A lot goes into a bot. Starting out it can be overwhelming trying to figure out what you need to get to make a working robot, where to go to get the parts you need, or how to put it all together. This section of the SPARC Getting Started Guide is meant to address all of those issues.

Major Vendors

www.botbitz.com
www.e0designs.com
www.fingertechrobotics.com
www.kitbots.com
www.robotmarketplace.com
www.robotpower.com
www.servocity.com
www.ttrobotics.com

Radio System

When selecting a radio system, the first thing you must do is confirm that the system will failsafe on all used channels. Fail safe means that if the signal to the receiver is lost, all drive and weapon systems will return to a non-active state. Any system incapable of this function will not be allowed to pass safety. 2.4 GHz radio systems are increasingly common and often required at events. There are a wide range of products available that meet the failsafe requirements and 2.4 GHz suggestion. If you're not sure that a system will failsafe properly, ask the merchant or manufacturer. The Robot Marketplace often will list if a system or component will failsafe properly on the product description.

Kill Switches

Commercial Switches
Being able to safely turn your robot on and off is another requirement to compete. The Whyachi MS-XX series and the Hella switch are two good commercial options for large bots. For smaller bots FingerTech Robotics has a power switch that works very well in the 150g-12lb class that has been used in bots up to 120lbs. Botbitz also sells an extremely small switch designed for the 150g-1lb classes.

Home Made
In addition to commercial switches, there are some styles of power switches that can be made at home. The most common involves using a plug to add a removable loop of wire between the battery and motor controllers. Using this method means you will physically remove part of the circuit to power off the robot.

Motor Control

There are several methods commonly used to control electric motors in robot combat. For full proportional speed control, an electronic speed controller (ESC) is generally the most reliable option. There are a wide range of ESCs available for robots ranging from 150g to 220lb. The key is to find a controller that is rated for your desired voltage or higher and can handle the current draw of the motors. The torque/AH calculator at www.killerbotics.com/kbtools/TentacleTools/

has many common drive motors and can be used to estimate stall and wheel spin amperage.
For motors that only need on/off functionality, contactors/DC solenoids can be used in conjunction with RC switches for more power handling capabilities at the cost of precise control.

Motor Selection

There are two main types of motors available, brushed and brushless. Brushed DC motors have been used in robot combat since the beginning. They're a bit bulky, spin at relatively low RPM and have great starting torque making them ideal for drive systems. Brushless motors have recently become the go-to option for high powered weapon (and occasionally drive) systems. Brushless motors tend to have a higher power-to-weight ratio and much higher RPM but often suffer from "cogging" when geared with low reduction and heavy attachments. Cogging means instead of smoothly accelerating, the motor sputters and often stops. The simplified version of why this happens is the large mass relative to the torque of the motor results in the controller and motor getting out of sync preventing proper acceleration. In weapons, this can result in slow or no spin-up, and in drive systems it can result in erratic low speed behavior. Brushless drive systems are less common as there are not many controllers available that give quick, proportional forward and reverse control, and the high RPM's can make gearing systems more difficult than with brushed motors. However some teams have found success pairing brushless motors with gearboxes designed for brushed motors.

Common Drive Systems

For a first build, wheels with tank style steering are the simplest option. Tracks and walking systems can be built, but on your first build, getting something working reliably should be the focus. The two main wheeled options are 2wd and anything greater than that, though usually in multiples of two. Two wheel drive robots will have two powered points of contact with the ground, and short of a balancing robot, this means at least one non powered point of contact will exist. This can either be a piece of chassis/armor dragging on the ground, a skid, or a caster. The best option will depend on the exact design of the robot and what arena it will compete in. Robots with greater than two driven wheels will likely have all points of contact with the ground powered, with the exception of hinged components that are meant to stay in constant contact with the ground.

Chassis Construction

Chassis construction generally takes one of a few different routes. The first is an internal frame with armor attached to it, the second uses the frame members as armor, often with connected plates of material forming the structure, and the third is unibody construction, where the majority of the frame and armor are cut from a single piece of material.

Building a chassis using an internal frame with armor panels mounted to it tends to be the heaviest of the three options, though often will be the most durable and easiest to repair as the portions of the armor most likely to be damaged are easier to remove from the rest of the robot. These frames typically involve a welded frame with armor bolted to it.

Frame as armor construction is generally in the middle when looking at strength vs. weight. By reducing frame and armor into a single part, you can reduce the size of the machine and use relatively thick materials in areas likely to come into contact with weapons. Frames like this are usually bolted together.

Unibody construction will typically be the strongest per pound, however it is also the most complicated to manufacture, as all features will need to be added to a single piece of material. This often involves repositioning the workpiece many times during the construction process. Care must be taken to avoid misalignment of holes as the workpiece is moved. The good strength-to-weight ratio, the best of the three mentioned, is due to the reduced need for fasteners to hold the chassis together and the lack of areas only held on by hardware.

Common Construction Materials

Metals

While there are many different types of commercially available metals on the market there are only a few that are well suited to robot combat. The four primary metal types used in robot combat are steel, titanium, aluminum, and magnesium. For each type of metal there is an alloy or set of alloys that find common usage as the mechanical properties of the alloy are a better match for combat use.

- Steel: Steel comes in a huge range of alloys and can have its properties dramatically altered by heat treating and tempering. That being said, steel will likely be the toughest armor option for a given shape, however it will also be the heaviest option. Steel is also frequently used for weapons as high grade steels can be heat treated to achieve a nice balance of stiffness and strength while not being so brittle that it will readily shatter. Common steels in robot combat are 4130, 4140, 1095, and S7. There are many other steel options out there and often you can find a specific alloy that is well suited to your application.
- Titanium: Titanium is a fantastic material if you've got the budget and tools to use it well. Grade 5 titanium provides a great balance of light weight and strength at the cost of being difficult to work with and expensive.
- Aluminum: Aluminum is a fairly light metal, easy to work with and isn't too expensive. There are many grades of aluminum available, but 6061, 2024 and 7075 are the most common in robot combat applications.
- Magnesium: Magnesium is the lightest metal listed here. Magnesium is fairly easy to machine, however heat control is a must as it burns energetically if it is allowed to get hot enough. AZ31b magnesium has a higher tensile strength than aluminum, which makes it a great material for armor if you can afford the cost, which rivals titanium.

Plastics

There is a wide range of plastic materials available and an entire guide could be written on them. The most common plastics in robot combat are polycarbonate, nylon, UHMW polyethylene, and delrin.

- Polycarbonate: This plastic is also known as Lexan and is the material used for arena walls. It once was a very common construction material due to its impact resistance, however it is prone to fracturing at hole locations and has become less common in recent years. It's still a fantastic option for energy absorbing panels but you'll need to minimize the number of holes and make sure it's shock mounted as the polycarbonate needs room to flex to work properly.

- Nylon: Nylon is a relatively rigid plastic with a high tensile strength. It is most commonly used as an internal structural member. Nylon is also one of the more durable economical options for 3D printed components. While 3D printing of metals is possible it is still prohibitively expensive for most uses. Printed Nylon parts are relatively cheap and easy to get. Look for variations on "strong & flexible" when looking for printed Nylon.
- UHMW polyethylene: UHMW has become one of the more popular construction materials. While relatively low strength it has proven to be an extremely durable construction material and is frequently used both as armor and main structural elements on robots. The light weight allows a large amount of material to be used and this results in a very tough frame member that is capable of absorbing a good deal of damage. UHMW also has a fairly low coefficient of friction so it is often seen used as skids or as bushing material.
- Acetal Delrin: Delrin, like Nylon, is a fairly high strength plastic. It holds its shape well and is fairly easy to work with. Delrin is also relatively heat resistant which means you'll often see it used in applications where heat is expected. A few common uses for Delrin are wheel hubs and the bodies of power switches.

Composites

Composite materials come in two forms, pre-made parts and raw fabric. The pre-made parts are often used as armor panels when weight is a serious concern. When used properly they can be as good as some metals, however their limitations must be kept in mind. Different composites will have specific types of applications they are good for. Some are better in tension and some are better in compression. This is due to what the composite is made of. The parts, commercial or DIY, are a mix of the fabric, (Kevlar, carbon fiber, fiberglass, etc…) and a resin. The fabrics generally perform well in tension, regularly exceeding the tensile strength of popular metals and the resin handles the compressive loads.

Batteries

Lithium Polymer

Lithium Polymer (LiPo) batteries are becoming the go-to battery option for most weight classes. These batteries provide the highest energy density of all battery types that are commercially available. The downside to LiPo batteries is that they deal with damage poorly. There have been several incidents where a LiPo battery taking damage has resulted in a spectacular fire. If you're planning to use LiPo batteries be sure to consider how you'll protect them from damage as a battery fire will likely ruin most of the parts near the battery. LiPo batteries also tend to swell under heavy loading, so using padded elements in your battery mounts can help minimize the risk of damage when this swelling occurs.

Lithium Ferrite

Lithium Ferrite (LiFe) batteries are another common battery type. This chemistry does not provide the same energy density of LiPo batteries, however it is still a substantial improvement over NiMh, NiCad, and SLA batteries. LiFe batteries are also less reactive to damage which means unlike LiPo batteries there are no major events that restrict the use of LiFe batteries.

NiMh/NiCad

Nickel Metal Hydride and Nickel Cadmium batteries have fallen out of favor in recent years as LiPo and LiFe batteries have become available. These chemistries were the go to option for years in the smaller weight classes. You may be able to get these batteries for less cost than LiFe and LiPo packs, but the price difference is shrinking quickly and the massive weight increase for the same power output makes them a less than ideal option for a new bot.

SLA

Sealed Lead Acid batteries are still seen in the heavier weight classes. These batteries are heavy, but they're generally quite stable and can handle putting out large amounts of current without issue. SLA batteries are mostly worth consideration for robots weighing 60lbs or more.