

# Holy Trinity High School

1st Invitational Robotics Competition

*Rules are adapted from National Robotics Competition (NRC) rules.*

# Combat Robot

## Contest Description

In the **Robot Combat** event, students will design and create a single custom-built robotic device that employs one or more methods of destroying or disabling the devices of their competitors. This device will be remote-controlled, but may include some autonomous operations. This competition utilizes a modified version of the SPARC Robot Construction Specifications v1.1.

## Rules

### Size Requirements

- The Robot must fit inside a 14" x 14" x 14" space.
- Any robot entered that does not meet the size requirement by the end of the device evaluation, or expands beyond that size during competition, will be disqualified.

### 1. Overview and Purpose

- 1.1. The SPARC Robot Construction Specifications standard was created to provide both builders and event organizers with an up-to-date and easily implemented 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. The Combat Robot rules are a modified version of the SPARC Robot Construction Specifications v1.2.
- 2.2. To simplify the understanding for the specifications, some sections of the original ruleset were completely removed. To view the original rules, go to [www.sparc.tools](http://www.sparc.tools).

### 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 injure yourself or others when building, testing, or 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 constitutes a borderline case, 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 the judges' sole discretion that a robot is allowed to compete. As a builder, you are obligated to disclose all operating principles and potential dangers to judges or other inspection personnel.
- 3.4. **Cardinal Safety Rules:** Failure to comply with any of the following rules may result in expulsion or worse, injury or 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 event organizers.
  - 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 organizers and their safety officials.
  - 3.4.3. All robots must be able to be **fully** deactivated, including 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 obstructed in a manner such that robot wheels or legs cannot allow movement if the robot were turned on. Runaway robots 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 painted in neon orange or another high-visibility color. Locking devices must be clearly capable of stopping, arresting, or otherwise preventing harmful motion of the weapon.
  - 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 their designated pit station. Please be alert and aware of your pit neighbors and people passing by.

#### 4. **Weight Class**

- 4.1. This event will be open solely to the *beetleweight* weight class. A *beetleweight* robot is defined as a
  - 4.1.1. rolling robot (i.e. wheels) of no more than *3 pounds (3 lbs)*,
  - 4.1.2. a shuffling robot (or one with any walking mechanism derived from continuous rotary motion) of no more than *4.5 pounds (4.5 lbs)*, or
  - 4.1.3. a non-wheeled robot (linear walking mechanisms or non-rotational motion) of no more than *6 pounds (6 lbs)*.
- 4.2. There is a 100% weight allowance bonus for non-wheeled robots. There is a 50% weight allowance bonus for "shuffler" robots, or robots with other forms of locomotion which do not fall within the definition of non-wheeled robot (**see 5.1.2**

for a definition of a “non-wheeled robot”).

## 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 the following
  - 5.1.1. **Rolling:** Rolling robots may roll by means of wheels, tracks, or the whole robot.
  - 5.1.2. **Non-wheeled:** Non-wheeled 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 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 the weight allowance bonus associated with this category. If you intend to enter a non-wheeled robot in any event, contact the event organizers as soon as possible to determine what (if any) weight allowance bonus your robot qualifies for.
  - 5.1.3. **Shuffling:** Shuffling robots utilize rotational cam operated legs of some kind.
- 5.2. Other methods of locomotion are not permitted, including, but not limited to, hovercraft locomotion, jumping or hopping, or flying.

## 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. The following radio system restrictions for this event, with corresponding weight and or weapon restrictions, will be in force.
  - 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 on any robot over *12 pounds (12 lbs)*. This may be inherent in the robot’s electrical system or be part of programmed fail-safes in the radio. Robots weighing no more than *1 pound (1 lb)* 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 (2)** frequencies or coded channels available is **required**. Lack of extra frequencies may result in forfeiture of the *Robot Combat* event. 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 organizers.

- 6.4.4. Toy radio systems are sometimes allowed at events for robots of up to *12 pounds (12 lbs)* in weight with no active weapons. Entrants must confirm the eligibility of their robot with the event organizers before registration.
  - 6.4.5. RC systems on the AM radio band are sometimes allowed at events for robots of up to *12 pounds (12 lbs)* in weight with no active weapons. Entrants must confirm the eligibility of their robot with the event organizers before registration.
- 6.5. This event does not require a separate power switch for the radio, but it is encouraged.
- 7. **Autonomous/Semi-Autonomous Robots:** 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 the event organizers before registration.
  - 7.1. Autonomous robots must have a clearly visible light for each autonomous subsystem that indicates whether or not it is in autonomous mode. Such lights are separate from any power or radio indicator lights used. *For example, if your robot has two autonomous weapons it should have two “autonomous mode” lights.*
- 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 include 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 organizers prior to registration.
  - 8.2. All onboard voltages above **48 volts** require prior approval from the event organizers.

*Note: It is understood that a charged battery's initial voltage state is above its nominal rated value.*
  - 8.3. All electrical power to weapons and drive systems (systems that could cause potential bodily injury) must have a manual disconnect that can be activated within **15 seconds** without endangering the person turning it off (i.e. without requiring a body part enter the reach or path of weapons or pinch points). Shutdown must include a **manually operated** mechanical method of disconnecting the main battery power, such as a switch (e.g. 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 shutdown time is specified in **3.4.3**.
  - 8.4. All efforts must be made to protect battery terminals from a direct short or from 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 exempted from this rule if there is no

practical way to isolate their grounding components. You must contact the event organizers prior to registration to obtain this exemption.

- 8.6. All robots must have a light that is easily visible from the outside of the robot that indicates when its main power is activated.

## 9. Pneumatics

- 9.1. Pneumatic systems on board the robot must only employ non-flammable, non-reactive gases (commonly CO<sub>2</sub>, Nitrogen, or air). It is not permissible to use fiber wound pressure vessels with liquefied gasses like CO<sub>2</sub> due to extreme temperature cycling.
- 9.2. You must have a safe and secure method of refilling your pneumatic system.
- 9.3. SPARC recommends the use of standard paintball fill fittings available at many retail outlets and online. For specs see *Part#12MPS* from Foster, at <http://www.couplers.com>.
- 9.4. All pneumatic components on board a robot must be securely mounted. Particular attention must be paid to pressure vessel mounting and armor to ensure that, if ruptured, it will not come free of the robot. (The terms “pressure vessel,” “bottle,” and “source tank” should be considered interchangeable)
- 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 for **any** component in your system at a judge’s discretion.
- 9.6. All pressure vessels must be rated for at least 120% of the pressure that they will use as part of the robot’s system, and have a current hydro test date. (This is to ensure a margin of safety if the robot is damaged during a fight.) If large actuators, lines, or other components are used at pressures **above 250 pounds per square inch (250 psi)**, such components must also be rated at 120% of their operating condition in order 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 the pressure vessel’s rating. (Most commercially available bottles come with the correct burst assemblies, so use of such bottles is encouraged.)
- 9.8. If regulators or compressors are used anywhere in the pneumatic system there must be an 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 shutoff valve to isolate the rest of the system from the source tank. This valve must be easily accessed for robot deactivation and refilling.
- 9.10. All pneumatic systems must have a manual bleed valve downstream of the main shutoff valve to depressurize the system. This bleed valve must be easily accessible 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. Robots must have the capacity to easily bleed all pressure in the device before it exits 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 the regulators. A gauge or other clear visual indication that the system is charged is strongly recommended for all pneumatic systems, whether or not they are specifically required.
- 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, employs heaters or pressure boosters, or employs pressures above *2500 pounds per square inch (2500 psi)* must be pre-qualified by the event organizers.

## 10. **Hydraulics**

- 10.1. Robots in the *12-pound* class or lighter are exempt from the remaining rules in this section, though sound engineering and best practices must be used in all hydraulic systems. **However the pressure for any robot of 12 pounds (12 lbs) or less is limited to hydraulic pressures of no greater than 250 pounds per square inch (250 psi) and there must be an easy way to determine this pressure.** Contact the event organizers with any questions.
- 10.2. All hydraulic components onboard a robot must be securely mounted. Particular attention must be paid 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 for **any** component in your system at the judges' discretion.
- 10.4. Any accumulators or large reservoir must be rated for at least 120% of the pressure at which they will operate. (This is to ensure a margin of safety if the robot is damaged during a fight.)
- 10.5. All hydraulic systems must have an over pressure bypass 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 one or more accessible manual bypass valves to easily render the system inoperable.
- 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 *5000 pounds per square inch (5000 psi)* without an accumulator, or pressures above *2000 pounds per square inch (2000 psi)* with an accumulator, must be pre-qualified by

the event organizers.

11. **Internal Combustion Engines (ICE) and Liquid Fuels:** Internal Combustion Engines (ICE) and liquid fuels are typically not allowed.
12. **Rotational Weapons and Spinning Robots:** Rotational weapons or full-body spinning robots are allowed at the event, with the following provisos.
  - 12.1. Spinning weapons that can contact the arena walls above 5 inches from the arena floor during normal operation must be pre-approved by the event organizers. (Spinning weapons that can contact the arena walls below 5 inches are allowed and do 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-pound* class or smaller, and those loaded simply by the weight of the robot (e.g. those used as part of suspension systems) are exempted 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 to load and actuate the spring remotely under the robot's power.
  - 13.3. **Under no circumstances** may a large spring be loaded when the robot is out of the arena or testing area.
  - 13.4. Small springs, such as those used within switches or other small internal operations, are exempted from this rule.
  - 13.5. Any flywheel or similar kinetic energy storing device may not be spinning or storing energy in any way unless inside the arena or testing area.
  - 13.6. There must be a way of generating and dissipating the energy from the device remotely under the robot's power.
  - 13.7. All springs, flywheels, and similar kinetic energy storing devices must assume a failsafe position upon 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 including, but 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, defined as weapons or defenses that can reasonably be expected to stop drive train and/or weapon motion by being wrapped around rotating parts, such as 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 two or more robots.
  - 14.2. Weapons that require significant cleanup, or in some way damages the arena to require repair for further matches including, but not limited to
    - 14.2.1. Liquid weapons (Additionally, a robot may not be designed such that it can spill liquid when the robot is superficially damaged.);
    - 14.2.2. Foams or liquefied gasses;
    - 14.2.3. Powders, sand, ball bearings, or other dry chaff weapons.
  - 14.3. Un-tethered projectiles (for rules concerning tethered projectiles, see **15.1**).
  - 14.4. Heat- or fire-based weapons including, but not limited to
    - 14.4.1. Heat or fire weapons not specifically allowed in **15.3**;
    - 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 or cartridge primers,
      - 14.4.3.3. Military explosives, etc.
  - 14.5. Light- or smoke-based weapons that impair the viewing of robots by an entrant, judge, official or viewer (though a robot is allowed to physically engulf an opposing robot) including, but not limited to,
    - 14.5.1. Smoke weapons not specifically allowed in **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 incorporated on a robot such that they may contact humans, or such that (within reason) they may contact humans in the event that the robot is damaged.
15. **Special Weapons**
- 15.1. Tethered projectiles are not allowed at this event.
  - 15.2. Heat- and fire-based weapons are not allowed at this event.
16. **Surrender Rule**
- 16.1. Each team will have a towel that can be thrown onto the Combat Arena to forfeit a match. This can be done at any time once the judges have started the match.
17. **Judgment:** Decisions made by the judges are final and binding.
18. **Battlefield:** The field measures 8 feet square, with an 8-inch interior height on a steel, concrete or plywood floor. All sides are matted black.

# Robot Maze Contest

## Contest Description

In the Robot Maze Contest, students can use a tactile or non-tactile robot to navigate a maze consisting of simple 90-degree left and right turns. The contest will be separated by grade level, with “grammar school” and high school competition divisions, respectively.

## Rules

1. Robots entering the contest may be of the following types:
  - 1.1. A tactile sensor-type, meaning that the robot can use physical contact with the walls as the means of navigating the maze; or
  - 1.2. a non-tactile type, meaning the robot does not physically utilize physical contact with the wall while navigating the maze.
2. The maze will
  - 2.1. Consist of a single-level with exclusively left and right turns,
  - 2.2. Be made of  $\frac{3}{4}$ -inch plywood painted matte white, and
  - 2.3. Have overall dimensions of *8 feet by 8 feet*, or *64 square feet*, with *8 inch high walls*.
3. Any type of commercially available or student-fabricated robot is eligible. Wired and wireless remote-control devices will not be allowed.
4. The maximum physical size of the robot may not exceed *8 inches in width, 8 inches in length, and 8 inches in height*.

*Note that the maze runways are a minimum of 14 to 15 inches wide and 7 to 8 inches high.*

5. Each robot is allowed three (3) attempts, with the best time being considered the official time.
6. The maximum allowed time for a root to complete the maze is 5 minutes.
7. Once an attempt begins, touching the robot forfeits that attempt.
8. Scoring is based on the following.
  - 8.1. The shortest elapsed time of a completed maze attempt in which the robot advances from the starting line to the finish line will be used to determine the winner in each division. The measured elapsed time will start when the front of

the robot crosses the starting line and will stop when the robot completely crosses the finish line.

- 8.2. In the event of a tie for a place, each team will be allowed two additional attempts. The team with the best time of these two additional attempts wins that place and the other team is awarded the next lower place.
  - 8.3. If the results of the two additional attempts (pursuant to the above) are also a tie, contestants will be asked to make an oral presentation showing the logic used to develop the robot and how the robot uses information received by the sensors to determine the path through the maze.
9. A pit area, with access to a 110-volt standard outlet, will be provided.
  10. Decisions made by the judges are final and binding.

# Sumo Robot

## Contest Description

The Sumo Robot Contest requires a student team to build a self-propelled, autonomous, sensing robot, designed to force another robot outside a ring. The competition ring will be a circle painted flat black, measuring 5 feet one inch across, enclosed by a 2-inch wide circle painted flat white. When any part of the robot crosses completely over the 2-inch white outer ring while being pushed by the opposing robot, it will lose the heat.

## Rules

1. The robot must be powered by electrical storage batteries. No other power sources will be allowed. These batteries must be sealed and all possible precautions must be incorporated into the design to prevent accidental spills. The judges may disqualify any design that is deemed to be unsafe. Arc or flux capacitors reactors are strictly prohibited.
2. If a design incorporates non-electric actuators (e.g. pneumatics, hydraulics) all power must come entirely from on-board sources, powered by electricity.

*For example, if a robot uses a pneumatic cylinder to run an arm, the robot would need to include an on-board air pump to provide the air pressure for operation.*

3. Robots must be self-controlled and use sensing devices to govern their motion. Robots must use sensors to either detect the other robot and/or the white line.
4. Any robot that is deemed too dangerous to other robots, the playing surface, or competitors will be disqualified.
5. Robot size limitations for teams of all grade levels are as follows.
  - 5.1. The robot must fit inside a 20-centimeter by 20-centimeter by 20-centimeter space, and weigh no more than 3 kilograms.
6. Any robot entered into the contest that does not meet the size requirements by the end of the device evaluation will be disqualified.
7. A robot may expand in size after a match begins, but must not physically separate into pieces, and must remain a single centralized robot. Robots violating these restrictions forfeit the match. Screws, nuts, and other robot parts with a total mass of less than 15 grams falling off from a robot will not induce the forfeiture of match.

8. Robot operation must begin automatically no less than five seconds after being started by the entrant. Robots starting before the five second mark will forfeit the heat.
9. Excluding wheels or tracks, all robot parts must maintain a minimum 5 millimeters of ground clearance from the playing surface.
10. The total weight of the robot shall not exceed 3kg.
11. Weight may not be added after the robot has been weighed and evaluated by the judges.
12. Robots must be carried or carted to and from the competition ring. Robots may not be driven outside of the competition ring.
13. Double elimination contests will decide the winner of each division.
14. At the beginning of each heat, with the robot deactivated, the entrants will position their respective robots 1 foot apart, as instructed by the judges. Four starting configurations will be possible, as illustrated below



15. At the judge's command, the entrants will activate their respective robots.
16. When one robot causes any part of the opponent to go past the outer white line, that robot is declared the winner of that engagement. A robot will not be considered to have lost if it was not pushed out by its opponent. Driving beyond the outer white line while not under direct contact with an opponent does not constitute a win for the opponent, but is instead declared a "fault."
17. If a fault is declared, the robots are positioned in the same starting configuration and the heat begins anew.
18. If a robot causes three faults in a row, the opponent is declared the winner of the heat.
19. If both robots leave the ring at the same time, a "no-contest" is declared, the two robots are randomly positioned in a new starting configuration, and the contest begins anew.
20. If, after 2 minutes, no winner is declared, the contest is determined to be a "draw," the two robots are randomly positioned in a new starting configuration, and the heat begins anew. If three heats in a row end in a "draw," the judges will declare a winner based on the actions observed within the ring and on the design of the selected robot.

21. A pit area, with access to a 110-volt standard outlet, will be provided.
22. At the conclusion of each heat, the winning robot must be weighed and measured to ensure that legal size limits have been maintained. Failure to pass this verification will result in a forfeiture of the heat.
23. Decisions made by the judges are final and binding.