (i.e. not a relay or speed controller output) must be color coded as follows:
- Use Red 12 AWG or White 16 AWG wire for +12Vdc.
 - Use Black 12 or 16 AWG wire for GND.
- C26. **Teams are responsible for any software bugs introduced into the Receiver's control program when using a custom program. If a software bug negatively impacts the performance of a robot during a competition match, it will not be grounds for a rematch or even a pause in the match.**

3.4 Materials Usage & Limitations

(see complete list of rules in Appendix A)

- K1. Each robot must be constructed exclusively from materials provided in the Kit of Parts ("the Kit") supplied by FIRST, with the following additions and exceptions:

- 2' x 4' x 1" ROHACELL™ P170 structural foam shipped to each team from FIRST.
- Material available from outside sources, as explained below.
- Material satisfying the unlimited quantity criteria, as explained below.
- The Kit container, part packaging, and any documentation in the Kit container may not be used to build the device.
- Adhesive tape may not be used except as an electrical insulator.
- Lubricants may not be used except to reduce friction within your own robot.

Outside Sources - Small Parts, Inc. Catalog

Each team receives an account with a \$425 credit balance which will be debited for the actual purchases you make. You may go beyond this dollar limitation for prototyping or to purchase spare parts, but your team is responsible for paying the balance on the account. See Appendix D for more details on accounting and ordering.

Up to \$425 worth of materials purchased from Small Parts, Inc. may appear on your final robot. Items which appear below in the unlimited quantity category do not count against the \$425 limit when used as described.

It has been brought to our attention that the actual prices of components purchased from Small Parts, Inc. may not match the prices printed in the catalog. Please use the catalog prices when calculating the cost of robot components from SPI for compliance with the \$425 limit.

If you use only a portion of what you buy from Small Parts, you may prorate the dollar amount used to the smallest quantity listed for purchase in the catalog. For example, if you buy 5' of rod which could have been purchased by the foot, but end up using only 6", you may calculate the amount used as the purchase price for one foot.

Outside Sources - Additional Hardware List

Materials on the Additional Hardware List may be obtained from any supplier, but in limited quantity. A specific list of materials and maximum quantities/dimensions is provided in Section 3.6. Cost is not considered.

If an item on the Additional Hardware List is available from Small Parts, Inc., then it may be purchased from SPI without being counted against the \$425 limit on materials purchased from SPI. However, any amount of the item purchased from SPI above and beyond the quantity allowed in the Additional Hardware List will count against the \$425 limit. Obviously, any item purchased from SPI will count against your credit limit, regardless of whether or not it is listed in the Additional Hardware List.

Unlimited Quantity Items

The following items may be used in unlimited quantity subject to the following criteria. (See rule K9)

- Fasteners, washers and adhesives -- if used for joining and fastening purposes only.
- Fasteners -- if used as pins in a linkage or as hinge pins.
- Crimp-on spade connectors -- if used to conduct electricity, used with the proper gauge wire, crimped properly, and fully insulated, such as the Thomas & Betts units provided in the kits.
- Adhesive tape -- if used as an electrical insulator.
- Lubricants -- if used to reduce friction within your own device.
- Teflon tape -- if used around the threads of pneumatic fittings to prevent leaks.
- Shrink wrap tubing of any diameter -- if used for electrical insulation.
- Pipe fittings (tees, reducers, elbows, and angles) -- if used to join sections of pipe
- Endcaps -- if used to cap pipe.

K2. Many of the materials in the Kit are raw materials. They are intended to be used for manufacturing structural or mechanical parts for your robot.

K3. There is no restriction on the total quantity of sprockets/pulleys and chain/belt that can appear on your robot. However, there is a restriction on the amount which can be obtained from outside sources other than SPI. (See the *Additional Hardware List and Rule K4* .) Any quantity above the amount listed on the Additional Hardware List must therefore be purchased from SPI, or manufactured from raw materials available from either the Kit, the Additional Hardware List, or SPI.

K4. As denoted in the Additional Hardware List, each team may purchase from an outside source sprockets (not gears) and/or pulleys and additional chain and/or belt, with the following conditions:

- On your final robot, you may use no more than a combined total of 4 sprockets and/or pulleys from outside sources other than SPI.
- On your final robot, you may use no more than a combined total of 10' of chain and/or belt from outside sources other than SPI. There are no restrictions regarding pitch or width of chain and/or belt. However, you may not purchase a wide belt, slice it lengthwise, and use more than a 10' length in the final robot.
- These components must be "commercially available," strictly *off-the-shelf* only. No custom or special orders.
- A double-sprocket or double-pulley assembly counts as two sprockets or pulleys, respectively.

- K5. Gears (not sprockets) must be purchased from SPI, or manufactured from raw materials available from either the Kit, the Additional Hardware List, or SPI.
- K6. The dimensions for sheets and boards listed in the Additional Hardware List represent the maximum length and maximum width which may be purchased, not the total area. The thickness represents a fixed quantity, not a maximum.
- K7. The dimensions for rods and shafts listed in the Additional Hardware List represent the maximum length that may be purchased for a given diameter of rod/shaft.
- K8. You may purchase only one of the three types of 1/2" or thicker wood listed in the Additional Hardware List; Plywood, Chipboard, or Particleboard.
- K9. Items listed as unlimited quantity items, when used without satisfying the criteria for unlimited use, must be purchased from SPI against the \$425 limit or manufactured from raw materials available in the Kit, from the Additional Hardware List, or from SPI.
- K10. Net material is allowed; however, if it is used to entangle opponents' robots, the referees may disallow it.
- K11. For safety reasons, you may not fabricate your own springs. However, it is acceptable to elastically deform and relax materials not designated as springs as long as the rate at which the energy is released does not exceed the rate at which the energy was stored. This is intended to allow reasonable use of the elastic properties of materials without creating unsafe conditions caused by sudden the release of stored energy in materials not designed to act as springs. Materials which are designated as springs include: All items listed in the Springs section of the Kit List, and compression, tension, torsion, constant force, and washer springs available from Small Parts, Inc. Latex tubing from SPI is not considered a spring.
- K12. A limited number of replacement parts will be made available by FIRST upon justified request. Otherwise, lost or damaged Kit materials may be replaced only with identical components of the same material, dimensions and treatment at the team's cost.
- K13. Materials in the Kit may not be changed chemically with the following exceptions:
- rope ends may be singed to prevent loose ends or to bind them together
 - resin and hardener may be mixed to produce epoxy.
 - metal may be heat treated in order to improve surface hardness
 - metal may be anodized to improve appearance

Completely melting and recasting a material is considered a chemical change. However, merely heating a material, such as a sheet of polycarbonate or ROHACELL™, in order to bend it into a new shape without cracking is not considered a chemical change.

- K14. The mailing tubes provided in the Kit are considered packaging material and may not be used during any Competition event.
- K15. All unused parts and materials must be returned to FIRST for proper recycling.
- K16. The control system is the property of FIRST and certain components must be returned at the conclusion of The Competition. The control system is not for sale. Teams wishing to borrow the control system for a limited amount of time after The Competition may do so by following the procedures outlined in Section 5.5. For teams that wish to operate their robots after this period, FIRST can provide basic instructions on how to refit the robots to use off-the-shelf remote control systems.

3.5 Kit of Parts

The following pages are a detailed packing list for all Components which make up the official Kit of Parts. A checklist has been included in your Kit which you should use as you go through the Kit to be sure you have received all parts. This checklist should be signed by a team member and returned to a FIRST staff member as you leave the Kickoff Workshop. Any materials you did not receive will be shipped to you as soon as possible.

List of Components

Bearings

Part Name/Description	Dimensions	Location	Qty /Kit	Product Supplier
2 Bolt Self-Aligning Flange	fits 1" bearing	Gray Container	2	The Torrington Company
2 Bolt Self-Aligning Flange	fits 1/2" bearing	Gray Container	8	The Torrington Company
Radial Ball Bearing w/Spherical OD	1/2" i.d., self locking collar	Gray Container	4	The Torrington Company
Radial Ball Bearing w/Spherical OD - for	1" i.d., self locking collar	Gray Container	1	The Torrington Company
Single Row Radial Flanged Ball Bearing	1/4" i.d.	Gray Container	4	The Torrington Company
Single Row Radial Flanged Ball Bearing	3/8" i.d.	Gray Container	4	The Torrington Company

Control System

Part Name/Description	Dimensions	Location	Qty /Kit	Product Supplier
2 Conductor Jacketed Wire	15', #16 AWG	Gray Container	1	General Cable
2 Conductor Jacketed Wire	20', #24 AWG	Gray Container	1	General Cable
2 Pin Power Connector	Black, European style header	Gray Container	1	Augat RDI
25 Pin Cable	DB25 Male to Female, 6' ,	Green	1	Brevan Electronics
25 Pin Connector	DB25, solder cup, male	Gray Container	2	Brevan Electronics
3 Conductor Shielded Wire	20', #24 AWG	Gray Container	1	General Cable
3 Headed Cable	DB9 F, DB9 M, High Density	Green	1	Brevan Electronics
8 Pin Connector	European style header	Gray Container	2	Augat RDI
9 Pin Cable	DB9 Male to Female, 6' ,	Green	2	Brevan Electronics
Battery Charger		Green	2	Emerson Electric
Battery, rechargeable	12 Vdc	Green	4	Emerson Electric
Circuit Breaker for Batteries	12 volt, 30 Amp, auto-resetting	Gray Container	2	Snap-Action, Inc.
Circuit Breaker for Drill Motors	12 volt, 20 Amp, auto-resetting	Gray Container	2	Snap-Action, Inc.
Crimping Tool for Spade Connectors		Green	1	Thomas & Betts Corp.
Diode	1 Amp max	Gray Container	2	Brevan Electronics
Dongle	DB9 Female, #1-8	Kick Off Check	1	Brevan Electronics
Flightstick Joystick	7 ft cable with Male DB15	Green	2	CH Products
Heat Shrink Tubing	3/4"Ø x 1', Black, 2:1 Shrink	Green	1	Raychem Corporation
Heat Shrink Tubing	3/8"Ø x 2', Black, 2:1 Shrink	Green	1	Raychem Corporation
Knob for Potentiometer		Shipped to	2	FIRST
Limit Switch		Gray Container	10	Honeywell - Microswitch Division
Muffin Fan	12 Vdc	Green	1	PAR Associates
Plastic Hood for 25 Pin Connector	fits DB25	Gray Container	1	Brevan Electronics
Potentiometer	50KΩ, linear	Shipped to	4	FIRST

List of Components

Power Connector for Valves	12 Vdc, Gray	Green	3	Numatics, Inc.
Power Supply	9 Vdc, 1.0 Amp max	Green	1	Golden Pacific Electronics, Inc.
Programming Software for Control	3.5" HD Floppy	Shipped to	1	FIRST / Parallax, Inc.
Project Box	Black or Almond	Green	1	Serpac
Receiver Box		Shipped to	1	FIRST
Reed Switch	Normally open, magnet	Gray Container	4	CP Clare
RNET 9600slm + Antenna (for	DB9 female	Shipped to	1	Motorola
RNET 9600slms + Antenna (for	High Density DB15 female	Shipped to	1	Motorola
Rocker Switch		Shipped to	8	Honeywell - Microswitch Division
Rocker Switch Cover	Black	Shipped to	1	Honeywell - Microswitch Division
Rocker Switch Cover	Blue	Shipped to	2	Honeywell - Microswitch Division
Rocker Switch Cover	Green	Shipped to	1	Honeywell - Microswitch Division
Rocker Switch Cover	Red	Shipped to	2	Honeywell - Microswitch Division
Rocker Switch Cover	White	Shipped to	1	Honeywell - Microswitch Division
Rocker Switch Cover	Yellow	Shipped to	1	Honeywell - Microswitch Division
Servo	Hitec/JR-style connector, 42	Green	2	Hitec RCD, Inc.
Servo Extension Cable	Hitec/JR-style, 36" long	Green	2	Hitec RCD, Inc.
Servo Y Cable	Hitec/JR-style, 24" long	Green	2	Hitec RCD, Inc.
Spade Connector	female, 12-10 AWG	Shipped to	20	Thomas & Betts Corp.
Spade Connector	female, 16-14 AWG	Shipped to	20	Thomas & Betts Corp.
Spade Connector	female, 22-18 AWG	Green	20	Thomas & Betts Corp.
Spade Connector	male, 12-10 AWG	Green	20	Thomas & Betts Corp.
Spade Connector	male, 16-14 AWG	Shipped to	20	Thomas & Betts Corp.
Spade Connector	male, 22-18 AWG	Green	20	Thomas & Betts Corp.
Speed Controller	7.2 - 12 Vdc, Reversing	Green	4	Tekin Electronics, Inc.
Terminal Strip	6 channel, tubular screw contact	Shipped to	2	Thomas & Betts Corp.
Tether Adapter	DB9 F-F, pins: 2->3, 3->2, 5->5	Green	1	Brevan Electronics
Transmitter Box		Shipped to	1	FIRST
Wire	16', #12 AWG, Black	Gray Container	1	General Cable
Wire	16', #12 AWG, Red	Gray Container	1	General Cable
Wire Nut	for 12 AWG wire	Gray Container	10	Home Depot
Wiring Harness for Air Pumps	fits Textron pumps, 6" leads	Green	2	McCord Winn Textron
Wiring Harness for Seat Motor	5', #16 AWG	Gray Container	4	Nova Biomedical

List of Components

Flexible Shaft Coupling	Black	Gray Container	4	FIRST
Folding Table Brace	9-1/2"	Green	4	Stanley Hardware
Hinged Hasp	3" Strap	Green	1	Stanley Hardware
Magnet	1/4-20 Plastic Thread	Gray Container	1	Honeywell - Microswitch Division
Magnet	8-32 Thread Mount	Gray Container	3	Honeywell - Microswitch Division
Pivot for Steel Track		Green	2	Stanley Hardware
Roller Guide for Steel Track	7/8" Ø x 1/4" wheel	Green	4	Stanley Hardware
Sash Guide w/Triangular Mount (LH)		Gray Container	1	Delphi Interior and Lighting
Sash Guide w/Triangular Mount (RH)		Gray Container	1	Delphi Interior and Lighting
Side Release Buckle	Fits 3/4" Strap	Gray Container	1	McMaster-Carr Supply Company
Steel Hinge w/ screws	3-1/2" x 3-1/2"	Green	2	Stanley Hardware
Steel Track w/Endstop	2'	Green	2	Stanley Hardware
Tape for Window Actuator (additional)	16'	Gray Container	1	Delphi Interior and Lighting
Trantorque Coupling	3/8" i.d, 3/4" o.d.	Gray Container	2	Small Parts, Inc.
Utility Draw Pull Latch	1-3/4" high x 3-9/32" wide,	Gray Container	1	McMaster-Carr Supply Company
Wheelchair Wheel	6" Ø, 5/16" i.d. bearings,	Gray Container	2	Skyway Recreation Products
Wheelchair Wheel	8" Ø, 5/16" i.d. bearings,	Gray Container	2	Skyway Recreation Products

Springs

<u>Part Name/Description</u>	<u>Dimensions</u>	<u>Location</u>	<u>Qty /Kit</u>	<u>Product Supplier</u>
Compression Spring	0.600" o.d. x 3" long x 0.059"	Gray Container	1	Associated Spring Raymond
Constant Force Spring, Large	1.02" i.d.	Gray Container	2	Associated Spring Raymond
Constant Force Spring, Medium	0.85" i.d.	Gray Container	1	Associated Spring Raymond
Constant Force Spring, Small	0.51" i.d.	Gray Container	2	Associated Spring Raymond
Latex Tubing	1/4" i.d., 3/8" o.d., 5'	Green	1	Totalmed
Small Tension Spring	0.650" o.d. x 2.875-3.000" long	Gray Container	1	Associated Spring Raymond
Snugger (Spring for Steel Track)		Green	4	Stanley Hardware
Spring Loaded Hinge	4" x 4", 30 in/lb max	Green	1	Stanley Hardware

Sprockets & Pulleys

<u>Part Name/Description</u>	<u>Dimensions</u>	<u>Location</u>	<u>Qty /Kit</u>	<u>Product Supplier</u>
Pulley with Fixed Eye	1 1/2" Ø, for 5/8" Rope	Green	2	Stanley Hardware
Pulley with Fixed Eye	1" Ø, for 5/16" Rope	Green	1	Stanley Hardware

Tools

<u>Part Name/Description</u>	<u>Dimensions</u>	<u>Location</u>	<u>Qty /Kit</u>	<u>Product Supplier</u>
5/32" Allen Wrench	comes with Spring Hinge	Green	1	Stanley Hardware

List of Components

Wiring Harness for Window Lift Motor	5', #16 AWG	Gray Container	2	Nova Biomedical
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Documentation

<u>Part Name/Description</u>	<u>Dimensions</u>	<u>Location</u>	<u>Qty /Kit</u>	<u>Product Supplier</u>
Kee Klamp Pipe Fitting Catalog + 2		Gray Container	1	Kee Industrial Products
Numacalc	manual and software for IBM	Green	1	Numatics, Inc.
Numatics Training Manual		Kick Off Check	1	Numatics, Inc.
Small Parts Catalog		Gray Container	2	Small Parts, Inc.

Fasteners

<u>Part Name/Description</u>	<u>Dimensions</u>	<u>Location</u>	<u>Qty /Kit</u>	<u>Product Supplier</u>
5 Minute Epoxy Gel	resealable 1 oz. dual syringe	Gray Container	1	McMaster-Carr Supply Company
Cable Tie	11.10" x 0.140"	Green	20	Thomas & Betts Corp.
Cable Tie	7.00" x 0.091"	Green	20	Thomas & Betts Corp.
Cable Tie Mounting Base	self-adhesive, holes for #8	Green	25	Thomas & Betts Corp.
Helical Plastic Wire Wrap	1/4" Ø x 24"	Gray Container	1	McMaster-Carr Supply Company
Hook & Loop Fastener	1" x 2', stick-on	Green	1	McMaster-Carr Supply Company
Rubber Band, Large	3-1/2" x 1/4" wide	Gray Container	5	Staples
Rubber Band, Small	3-1/2" x 1/8" wide	Gray Container	5	Staples
Velcro Stick Back Coins	5/8"Ø, 15 sets per pack	Green	1	Velcro USA, Inc.
Velcro Sticky back Hook & Loop Tape	3/4" x 18"	Green	1	Velcro USA, Inc.
Velcro Trunk Strap	5/8" x 15'	Green	1	Velcro USA, Inc.

Field Components

<u>Part Name/Description</u>	<u>Dimensions</u>	<u>Location</u>	<u>Qty /Kit</u>	<u>Product Supplier</u>
Apex Bracket for Game Goal	3 legged top joining bracket	Gray Container	1	Sylvester Sheet Metal
Rubber Inner Tube	KR14/15	Green	1	Carol Tire

Motors & Pumps

<u>Part Name/Description</u>	<u>Dimensions</u>	<u>Location</u>	<u>Qty /Kit</u>	<u>Product Supplier</u>
Battery Contact Assembly		Green	2	Emerson Electric
Battery Retaining Clip		Green	2	Emerson Electric
Drill Gear Shift Lever		Green	2	Emerson Electric
Drill Gearbox	1100/400 RPM, slip clutch	Green	2	Emerson Electric
Drill Housing, Right and Left Half	Holds motor, gearbox, battery	Gray Container	2	Emerson Electric
Drill Housing Screws	Torx Head T10 pan head	Green	14	Emerson Electric
Drill Motor	12 Vdc, with Metal Pinion	Green	2	Emerson Electric
High Output Lumbar Pump MWT Motor	12 vdc, 22 psi max, 3/16" o.d.	Green	1	McCord Winn Textron
Low Output Lumbar Pump Johnson Motor	12.vdc, 4 psi max, 3/16" o.d.	Green	1	McCord Winn Textron

List of Components

Seat Motor	12 Vdc	Gray Container	4	Delco Electronics Corporation
Window Lift Motor with Tape Drive	left hand side	Gray Container	1	Delphi Interior and Lighting
Window Lift Motor with Tape Drive	right hand side	Gray Container	1	Delphi Interior and Lighting

Other

Part Name/Description	Dimensions	Location	Qty /Kit	Product Supplier
Carpet Sample	12" x 12", 20 oz., closed loop	Gray Container	1	FIRST
Co-Polymer Gutter Guard	6" x 24"	Gray Container	1	Home Depot

Pneumatics

Part Name/Description	Dimensions	Location	Qty /Kit	Product Supplier
Adapter fitting for Pressure Switch	1/4" NPT female to 1/8" barb	Shipped to	2	Numatics, Inc.
Air Cylinder	1-1/16" bore, 4" stroke	Gray Container	1	Numatics, Inc.
Air Cylinder	7/16" bore, 12" stroke	Gray Container	1	Numatics, Inc.
Barbed Fitting	1/8" i.d. to 1/8 NPTF	Green	4	Numatics, Inc.
Barbed Fitting	1/8" i.d. to 10-32 UNF	Green	12	Numatics, Inc.
Barbed T-Connector	1/8" Ø barbs	Green	2	Value Plastics, Inc.
Check Valve	1/8" Ø barbs	Green	2	Air Logic
Detachable Barbed Connector	1/8"Ø to 1/8"Ø	Green	3	Value Plastics, Inc.
Detachable Barbed Reducing Connector	1/8"Ø barb to 1/4"Ø PTF	Green	1	Value Plastics, Inc.
Detachable Barbed Reducing Connector	3/16"Ø to 1/8"Ø	Green	1	Value Plastics, Inc.
Detachable Barbed Reducing Connector -	3/16"Ø to 1/8"Ø	Green	1	Value Plastics, Inc.
Detachable Rotating Barbed Connector	1/8"Ø to 1/8"Ø	Green	1	Value Plastics, Inc.
Double Solenoid Valve	12 VDC, 10-32 UNF-3B	Green	1	Numatics, Inc.
Numatrol Tubing	1/4" o.d., 1/8" i.d., 15'	Gray Container	1	Numatics, Inc.
Plug for Valves	10-32 UNF	Green	5	Numatics, Inc.
Plug for Volume Chamber	1/4"Ø PTF	Green	1	Value Plastics, Inc.
Polyurethane Tubing	3/16" i.d., 5/16"o.d. x 4'	Gray Container	1	Value Plastics, Inc.
Pressure Switch	1/4" NPT male thread	Green	2	Numatics, Inc.
Single Solenoid Valve	12 VDC, 10-32 UNF-3B	Green	1	Numatics, Inc.
Syringe	140 cc, Luer Lock Tip	Green	1	Lowell Medical Instrument
Volume Chamber	approx 1 liter, 1/4NPTF ports	Gray Container	1	Numatics, Inc.

Rods & Shafts

Part Name/Description	Dimensions	Location	Qty /Kit	Product Supplier
Aluminum Rod	1/2" Ø x 24"	Gray Container	2	McMaster-Carr Supply Company
Brazing Rod	1/16" Ø x 18"	Gray Container	6	McMaster-Carr Supply Company
Brazing Rod	1/8" Ø x 18"	Gray Container	2	McMaster-Carr Supply Company

List of Components

Delrin (Acetal) Rod	1/4" Ø x 24"	Gray Container	1	McMaster-Carr Supply Company
Drill Rod	1/2" Ø x 18"	Gray Container	2	McMaster-Carr Supply Company
Drill Rod	1/4" Ø x 18"	Gray Container	2	McMaster-Carr Supply Company
Drill Rod	3/8" Ø x 18"	Gray Container	2	McMaster-Carr Supply Company
Drill Rod	5/16" Ø x 18"	Gray Container	2	McMaster-Carr Supply Company
Drill Rod for Goal	1" Ø x 5"	Gray Container	1	McMaster-Carr Supply Company
Flexible Motor Shaft	13.5" long, Fits Seat Motor	Gray Container	4	Delco Electronics Corporation
LDPE Rod	1" Ø x 24"	Gray Container	1	McMaster-Carr Supply Company
Threaded Rod with 8 Hex Nuts	1/4" Ø x 24", 20 pitch coarse	Gray Container	1	McMaster-Carr Supply Company
Wooden Dowel	1/4" Ø x 18"	Gray Container	2	McMaster-Carr Supply Company

Sheets & Boards

Part Name/Description	Dimensions	Location	Qty /Kit	Product Supplier
Aluminum Plate	1/4" x 3" x 12"	Gray Container	1	McMaster-Carr Supply Company
Aluminum Sheet	1/16" x 12" x 18"	Gray Container	1	McMaster-Carr Supply Company
HDPE Block	1" x 2" x 6"	Gray Container	1	McMaster-Carr Supply Company
Masonite Board	1/4"x12" x 12"	Gray Container	1	Home Depot
Particle Board - Sample (see Add'l	5/8" x 6" x 12"	Gray Container	1	Home Depot
Pine Board	3/4" x 1-1/2" x 9"	Gray Container	1	Home Depot
Pine Board	3/4" x 2-1/2" x 9"	Gray Container	1	Home Depot
Pine Board - Sample (see Add'l Hardware	3/4" x 3-1/2" x 9"	Gray Container	1	Home Depot
Plywood	3/8" x 6" x 12"	Gray Container	1	Home Depot
Plywood - Sample (see Add'l Hardware	1/2" x 6" x 12"	Gray Container	1	Home Depot
Polycarbonate Sheet	1/16" x 12" x 12"	Gray Container	1	McMaster-Carr Supply Company
Rohacell© P170 Structural Foam	1" x 24" x 49"	Shipped to	1	Richmond Aircraft Products
Rubber Sheet, Black	3/32" x 6" x 18"	Gray Container	1	McMaster-Carr Supply Company
Rubber Sheet, Red	1/16" x 6" x 18"	Gray Container	1	McMaster-Carr Supply Company

Small Parts

Part Name/Description	Dimensions	Location	Qty /Kit	Product Supplier
4 - Tooth Tape Engaging Snap Clip		Gray Container	8	Delphi Interior and Lighting
Cabinet Catch Magnet w/ Plastic Case		Green	1	Stanley Hardware
Channel for Tape Drive	left hand side	Gray Container	1	Delphi Interior and Lighting
Channel for Tape Drive	right hand side	Gray Container	1	Delphi Interior and Lighting
Double Magnet Cabinet Catch		Green	1	Stanley Hardware
Flat Washers	1/4" i.d., 7/8" o.d.	Gray Container	4	McMaster-Carr Supply Company

3.6 Additional Hardware List

The parts listed on this page may be purchased from Small Parts, Inc. or other sources, and are subject to the limitations mentioned in Section 3.4.

Fasteners

Hose Clamp	up to 10 of any size
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Other

Fiberglass Matting	4' x 4' x up to 1/8"
Resin + Hardner	as needed for Fiberglass

Rods & Shafts

Closet Rod	1 1/4" Ø x 6'
Copper Water Pipe	1/2" Ø x 10'
Electrical Conduit Pipe (EMT)	1" Ø x 10'
Electrical Conduit Pipe (EMT)	1/2" Ø x 10'
Electrical Conduit Pipe (EMT)	3/4" Ø x 10'
Flexible Conduit (ENT)	1/2" Ø x 10', PVC
PVC Pipe	1" i.d. x 10', schedule 40
PVC Pipe	1-1/2" i.d. x 10', schedule 40
PVC Pipe	1/2" i.d. x 10', schedule 40
PVC Pipe	3/4" i.d. x 10', schedule 40

Rope, Belts, & Chain

Nylon Braided Rope	5/16"Ø x 20'
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Sheets & Boards

1/2" Plywood, 5/8" Chipboard OR 7/16" Particle Board	4' x 4'
Aluminum Plate	1' x 2' x 1/4"
Aluminum Plate	4' x 4' x 1/32"
Pine Board	3/4" x 3-1/2" x 10'
Polycarbonate Sheet	1/4" x 4' x 4'
Polycarbonate Sheet	3/8" x 2' x 4'

Sprockets & Pulleys

Chain/Belt to match Sprocket/Pulley	up to 10' total, any combo
Sprockets or Pulleys	up to 4 total, any size/combo

3.7 FIRST Policy on Repair and Replacement of Non-functional Control System Components

FIRST has developed the following policies on the repair and replacement of control system components.

If you experience a failure in any of your control system equipment, please call FIRST to insure that all components are correctly configured. If this does not resolve the problem, you will be instructed to follow the steps outlined below. Please note the differences in procedure based on the component that is determined to be non-functional.

- If, during examination of the failed components, the failure is determined to be due to misuse or mis-wiring, you will be charged according to the rates below.
- If the affected unit(s) failed due to a manufacturing defect, you will not be charged.
- Any team with an outstanding balance will not be allowed to register or compete at any Competition event until the balance is paid. Teams will be allowed to pay outstanding balances, by check only, at the registration desk at each Competition event.

Transmitter Box or Receiver Box

- 1) Ship the non-functional unit to FIRST.
- 2) Upon receipt of the unit, it will be examined to determine whether it can be repaired or must be replaced.
- 3) FIRST will ship the repaired or replacement unit to the team via 2nd day UPS shipment within 1 business day of receipt.
- 4) If the failure was determined to be a result of misuse or mis-wiring, the following charges will be assessed:

Replacement of Transmitter Board, or Receiver Board: \$150.00

Repair of Transmitter Board, or Receiver Board: \$50.00

Speed Controllers

The speed controllers have a 90 day warranty. Teams have the option of contacting Tekin for repair/replacement of defective units. Tekin estimates an approximate 3 day turnaround time from receipt of units to shipment of repaired/replacement units.

If teams wish to obtain a replacement speed controller through FIRST, we will provide a new unit, shipped via 2nd Day UPS, for the list price of \$205.00.

FIRST is able to provide these replacement speed controllers through a special arrangement with Tekin, and has only a limited number of speed controllers available. This policy is intended to provide teams with failed units a timely

method of obtaining replacements. Teams wishing to obtain spare speed controllers must go through regular retail channels.

If you do experience a failure, you should seriously consider the fact that if one speed controller failed with the current vehicle design, a replacement may also fail during The Competition. Carefully evaluate the abrupt startup and reversing loads on the motor, the interim and overall gear ratios, and the driving techniques used.

RNets

- 1) Ship both RNets to FIRST.
- 2) FIRST will ship a pair of replacement RNets via 2nd day UPS shipment within 1 business day of receipt.

Servos & Servo Cables

Replacements can be purchased from FIRST for \$15. These units will be shipped via 2nd day UPS air. As with speed controllers, FIRST has a limited number of servos available. Teams wishing to purchase spare servos may purchase equivalent models through regular retail channels.

Joysticks

The Flightstick joysticks have a 1 year warranty. Teams have the option of contacting CH Products for resolution of problems with defective units. Alternately, Flightstick joysticks are available in most computer stores.

Drill Motors and Gearboxes

There are only a limited number of replacement motors and gearboxes available.

If you have a burned out motor:

- 1) Ship the non-functional motor to FIRST.
- 2) FIRST will ship a replacement motor to the team via 2nd day UPS shipment within 1 business day of receipt.

If you have a non-functional gearbox:

- 1) Ship the gearbox to FIRST.
- 2) Seriously consider the fact that if a brand new gearbox failed with the current vehicle design, a replacement may also fail during The Competition. Carefully evaluate the shock loading of the gearbox, the interim and overall gear ratios, and the driving techniques used.
- 3) FIRST will ship a replacement gearbox to the team via 2nd day UPS shipment within 1 business day of receipt.

Note: If you modify the gearbox, and a failure occurs, FIRST will not provide a replacement.

Alternately, teams may purchase a new Skil 12 volt cordless drill from a standard retail outlet and use the motor and/or gearbox.

Seat Motors and Tape Drive Window Mechanisms

- 1) Ship the motor to FIRST.
- 2) FIRST will ship a replacement motor to the team via 2nd day UPS shipment within 1 business day of receipt.

As with other components, FIRST has a limited number of replacement motors available. Teams wishing to purchase spare motors may purchase equivalent models through General Motors parts distributors.