

SPARC Robot Construction Specifications v1.6

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Content changes from SPARC Robot Construction Specifications v1.5 will be highlighted in blue. Modification for HORD in RED

1. Overview and Purpose

- 1.1. The SPARC Robot Construction Specifications was created to provide both builders and event organizers with an up to date and easy to implement ruleset.
- 1.2. The SPARC Standard Ruleset will call out areas where the rules are often altered by the events and will provide the most frequently used options for easy adaptation.
- 1.3. If you choose to utilize the SPARC Robot Construction Specifications and modify the rules to adapt to your event please note specific areas that differ from the standard SPARC rules in section 2.

2. Deviations From Robot Construction Specifications

- 2.1. This section is provided as a location to provide a brief outline of where the rules for a specific event differ from the SPARC Robot Construction Specifications.
- 2.2. All changes from the baseline SPARC Robot Construction Specifications shall be clearly highlighted to allow easy identification of deviations from the original document. Use a strikethrough to mark off removed rules text

3. General

- 3.1. All participants build and operate robots at their own risk. Combat robotics is inherently dangerous. There is no amount of regulation that can encompass all the dangers involved. Please take care to not hurt yourself or others when building, testing and competing.
- 3.2. If you have a robot or weapon design that does not fit within the categories set forth in these rules or is in some way ambiguous or borderline, please contact the event organizer. Safe innovation is always encouraged, but surprising the event staff with your brilliant exploitation of a loophole may cause your robot to be disqualified before it ever competes.
- 3.3. Each event has safety inspections. It is at their sole discretion that your robot is allowed to compete. As a builder you are obligated to disclose all operating principles and potential dangers to the inspection staff.
- 3.4. Cardinal Safety Rules: Failure to comply with any of the following rules could result in expulsion or worse, injury and death.
 - 3.4.1. Radios that do not operate using spread spectrum technology may not be turned on at or near events for any purpose without obtaining the appropriate frequency clip or explicit permission from the event.

- 3.4.2. Proper activation and deactivation of robots is critical. Robots must only be activated in the arena, testing areas, or with expressed consent of the event and its safety officials.
- 3.4.3. All robots must be able to be FULLY deactivated, which includes power to drive and weaponry, **in under 60 seconds by a manual disconnect.**
- 3.4.4. All robots not in an arena or official testing area must be raised or blocked up in a manner so that their wheels or legs cannot cause movement if the robot were turned on. Runaway bots are VERY dangerous.
- 3.4.5. Locking devices: Moving weapons that can cause damage or injury must have a **clearly visible** locking device in place **at all times** when not in the arena. Locking devices must be clearly identified. Examples of acceptable options include neon paint, brightly colored tabs, and remove before flight tags. Locking devices must be clearly capable of stopping, arresting or otherwise preventing harmful motion of the weapon. Locking devices must securely affix in place on the robot such that they cannot easily come loose or fall off without intent.
- 3.4.6. Weapon locking pins **must** be in place when weapon power is applied during a robot's power-on procedure. This includes **all** powered weapons regardless of the power source or weight class.
- 3.4.7. It is expected that all builders will follow basic safety practices during work on the robot at your pit station. Please be alert and aware of your pit neighbors and people passing by.

4. Weight Classes

This event offers the **weight classes listed on the event registration page.**

4.1. Locomotion Weight Bonuses

4.1.1. Shufflers receive a 1.25x weight bonus

4.1.2. Non-Traditional receive a 1.5x weight bonus

4.1.3. Walkers receive a 2x weight bonus

Rolling	Shufflers	Non-Traditional	Walker
0.33lb / 150g	187.5 g	225 g	300 g
1lb / 454g	1.25 lb	1.5 lb	2 lb
3lb / 1.36kg	3.75 lb	4.5 lb	6 lb
12lb / 5.44kg	15 lb	18 lb	24 lb
30lb / 13.61kg	37.5 lb	45 lb	60 lb
60lb / 27.22kg	75 lb	90 lb	120 lb
120lb / 54.43kg	150 lb	180 lb	240 lb
242.5lb / 110kg ¹	303.13 lb	363.75 lb	485 lb
250lb / 113.4kg ²	312.5 lb	375 lb	500 lb

5. Mobility

- 5.1. All robots must have easily visible and controlled mobility in order to compete. Methods of mobility include but are not limited to:
 - 5.1.1. Rolling (wheels, tracks or the whole robot)
 - 5.1.2. Walking: Walking robots have **no** rolling elements in contact with the floor and **no** continuous rolling or cam operated motion in contact with the floor, either directly or via a linkage. Motion is “continuous” if continuous operation of the drive motor(s) produces continuous motion of the robot. Linear-actuated legs and novel non-wheeled drive systems may qualify for this bonus. If you are intending to enter a non-wheeled robot in any event contact the event as soon as possible to determine what if any weight bonus you will qualify for.
 - 5.1.3. Shuffling (rotational cam operated legs)
 - 5.1.4. Non-Traditional
 - 5.1.4.1. Bristle/Torque Drive: Vibration or torque reaction of a powered system to generate motion
 - 5.1.4.2. Gyro Walker: Gyroscopic forces used in conjunction with a rotating arm that tilts a portion of the robot to generate motion
 - 5.1.4.3. Ground effect air cushions (hovercrafts)
 - 5.1.4.4. Jumping and hopping may be allowed at some events, contact the event organizer if you’re intending on using this as a method of locomotion.
 - 5.1.4.5. Flying (airfoil using, helium balloons, ornithopters, etc.) may be allowed at some events, contact the event organizer if you’re intending on using this as a method of locomotion.

6. Robot control requirements

- 6.1. Tele-operated robots must be radio controlled, or use an approved custom system as described in 6.4.3. Radio controlled robots must use approved ground frequencies, typically 27/49/50/53/75/900/2400 for the United States.
- 6.2. Tethered control is not allowed.
- 6.3. Pre-1991 non-narrow band radio systems are not allowed.
- 6.4. Radio system restrictions for this event with corresponding weight and or weapon restrictions:
 - 6.4.1. Radio systems that stop all motion in the robot (drive and weapons), when the transmitter loses power or signal, are required for all robots with active weapons or any robot over 12lbs. This may be inherent in the robots electrical system or be part of programmed fail-safes in the radio. Robots 1 lb and less typically will be required to have drive fail-safes.
 - 6.4.2. All robot radio systems must have a way to change frequencies or coded channels to prevent radio conflicts. Having at least **two** frequencies or coded channels available is **required**. Lack of extra frequencies may result in a forfeit. Digital spread-spectrum radios that use frequency hopping or automatic channel selection qualify under this rule.

- 6.4.3. If you are using a home built control system, or a control system not covered here, you must first clear it with the event you plan to attend.
Contact registration coordinator if you intend to use Home Built Controls
- 6.4.4. Toy radio systems are sometimes allowed at events for robots up to 12 lbs with no active weapons.
Contact registration coordinator if you intend to use Toy Radio.
- 6.4.5. RC systems on the AM band are sometimes allowed at events for robots up to 12 lbs with no active weapons.
Contact registration coordinator if you intend to use AM Band.
- 6.4.6. All robots that are either: a.) 30 lbs or above or b.) 12 lbs or above with an active weapon **MUST** use a radio systems on the FM band with PCM, IPD coding, a digitally coded 900 MHz or 2.4GHz system (for example IFI, Spektrum, etc.), or an approved custom control system.
- 6.5. This event does not require a separate power switch for the radio.
- 6.6. Most events do not provide reserved frequencies/channels for testing and safety.

7. Autonomous/Semi-Autonomous Robots

- 7.1. Any robot that moves, seeks a target, or activates weapons without human control is considered autonomous. If your robot is autonomous you are required to contact this event before registration.
- 7.2. Autonomous robots must have a clearly visible light for each autonomous subsystem that indicates whether or not it is in autonomous mode, e.g. if your robot has two autonomous weapons it should have two “autonomous mode” lights (this is separate from any power or radio indicator lights used).
- 7.3. Robots in the 12 pound or under classes are exempt from the remaining rules below, but safe operation, arming, and disarming must be demonstrated in safety inspections.
- 7.4. The autonomous functionality of a robot must have the capability of being remotely armed and disarmed. (This does not include internal sensors, drive gyros, or closed loop motor controls.)
 - 7.4.1. While disarmed, all autonomous functions must be disabled.
 - 7.4.2. When activated the robot must have no autonomous functions enabled, and all autonomous functions must failsafe to off if there is loss of power or radio signal.
 - 7.4.3. In case of damage to components that remotely disarm the robot, the robots autonomous functions are required to automatically disarm **within one minute** of the match length time after being armed.

8. Batteries and Power

- 8.1. The only permitted batteries are ones that cannot spill or spray any of their contents when damaged or inverted. This means that standard automotive and motorcycle wet cell batteries are prohibited. Examples of batteries that are permitted: gel cells, Hawkers, NiCads, NiMh, dry cells, AGM, Llon, LiFe, LiPoly, etc. If your design uses a new type of battery, or one you are not sure about please contact the event you’re planning to attend.

- 8.2. All onboard voltages above 48 Volts require prior approval from this event. (It is understood that a charged battery's initial voltage state is above their nominal rated value)
- 8.3. All electrical power to weapons and drive systems (systems that could cause potential human bodily injury) must have a manual disconnect that can be activated within 15 seconds without endangering the person turning it off. (E.g. No body parts in the way of weapons or pinch points.) Shutdown must include a manually operated mechanical method of disconnecting the main battery power, such as a switch (Hella, Whyachi, etc) or removable link. Relays may be used to control power, but there must also be a mechanical disconnect. Please note that complete shut down time is specified in section 3.4.3.
- 8.4. All efforts must be made to protect battery terminals from a direct short and causing a battery fire.
- 8.5. If your robot uses a grounded chassis you must have a switch capable of disconnecting this ground. ICE robots are excepted from this rule if there is no practical way to isolate their grounding components. You must contact this event for this exception.
- 8.6. All Robots must have a light easily visible from the outside of the robot that shows its main power is activated.

9. Pneumatics

- 9.1. Pneumatic systems on board the robot must only employ non-flammable, nonreactive gases (CO₂, Nitrogen and air are most common). It is not permissible to use fiber wound pressure vessels with liquefied gasses like CO₂ due to extreme temperature cycling.
- 9.2. You must have a safe and secure method of refilling your pneumatic system. 9.2.1. SPARC recommends the use of standard paintball fill fittings available at many retail outlets and online. For specs see Part#12MPS from Foster, <http://www.couplers.com>.

9.3. Exemptions

- 9.3.1. Robots **12lbs** and under and systems with gas storage of **2 fl oz** or less are exempt from the remaining rules in this section provided that the maximum actuation pressure is **250psi** or less and all components are used within the specifications provided by the manufacturer or supplier. If the specifications aren't available or reliable, then it will be up to the EO to decide if the component is being used in a sufficiently safe manner.
- 9.3.2. Pneumatic systems with pressures below 100 PSI, small volumes (12-16g CO₂ cartridges), single firing applications, or pneumatics used for internal actuation (as opposed to external weaponry) **may** also be exempted from the remaining pneumatic rules. You are required to contact this event if you would like an exception.
- 9.4. All pneumatic components on board a robot must be securely mounted. Particular attention must be made to pressure vessel mounting and armor to ensure that if ruptured it will not escape the robot. (The terms 'pressure vessel, bottle, and source tank' are used interchangeably)

- 9.5. All pneumatic components within the robot must be rated or certified for AT LEAST the maximum pressure in that part of the system. You may be required to show rating or certification documentation on ANY component in your system.
- 9.6. All pressure vessels must be rated for at least 120% of the pressure they are used at and have a current hydro test date. (This is to give them a margin of safety if damaged during a fight.) If large actuators, lines, or other components are used at pressures **above 250psi** these will also need to be over-rated and are to be pre-approved for this event.
- 9.7. All primary pressure vessels must have an over-pressure device (burst/rupture disk or over-pressure 'pop off') set to no more than 130% of that pressure vessels' rating. (Most commercially available bottles come with the correct burst assemblies, use of these is encouraged)
- 9.8. If regulators or compressors are used anywhere in the pneumatic system there must be an (additional) over-pressure device downstream of the regulator or compressor set for no more than 130% of the lowest rated component in that part of the pneumatic system.
- 9.9. All pneumatic systems must have a manual main shut off valve to isolate the rest of the system from the source tank. This valve must be easily accessed for robot de-activation and refilling.
- 9.10. All pneumatic systems must have a manual bleed valve downstream of the main shut off valve to depressurize the system. This bleed valve must be easily accessed for deactivation. This valve must be left OPEN whenever the robot is not in the arena to ensure the system cannot operate accidentally.
 - 9.10.1. It is **required** to be able to easily bleed all pressure in the robot before exiting the arena. (You may be required to bleed the entire system if it is believed that you have any damaged components.)
- 9.11. All regulated pneumatic systems must have an appropriate gauge scaled for maximum resolution of the pressure on the low-pressure side of the system. HPA (air, nitrogen, or inert gas) systems must have gauges on both the high AND low pressure sides of regulators. A gauge or other clear visual indication that the system is charged is strongly recommended for all pneumatic systems. Whether specifically required or not.
- 9.12. If back check valves are used anywhere in the system you must ensure that any part of the system they isolate can be bled and has an over-pressure device.
- 9.13. Any pneumatic system that does not use a regulator, or employs heaters or pressure boosters, or pressures above 2500psi must be pre-qualified by the event you're planning to attend.

10. Hydraulics

- 10.1. Robots in the 12 lb class or lighter are exempt from the remaining rules in this section, but good engineering and best practices must be used in all hydraulic systems. **However the pressure for 12 pound or less robots is limited to 250psi and there must be an easy way to determine this pressure.** Contact the event with any questions.
- 10.2. All hydraulic components onboard a robot must be securely mounted. Particular attention must be made to pump and accumulator mounting and armor to ensure that if ruptured direct fluid streams will not escape the robot.

- 10.3. All hydraulic components within the robot must be rated or certified for AT LEAST the maximum pressure in that part of the system. You may be required to show rating or certification documentation on ANY component in your system.
- 10.4. Any accumulators or large reservoirs must be rated for at least 120% of the pressure they are used at. (This is to give them a margin of safety if damaged during a fight)
- 10.5. All hydraulic systems must have an over pressure by pass device set to no more than 130% of the lowest component rating. It must be rated to bypass the full volume of the hydraulic pump.
- 10.6. All hydraulic systems must have a(n) accessible manual bypass valve(s) to easily render the system harmless.
- 10.7. All hydraulic systems must have appropriate gauges scaled for maximum resolution of the pressures in that part of the system.
- 10.8. All hydraulic systems must use non-flammable, non-corrosive fluid and must be designed not to leak when inverted.
- 10.9. Any hydraulic system using pressure boosters, or pressures above 5000psi (without accumulator) or pressures above 2000psi (with accumulator) must be pre-qualified by the event.
- 10.10. Please note that some simple low pressure and volume hydraulic systems, like simple braking, may not need to adhere to all the rules above. You are required to contact the event if you would like an exception.

Internal Combustion Engines are not currently allowed at ORC events

11. ~~Internal Combustion Engines (ICE) and liquid fuels~~

- 11.1. Internal combustion engines and liquid fuels are not allowed. The rest of this section only applies if this line is struck out in the event rules.
- 11.2. Fuel and Fuel Lines
 - 11.2.1. All commercially available grades of automobile or RC hobby fuel are allowed. Alcohol, Nitro-methane, jet fuel and other specialty grades of fuel require prior approval.
 - 11.2.2. Fuel lines and tanks must be made of high quality materials and all ends must be clamped securely.
 - 11.2.3. All fuel tanks and lines must be well protected and armored from all sides including moving parts and heat sources inside the robot.
- 11.3. Fuel tank volume, on any robot, shall not be greater than the amount required to operate the engine for more than **1 minute longer than the match time** at combat power plus a reasonable pre-match warm-up period. Total fuel volume, including fuel for both ICE and flame weapons (if allowed) may not exceed **20oz** unless prior approval is granted from this event.
- 11.4. The output of any engines connected to weapons or drive systems must be coupled through a clutch which will decouple the motor when it is at idle. (This does not include motors used for generators and hydraulic pumps.)
- 11.5. Any engine connected to a weapon **must** be capable of being started while the weapon locking pin is in place (see 3.4.6).
- 11.6. All engines must turn off or return to idle at loss of **radio signal** and turn off at loss of radio **receiver power**.

- 11.7. All engines must have a method of remotely shutting off.
- 11.8. Any robot with liquid fuel and oil must be designed not to leak when inverted. (Minor oil leakage may be tolerated, however if it affects the other robot or becomes a large cleanup issue you may be called and the leaking robot will forfeit.)
- 11.9. Use of engines other than standard piston engines (i.e. turbines etc.) require prior approval for any event.

12. Rotational weapons or full body spinning robots

- 12.1. Spinning weapons that can contact the outer arena walls during normal operation must be pre-approved by the event. (Contact with an inner arena curb, or containment wall is allowed and does not require prior permission.)
- 12.2. Spinning weapons must come to a full stop within **60 seconds** of the power being removed using a self-contained braking system.

13. Springs and flywheels

- 13.1. Springs used in robots in the 12 lbs class or smaller and those loaded simply by the weight of the robot(eg. suspension systems) are excepted from the rules in this section. However safe operation and good engineering are always required.
- 13.2. Any large springs used for drive or weapon power must have a way of loading and actuating the spring remotely under the robot's power.
 - 13.2.1. Under no circumstances must a large spring be loaded when the robot is out of the arena or testing area.
 - 13.2.2. Small springs like those used within switches or other small internal operations are excepted from this rule.
- 13.3. Any flywheel or similar kinetic energy storing device must not be spinning or storing energy in any way unless inside the arena or testing area.
 - 13.3.1. There must be a way of generating and dissipating the energy from the device remotely under the robot's power.
- 13.4. All springs, flywheels, and similar kinetic energy storing devices must fail to a safe position on loss of radio contact or power.

14. Forbidden Weapons and Materials

The following weapons and materials are absolutely forbidden from use:

- 14.1. Weapons designed to cause invisible damage to the other robot. This includes but is not limited to:
 - 14.1.1. Electrical weapons
 - 14.1.2. RF jamming equipment, etc.
 - 14.1.3. RF noise generated by an IC engine. (Please use shielding around sparking components)
 - 14.1.4. EMF fields from permanent or electro-magnets that affect another robot's electronics.
 - 14.1.5. Entangling Weapons or defenses: these are weapons or defenses that can reasonably be expected to stop drive train and/or weapon motion by

- being wrapped around rotating parts. This includes nets, tapes, strings, and other entangling materials or devices.
- 14.1.6. Weapons or defenses that can reasonably be expected to stop combat completely of both (or more) robots.
 - 14.2. Weapons that require significant cleanup, or in some way damages the arena to require repair for further matches. This includes but is not limited to:
 - 14.2.1. Liquid weapons. Additionally a bot may not have liquid that can spill out when the robot is superficially damaged.
 - 14.2.2. Foams and liquefied gasses
 - 14.2.3. Powders, sand, ball bearings and other dry chaff weapons
 - 14.3. Un-tethered Projectiles (see tethered projectile description in Special Weapons section 15.1)
 - 14.4. Heat and fire are forbidden as weapons. This includes, but is not limited to the following:
 - 14.4.1. Heat or fire weapons not specifically allowed in the Special Weapons section (15.2)
 - 14.4.2. Flammable liquids or gases
 - 14.4.3. Explosives or flammable solids such as:
 - 14.4.3.1. DOT Class C Devices
 - 14.4.3.2. Gunpowder / Cartridge Primers
 - 14.4.3.3. Military Explosives, etc.
 - 14.5. Light and smoke based weapons that impair the viewing of robots by an Entrant, Judge, Official or Viewer. (You are allowed to physically engulf your opponent with your robot however.) This includes, but is not limited to the following:
 - 14.5.1. Smoke weapons not specifically allowed in the Special Weapons section (15.3)
 - 14.5.2. Lights such as external lasers above 'class I' and bright strobe lights which may blind the opponent.
 - 14.6. Hazardous or dangerous materials are forbidden from use anywhere on a robot where they may contact humans, or by way of the robot being damaged (within reason) contact humans. Contact the event you plan to attend if you have a question.

15. Special weapon descriptions

- 15.1. Tethered Projectiles are ~~not~~ allowed at this event.
 - 15.1.1. If allowed tethered projectiles must have a tether or restraining device that stops the projectile and is no longer than 8 feet.

Contact registration coordinator if you intend to use Tethered projectiles
- 15.2. Heat and Fire are not allowed at this event. The subsequent rules in this section apply when heat and fire are allowed. Flame weapon rules are subject to change to comply with local fire regulations and fire officials.
 - 15.2.1. Fuel must exit the robot and be ignited as a gas. It cannot leave the robot in a liquid or gelled form or use oxidizers.
 - 15.2.2. Fuel types allowed are propane and butane, the maximum quantity allowed is 4 fl oz in robots up to 30 lbs, 8 fl oz for robots 60 lbs and above.

- 15.2.3. The fuel tank must be as far from the outer armor of the robot as practicable and be protected from heat sources within the robot.
- 15.2.4. The ignition system must have a remotely operated shut-off that allows the operator to disable it using the radio control system.
- 15.3. Smoke Effects are not allowed at this event.
 - 15.3.1. Small smoke effects may be used, please contact the event if you plan on using it.

Weight Class variants are not currently at ORC events

16. ~~Weight Class Variants~~

A robot may be entered into any of the below classes if it complies with the additional rules in this section. Any robot may be entered in the “standard” class of the same weight.

16.1. ~~Sportsman Class~~

- 16.1.1. **Active Weapon Required.** Your bot must include an active weapon or device. These include but are not limited to lifters, hammers, clamps, spinning weapons (within limitations, see below), etc. Weapons such as a fixed spike that require the movement of the bot to function do not qualify as active weapons. (within the limitations specified in 4.2.3)
- 16.1.2. **Limitations on Spinning Weapons.** All devices rotating more than 360 degrees are allowed to operate with a tip speed at or below 20ft/s.

(Approximate tip speed = no load RPM * diameter in inches * 0.00436) Weapon rpm will be measured by tachometer prior to the start of the event. Specific weapons of sufficiently high mass or moment of inertia (MOI) may be limited to lower speeds or disallowed by officials if they deem the weapon to be too destructive. Officials may require submission of specifications including motor, voltage, gearing ratio, weapon weight and dimensions prior to the event.

- 16.1.2.1. Sawing, drilling and other spinning weapons will be allowed to exceed the 20ft/s limit so long as they meet the following requirements:
 - 16.1.2.1.1. The effective tooth pitch for the saw or saw like weapon is ≥ 5 . (Effective pitch = tooth count / diameter) For example, a 10” saw blade with 60 teeth would meet this requirement. A 10” saw blade with 40 teeth would not. For abrasives the grit size will be used to determine if the requirements are met. (Tooth count = grit * circumference)
 - 16.1.2.1.2. Saws and saw-like weapons are limited to the manufacturer's rated RPM. If you are using a custom blade it will be limited to the rated rpm of an equivalent commercial blade. ($\pm 5\%$ on tooth count, diameter, thickness) Additionally, the maximum spinning mass for saws and saw-like weapons is 15% of the total bot mass. This includes any mounting hubs, shafts, flywheels,

pulleys, and other structures mechanically linked to the rotation of the saw blade.

16.1.2.1.3. Wheel-like and rubber spinning weapons are allowed without a specific tooth density requirement. Excessively destructive implementations may be restricted at the event organizers discretion.

16.1.2.1.4. All weapons operating above the 20ft/s limit must be submitted to the event organizer for approval during the registration period.

16.1.3. **Wedge Limitations.** Active wedges are allowed with no restrictions. A robot may only have a single passive wedge.

16.1.3.1. An active wedge is defined as a wedge that is articulated and actuated independently of the drive system.

16.1.3.2. A passive wedge is any wedge or wedge-like object (forks, series of small, hinged, independent wedges along the same face of the robot) that does not meet the requirements for classification as an active wedge.

16.1.3.3. At the event organizers discretion any weapons being primarily used as a passive wedge may be required to undergo modifications to reduce or remove this potential prior to continuing in a tournament should this use result in the robot being in violation of the restriction on the number of passive wedges permitted.

16.1.4. **Excessively Destructive Weapons.** Weapons deemed too destructive by virtue of their mass, MOI or other characteristics may be further limited or disallowed at the discretion of the event. Please contact the event organizer concerning your design to avoid problems.

16.1.5. **Standard SPARC Rules Apply.** Unless otherwise stated, all other standard SPARC rules will apply. This includes walkers and their weight bonuses. However, a walker that uses the weight bonus for a spinning (or other) weapon that is too destructive will be disqualified.

16.2. ~~Open Air Combat Classes~~

For events where some or all classes compete in an open air environment the following restrictions apply.

16.2.1. Slow spinners are allowed with an absolute maximum tip speed of 20 feet per second and may spin in any direction. The tip speed in feet per second is calculated by this formula: $\text{Tip Speed} = \text{RPM} \times \text{Diameter} \times .00436$.

16.2.2. Additionally, any weapon systems that may be capable of tearing off pieces of the opponent (flippers, axes, etc...) must be cleared with the event organizer prior to competing.

16.3. ~~Plastic Class~~

The spirit of this class is to create an accessible and affordable class that encourages experimentation and rapid iteration by utilizing 3D printing.

16.3.1. Allowed materials

- 16.3.1.1. Frames, weapons and other custom parts may only be made from PLA, PLA+, PET, PETG, ABS, or ASA and must be FDM/FFF 3D printed.
- 16.3.1.2. Materials that are functionally identical to PLA+ but have a different name for marketing purposes will be considered PLA+ when determining legality. (ex. PLA Pro, Super PLA)
- 16.3.1.3. No other types of plastics or materials are allowed (ie. metal, carbon fiber, UHMW, etc).
- 16.3.1.4. Composite and blended materials that use legal materials as a base are not permitted. Examples include but are not limited to: Carbon Fiber PLA, Glass Filled ABS, and Flex PLA.

16.3.2. COTS Parts

- 16.3.2.1. Commercial Off The Shelf parts can be made from any material. This includes components such as motors, electronics, axles, bushings, bearings, fasteners, and adhesives.
 - 16.3.2.1.1. COTS parts may not be used outside of their typically accepted function. Examples include:
 - 16.3.2.1.1.1. Permitted: Using shafts and bearings to allow wheels or a weapon to spin freely, using screws to attach two parts together.
 - 16.3.2.1.1.2. Not Permitted: Using COTS parts as counterbalances for weapons, as weapon impactors, or as armor.
 - 16.3.2.1.2. COTS parts may be modified if necessary so long as the function of the part is not significantly changed. Examples include shortening motor shafts and adding flats for set screw contact.
 - 16.3.2.1.3. COTS equivalent parts are allowed.
 - 16.3.2.1.3.1. Examples of COTS equivalent parts include but are not limited to builder sourced/manufactured gearmotors, custom electronics, prototype components, and axles that are not commercially available.
 - 16.3.2.1.4. Magnets to enhance traction or downforce are prohibited.

16.3.3. Tires, Wheels and Other Traction Elements

- 16.3.3.1. Non-allowed materials may be used if they meet the following requirements:
 - 16.3.3.1.1. Tires and other traction elements may be made from COTS rubber material, custom cast rubber, rubber coatings, or foam.
 - 16.3.3.1.2. Parts between motors/shafts and Tires should either be COTS, Foam, or printed from Allowed Materials.
 - 16.3.3.1.3. Printed elements including COTS components must be from the allowed materials list.

- 16.3.3.1.4. Tires, wheels, wheel components, and other traction elements made from materials not on the allowed materials list may not be designed such that they provide more armor or structure than a COTS equivalent part.
- 16.3.4. Coatings and Post-Processing
 - 16.3.4.1. Painting or otherwise marking robots is permitted if done solely for aesthetic purposes. Excessive coatings are subject to event organizer review and approval.
 - 16.3.4.2. Post-processing of materials using techniques that enhance durability is not permitted. Disallowed processes include but are not limited to annealing, acetone soaking, and boiling of parts.
- 16.3.5. Robots may be disqualified at the Event Organizer's discretion if it is deemed to violate the spirit of the class. Contact the event organizer ahead of time if you are not sure your robot meets the above definition.