

APPENDIX A: ROBOT RULES

The rules governing robot construction are divided into three sections. See below for an explanation of the labeling.

<u>Prefix</u>	<u>Rules Designation</u>
M	M achine Design & Operation
C	C ontrol System
K	K it Materials Usage and Limitations

M Machine Design & Operation Rules

- M1. Energy used by FIRST Robotics Competition robots must come solely from:
- Electrical energy derived from the onboard battery.
 - Storage achieved by deformation of springs or latex tubing.
 - Compressed air stored in the pneumatic system, but only by the Pump included in the kit with a maximum pressure of 120 PSI.
 - A change in the altitude of the device's center of gravity.
- M2. Robots must:
- Sit, unconstrained, inside a 36"x30" rectangular footprint.
 - Be no more than 60" high unconstrained at the start of a match.
 - Weigh no more than 130.0 pounds. (Weight limit includes battery and control system)

Size ≤ 36" long dimension x 30" short dimension x 60" high; Weight ≤ 130.0 pounds

TIP: *Keep in mind that these are maximum dimensions. It is recommended that you design your robot 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/or weight while preserving functionality is no easy task after the robot has been constructed. Also, many shippers such as UPS and Fed Ex 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 their design goals.*

- M3. All robots will be inspected, weighed, and measured during the practice day at each FIRST Robotics Competition event. **The robot must pass inspection before competing in any competition matches, but is allowed to practice on Thursday before being inspected.** Robots may be re-inspected at anytime during an event at the discretion of FIRST. If modifications to your robot are necessary to comply with the Robot Rules, you must complete them before the robot will be allowed to compete in further competition matches. If a team wishes to have their robot re-inspected to ensure rules compliance, they may ask FIRST officials to do so. If you suspect that another team's robot is in violation of the robot rules, please approach FIRST officials and we will review the robot in question. This is an area where "Gracious Professionalism" is very important.
- M4. Teams are expected to design and build robots to withstand vigorous interaction with other robots.

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- M5. Until the controls are enabled at the beginning of each match, robots must remain unconstrained within the 36"x30"x60" starting size. Once a match begins, robots may extend beyond that limit under their own power.
- M6. Robots may be designed to operate by reacting against the carpeted surface of the playing field, the innermost face of the field border, the goals, balls, other robots, and the air. Robots should not be designed to react off of the top of the field border or other parts of the field border. If your robot inadvertently drives on the top of the field border, you will not be penalized unless the playing field is damaged.
- 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, teams must display their number on at least two opposite sides (180 degrees apart) of the robot. Numbers should be at least 5 inches high and clearly visible from a distance of not less than 50 feet.
- M8. Robots must use the rotating light provided in the kit to display alliance color (red or blue). The light must be mounted upright on the robot such that the color is visible in at least 4 locations 90 degrees apart around the sides of the robot from a distance of at least 50 feet. The light should be mounted to allow easy changeover of the colored lens before matches. *See Section 2.1.2 for wiring information.*
- M9. Teams may add "Non-functional" decorations to robots under the following conditions:
- Decorations must not cause the robot weight or size to exceed initial requirements.
 - Decorations must not affect the outcome of the match.
 - Any decorations, which involve broadcasting a signal to/from the robot, such as remote cameras, must be cleared with FIRST prior to use. 900 MHz camera systems may not be used.
 - Decorations may draw power from the control system as long as they are powered via a dedicated 20A or 30A circuit breaker and do not affect the operation of other control system components.
 - Non-functional decorations do not count against the quantity limits on Additional Hardware List items.
 - Decals, paint, bumper stickers, etc. are considered non-functional decorations.
 - Decorations **must** be on your robot at time of inspection.
- M10. You must design your Robot to be operated by the wireless, programmable control system.
- M11. Gaining traction by using adhesives or by damaging the surface of the playing field or the balls is not allowed. Using Velcro to adhere to the carpet has the potential to damage the carpet and is, therefore, prohibited.
- M12. During robot inspection, you must present *all* mechanisms that will be used on the robot at the event. It is acceptable, however, for a robot to play matches with a subset of the mechanisms that were present during inspection. Mechanisms that were present during the inspection may be added, removed, or reconfigured between matches. Also, you may reprogram the control system between matches.

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- M13. 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.
 - Tubing may be compressed in order to block the flow of air.
 - Tubing may not be compressed in order to generate compressed air or vacuum.
*Not Allowed: Custom-made pneumatic components (fittings, air cylinders, pumps, valves, etc). You may not use materials from **SMALL PARTS INC** (tubing, fittings, etc.) for pneumatics.*
- M14. Pneumatic components supplied in the Kit (pump, regulators, cylinders, valves, fittings, tubing, etc.) may not be modified except as follows:
- Tubing may be cut.
 - The wiring for the valves and pressure switch may be modified as necessary to interface with the rest of the control system.
 - The pressure switches may be calibrated by the normal operation of the adjustment screws.
 - Mounting and connecting pneumatics components using the pre-existing threads, mounting brackets, etc. is not considered a modification of the components.
- M15. All mechanisms on the robot should be fabricated/assembled by the 2002 team after the start of the Kick-off Workshop. Mechanisms may not be reused from previous year's robots.
- M16. Referees may disallow mechanisms that present a risk of entanglement.
- M17. The motors in the kit may **not** be modified except as follows:
- It is acceptable to modify the mounting brackets and/or other structural parts of the motors (output shaft, housing, etc.) as long as the electrical system is not modified and the integral mechanical system of the moving parts (bearings, bushings, worm gear output stages, etc.) is not changed or removed.
 - The gearboxes for the Fisher-Price, Drill, and Globe motors are not considered "integral" and may be separated from the motors. FIRST will not provide replacement for parts that fail due to modification.
- M18. In order to help reduce the impact forces that the robot will experience during collisions with other robots and/or the goals, teams may add external "bumpers" to the robot. If used, bumpers must satisfy the following constraints:
- Bumpers may extend outside the normal 30"x36"x60" robot starting dimensions as follows:
 - Bumpers may extend out (in the horizontal plane) from the 30"x36" robot base up to 4".
 - Bumpers may be located in a region from 2" to 8" above the playing field.
 - Bumpers may not cause the weight of the robot to exceed the 130.0 lb limit.
 - Bumpers must be removable in order to allow the 30"x36"x60" robot starting size to be easily measured during robot inspection.
 - Materials used for bumper construction are not restricted by Rule K1. Instead, the following restrictions apply:
 - Bumpers and any mounts that extend beyond the regular robot starting size may not contain "hard" materials such as metal, wood, or hard plastics. The definition of "hard" is one of common sense, i.e. if you can punch it and not hurt your hand, then it is ok.
 - Adhesive tape may not be used.

An example of an acceptable bumper design is a series of foam rubber tubes held in place by Velcro straps around the perimeter of the robot.

C Control System Rules

- C1. The control system is provided to allow wireless control of the robots. The Operator Interface, Robot Controller, Servos, Speed Controllers, Relay Modules, Radio Modems, Batteries, Battery Charger, Power Supply, 9 pin cables, circuit breakers, fuses, and joysticks may not be tampered with, modified, or adjusted in any way, with the following exceptions:
- The dip switches on the Operator Interface and Robot Controller may be set as appropriate.
 - The program select jumper on the Robot Controller may be set as appropriate.
 - The user programmable code in the Robot Controller may be customized.
 - The Speed Controllers may be calibrated as described in owner's manuals.
- Tampering includes drilling, cutting, machining, gluing, rewiring, etc. All items listed in Rule C1 must be mounted without alteration*
- C2. The Radio Modem connected to the Operator Interface must be able to reach the mounting bracket on the operator stations. Be sure to leave sufficient slack in the 9 pin cable.
- C3. The wire supplied in the Kit may be used to conduct electricity. The chassis of the robot may not be used to conduct electricity. You may use additional wire as long as it meets the gauge and insulation color requirements as described in Section 2.
- C4. Electrical devices may only be wired as described in Section 2 and/or Appendix A.
- C5. You must use 6 AWG wire to connect the battery to the 60A main circuit breaker and fuse panels.
- C6. You must use 10 AWG or larger diameter wire for connections to and from the Speed Controllers if they are used with the drill, Mabuchi, Fisher-Price, or van door motors.
- C7. You must use 16 AWG or larger diameter wire to connect Globe, Johnson, seat, or window lift motors to the Speed Controllers, from the Fuse Panels to the Robot Controller and custom circuit board for the large muffin fan, and for any connections to and from the Relay Modules. The only exceptions are that 24 AWG wire may be used to connect the small muffin fans, and any LEDs to the outputs of a Relay Module.
- C8. You must use 24 AWG or larger diameter wire for connecting sensors (switches, potentiometers, yaw rate sensor) to inputs, for extending the PWM cables, for the small muffin fans, or for wiring the LEDs.
- C9. A Relay Module may power no more than one motor or pump. Section 2.1.1 details acceptable Relay Module output configurations.
- C10. Only the Robot Controller, Relay Modules, Speed Controllers, 12 Vdc LEDs, Custom Circuit Board, Speed Controllers, and muffin fans may be connected directly to the 20A circuit breaker outputs. Only the Speed Controller may be connected to the 30 A circuit breaker outputs.
- C11. The drill motors, Mabuchi motor, Fisher-Price motors, Globe motors, and van door motors may only be powered by the Speed Controllers. Do not connect the drill motors, Mabuchi motor, Fisher-Price motors, Globe motors or van door motors to the Relay Modules.
- C12. No more than one drill motor, Mabuchi motor, Fisher-Price motor, Globe motor, or van door motor may be powered by each Speed Controller.

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- C13. The seat motors, window lift motors, Johnson motor, and 12 Vdc LEDs may be powered by the Speed Controllers or the Relay Modules. A maximum of two of these types of motors may be powered by each Speed Controller.
- C14. One 20A or 30A circuit breaker (provided in the Kit) must be installed in series with each Speed Controller on the +12 Vdc input. All circuit breakers must be accessible for inspection at each FIRST Robotics Competition event.
- C15. You must install the 60A circuit breaker in series with the positive terminal of the battery such that all battery output flows through the breaker before being distributed to any electrical component on the robot. The breaker must be accessible for inspection at each FIRST Robotics Competition event.
- C16. Do not connect 12 Vdc power, Relay Module outputs, Speed Controller outputs, or PWM outputs to the analog or switch inputs on the Robot Controller.
- C17. You must connect all sensors used on the robot directly to the analog or switch inputs on the Robot Controller or custom circuit board. Sensors may not be wired in series with the motors. It is acceptable to wire switches in series or parallel with each other.
- C18. If the control system is damaged due to improper wiring or misuse, Innovation First will charge for repair or replacement of the affected items.
- C19. During each competition match, your robot may be powered by only one of the two batteries provided by FIRST. *See Rule K9.*
- C20. When recharging Kit batteries, you may only use the charger provided by FIRST, or one with equivalent charging characteristics. *See Appendix G for charger specs.*
- C21. All wires distributing power with a constant polarity (i.e., not a Relay Module, Speed Controller or sensor output) must be color-coded as follows:
- Use Red or White wire for +12 Vdc and +5 Vdc connections.
 - Use Black wire for Ground connections.
- C22. Teams are responsible for any software bugs introduced into the Robot Controller's control program when using a custom program.
- C23. Teams are responsible for any unwanted or unanticipated robot behavior when using a custom circuit board.
- C24. The Robot Controller must be positioned within the robot so that its LED's may be seen during operation in a match. This will greatly facilitate analysis in case of problems and will be beneficial to you and field personnel during the FIRST Robotics Competition.

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- C25. Position the 12 Vdc battery within your robot so that it is accessible and may be easily changed out between matches, but is fastened in place, such as by straps, to keep it from falling out. The terminals on the battery must be insulated with electrical tape to reduce the risk of short circuits.
- C26. A Relay Module must power the rotating light provided in the kit such that it turns on when the robot is enabled, and turns off when the robot is disabled. Also, the light must be mounted upright and on a non-conductive surface such as plywood or polycarbonate. *See section 2.1.2 for details.*
- C27. The team number settings on the Robot Controller and Operator Interface must be set to the team number assigned to the team by FIRST.
- C28. Teams may not use Innovation First Operator Interfaces from previous years competitions.
- C29. Teams may construct a custom circuit board using allowed components from the Additional Hardware list. The circuit board must draw power from a 20A circuit breaker.

All outputs from the circuit board must be connected to the sensor inputs on the Robot Controller.

Inputs to the circuit board may be connected to the following sources:

- 20A or 30A circuit breaker outputs
- Speed Controller or Relay module outputs
- PWM or Relay outputs on Robot Controller
- Switches, Potentiometers, the Yaw Rate Sensor, Optical Sensors, Motors and other sensors allowed in the Additional Hardware list.

The custom circuit board may be used to indirectly affect the robot outputs, by providing enhanced sensor feedback to the Robot Controller to allow it to more effectively decide how to control the robot outputs.

Custom Circuit boards may not:

- Interfere with the operation of other robots
- Directly affect any output devices on the robot, such as by providing power directly to a motor, supplying a PWM signal to a speed controller, or supplying a control signal to the relay module. (High impedance voltages monitoring inputs or low impedance current monitoring inputs on the custom circuit board connected to the robot outputs are acceptable, because the effect on the robot outputs should be inconsequential.)
- Be used for wireless communication, such as sending or receiving a signal to and/or from the alliance station
- Connect to the programming, radio, or tether ports on the robot controller

K Kit Materials Usage & Limitations

- 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:
- Material available from outside sources, as explained below.
 - The Kit containers, 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 be used to reduce friction within the robot.

Outside Sources - SMALL PARTS, INC.

- You may use any part listed in the Small Parts, Inc. (SPI) online catalog. See Appendix D for details on SPI Ordering Information.

Outside Sources - Additional Hardware List

- *Materials on the Additional Hardware List may be obtained from any supplier, unless otherwise specified, but may be limited by size, quantity, or cost.* A specific list of materials and maximum quantities/dimensions is provided in Appendix C.

- 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. Items listed in the Additional Hardware List must be "commercially available," strictly *off-the-shelf* only. No custom or special orders. Items that are normally purchased in a custom size, such as an off-the-shelf belt cut to length for the customer, are not considered custom or special orders.
- K4. 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.
 - Springs from **SMALL PARTS, INC.**
 - Latex tubing.
- Pneumatic actuators may not modified or plugged in any way for use as a spring.
- K5. Teams may replace lost or damaged Kit materials only with identical components of the same material, dimensions and treatment.
- K6. 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
 - Metal may be anodized to improve appearance
- The melting and recasting of materials, such as a block of aluminum, is allowed as long as the basic alloy or chemical composition is not changed. Note, however, that other rules restrict which parts may and may not be modified. For example, the motors and pneumatic cylinders in the kit may not be melted and recast.
- K7. The mailing tube provided in the Kit is considered packaging material and may not be used on the robot.

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- K8. Although SPI can special order parts in sizes other than those listed in the catalog, special ordered parts may not be used on the robot. The only exception to this is for parts which are also listed in the Additional Hardware List.

- K9. The robot may not contain more than one of the batteries provided in the kit during a match.