

Tool Recommendations for *FIRST*[®] Robotics Competition Teams

Introduction

This guide is written by Team 3847, Spectrum in collaboration with *FIRST*. It is intended for teams that are new to *FIRST*[®] Robotics Competition (0-2 years old). This often means your team only has a few mentors who may have limited experience with tools and manufacturing. Many teams also have limited space, so smaller tools are more beneficial.

Fabrication Techniques

One of the great things about the *FIRST* Robotics Competition is that teams are free to choose what materials, tools, and design styles they want to use to build their robots. There isn't any "right" way to build a *FIRST* Robotics Competition robot. Each team should evaluate their own resources and choose how they want to construct their robot. The tool recommendations in this document are one suggestion for entering the sport. However, if your team's mentors or sponsors have other experience, equipment, and resources, there may be other design styles and materials that are more effective for your team.

Beginner Tools for the *FIRST* Robotics Competition

Here is a beginner tool list for *FIRST* Robotics Competition teams. These are tools that are likely found in every *FIRST* Robotics Competition workshop and are used to assemble the standard Kit of Parts Chassis (AndyMark AM14U).

1. Safety Equipment
 - a. Safety Goggles
 - b. Gloves
 - c. Hearing Protection
2. Hand Tools
 - a. Allen Wrenches (hex wrenches)
 - i. For US-based teams, standard sizes are going to be most common for the bolts you use to assemble your robot, but having at least one metric set is useful for some of the bolts used for motor mounting and other specific items.
 - ii. For international teams, you may choose to use metric for most of your hardware but specific parts from the US will often have standard sizes too.
 - b. Wrenches
 - i. A set of combination (open end and box end) wrenches is going to be very useful. 3/8" and 7/16" are the two most common sizes for standard *FIRST* Robotics Competition bolts so it may be useful to buy a few of each of those.
 - c. Pliers
 - i. A pair of locking pliers (vise grips) is a must.
 - ii. A few other pliers such as needle-nose pliers and tongue-and-groove

- pliers (Channellock) will be useful for various robot tasks.
- d. Socket Wrench Set
 - i. A basic set of sockets and a socket wrench will help with robot assembly.
 - ii. Useful sizes include - 5/16", 11/32", 3/8", 7/16", 1/2" and 9/16"
 - e. Hacksaw
 - i. This is the manual way to cut through metal commonly used on a robot. It takes longer than with a powered saw, but it's often the best way for teams as they are starting out.
 - f. Mallet
 - i. There are times when you will need to use force to get something to fit. Often, a rubber mallet will be better at this for robot building than a hammer which will often dent or damage parts.
 - g. Clamp-on Bench Vise
 - i. If you have a workbench and can afford a bigger vise, buy a larger one, but a small clamp-on bench vise works well for most robot applications.
 - h. Screwdrivers
 - i. Purchase from the dollar store. You won't need these too often for actual robot building.
 - ii. Buy a set of small precision screwdrivers as well. You may need these for some electrical tasks.
 - i. Flush Cutters
 - i. Used for cutting zip ties or wires
 - j. Metal Files
 - i. Used to remove rough or sharp edges after a part is cut or drilled
 - k. Clamps
 - i. A few C-clamps or F-clamps/Bar Clamps are very useful when constructing your robot.
3. Layout Tools
- a. Tape Measure
 - i. Basic measuring
 - b. Combination Square
 - i. Very useful for drawing straight lines and basic layout when making parts
 - c. Automatic Center Punch
 - i. Used to mark hole locations before drilling and prevent the drill bit from "walking"
 - d. Pencils/Markers
 - i. Depends on the materials you are using
 - ii. Metallic (silver/gold) sharpies work well when marking black items.
4. Power Tools
- a. Drill
 - i. A corded or cordless drill, depending on how much you want to spend, is a necessary tool for robot construction.
 - b. Drill Bits
 - i. You'll also need a set of drill bits.
 - ii. It's often useful to buy extras of the sizes you use most commonly. (For #10 bolts that's commonly a #7 drill or a 13/64" drill)
 - iii. A step drill bit that can drill a 1-1/8" hole is also useful as it is a common

- size for bearings.
 - c. Jigsaw
 - i. An inexpensive jigsaw is very useful for cutting sheet material such as plywood.
- 5. Electrical Tools
 - a. Multimeter
 - i. Used for measuring the state of your robot batteries and for diagnosing electrical issues
 - b. Wire cutter and stripper
 - i. Used for preparing electrical wires for the robot
 - c. Crimping Tool
 - i. Ratcheting crimpers are the preferred option.
 - ii. The type of crimp your team uses will determine the specific type of tool you need.
 1. The most basic crimp type is the automotive-style connectors that often come in yellow, blue, and red.
 2. A preferred but slightly more expensive option are Anderson Power Pole connectors and their respective crimping tool.

Tool Sources

Common sources to purchase tools:

- Harbor Freight
 - A dedicated tool store that offers very inexpensive tools. If there is one in your area this is one of the most inexpensive places to purchase tools.
- Home Improvement Stores
 - Lowes, Home Depot, Ace Hardware, etc.
 - Compare prices and check for sales. Black Friday weekend sales are often very useful for purchasing tools at these stores at lower prices.
- Amazon
 - You can purchase many tools from Amazon. Be sure to read some of the reviews as you aren't always sure how the quality of the tools compares to other brands or stores.
- Walmart
 - They have a variety of tools that may be useful for robot building.
- AndyMark.com
 - AndyMark is a common *FIRST* supplier and they also sell tools; it may be convenient to purchase tools from them when ordering other items or with some restricted grant funds.

FIRST \$1000 Tools

This list is a recommendation for the first \$1000 to spend on tools for your team.

Item	Approximate Price	Why do you need it, how we use it, etc.
3D Printer - Ender 3 V2	\$200.00	3D printers have become very useful for <i>FIRST</i> Robotics Competition teams. You are able to print many parts such as spacer, pulleys, and mounts.
Chop Saw - Evolution Power Tools RAGE4	\$150.00	This tool is used for cutting aluminum tubes, 2x4s, etc.
BladeRunner X2 Saw	\$100.00	Tabletop jigsaw. Light and blades are cheap and easy to swap. Cuts through aluminum extrusion and shaft. Cheaper than a tabletop bandsaw.
8" Drill Press	\$100.00	Drilling more precise holes than a handheld drill can make. Also has more torque for drilling larger holes or through steel, etc.
Belt Sander	\$60.00	Used to smooth cut edges, every part should go through the sander before going on the robot
200+lb Postal Scale	\$35.00	You want a 200+ lb. postal scale with a corded display. This way you can weigh your robot in your shop.
Bench Vise	\$30.00	Holding things for drilling and cutting, bending things, etc. A 4" to 5" vise is normally enough.
Jigsaw	\$30.00	Cutting plywood, etc. Especially for field building, building a cart, etc.
Anderson Crimping Tool	\$30.00	Used to crimp Anderson Powerpole connectors which we use for all our motors.
Corded Drill	\$30.00	A corded drill is much cheaper, and you won't have to worry about extra batteries. It would be smart to get a 1/2" Chuck drill in the future as well.
Rivet Gun	\$20.00	A rivet gun is used with pop rivets. A two handed version or a drill-powered version are often easier to use.
Combination Wrench Set	\$20.00	Standard and Metric wrenches include some smaller wrenches in duplicate sizes which makes it easier to tighten some nuts and bolts that need the same size wrench. Having a second set or at least another standard set is very useful.
Drill Bit Set (3/8" shank)	\$20.00	Simple Drill bit set for 3/8" chuck drill. You will want to get more drill bits as you go.
Socket Set	\$15.00	We always end up losing sockets and bits, so we just buy cheap ones. For most stuff, we can't tell the difference. Home Improvement Stores normally have \$10 to \$15 sets.
Hacksaw	\$13.00	This is the manual way to cut through metal commonly used on a robot. It takes longer than with a powered saw but it's often the best way for teams as they are starting out.
Furniture Dolly	\$12.00	Used to move things around including the robot if you don't have a better cart. We use them to move our batteries (in a bin) and our robots at demos, etc.

Item	Approximate Price	Why do you need it, how we use it, etc.
Multi-Tool Wire Stripper	\$12.00	Good multi-purpose wire stripper. Should handle most wire stripping needs. Many can also cut bolts and crimp insulated and non-insulated terminals
Heat Gun	\$12.00	All sorts of stuff, heat shrink, polycord melting, etc.
Aviation Snips straight	\$10.00	These are one of our favorite tools that we own. They cut through sheets of plastic and thin sheet metal easily. We reach for these a lot and they are always in our tool bag that stays on our cart.
Locking Pliers (aka Vise-Grips)	\$10.00	Buy at least two locking pliers. Look around for deals, we don't suggest the dollar store versions of these as they don't hold up as well.
Step Drill	\$10.00	Used for drilling larger holes in thin metal and plastic. Get one that has 1-1/8" and 7/8" sizes
Precision Pliers Set	\$10.00	Used for all sorts of gripping tasks.
Deburring Tool	\$10.00	Used to clean the inside of holes, etc. May want to get a few of these.
Combination Square	\$10.00	90-degree angles are hard, this makes it easier to mark them.
Multimeter	\$10.00	Used for measuring the state of your robot batteries and for diagnosing electrical issues.
Hex Key Set	\$8.00	You will use these a lot, getting another SAE set would be a good idea. Dollars stores often have cheap sets as well. Buy multiple sets.
Metal File Set	\$8.00	Used to remove sharp edges or making items slightly smaller. A needle file set is also a useful investment but not required.
Precision Screwdriver Set	\$5.00	You will need these for some electrical tasks.
Flush Cutter	\$4.00	Used for cutting wires and zip ties. Awesome to have a couple of these around.
Automatic Center Punch	\$4.00	Used to mark hole locations before drilling and prevent the drill bit from "walking".
6 in Bar Clamps	\$3.00	Used for clamping things to a table to cut them, or holding robot parts together while you match drill them.
Tape Measure	\$2.00	Basic measuring
Screwdrivers	\$1.00	Get a few cheap dollar store sets for now.
Gloves	\$1.00	Dollar Store gloves will do the job to start.
Fabric Tape Measure	\$1.00	Get one from a Dollar Store or Michael's or Hobby Lobby. Used for measuring Frame Perimeter. Should be longer than 120 inches
Utility Knife	\$1.00	Dollar Store
Scissors	\$1.00	Find some decent dollar store scissors, look in the kitchen section.
Rubber Mallet	\$1.00	Repositioning parts without leaving dents or damage
Hammer	\$1.00	A small hammer from a dollar store is often enough.
Total	\$1,000	

Additional Tool Options

As you are able to grow your team and resources there are many other tools that you may want to purchase. Here is a brief list of some of the most useful tools for *FIRST* Robotics Competition teams.

- Toolboxes and Organization
 - Keeping your shop organized is very important.
 - Consider how you will organize your tools both in your shop and when you go to events.
 - DeWalt Tstak toolboxes are very convenient for taking your tools to events.
 - Harbor Freight's US General brand of Toolboxes is robust yet inexpensive compared to other quality brands.
- Cordless Drill and Tools
 - Buying battery-powered drills, saws, impact drivers, or even rivet guns can be convenient for many teams.
 - Using the same brand and battery for all your tools is ideal so you can share batteries and chargers.
 - Smaller 12V tools are more compact and easier to use in tight spaces.
 - Commonly Recommend Brands
 - Milwaukee
 - DeWalt
 - Ryobi
- Metal Lathe and Tooling
 - Create cylindrical parts, such as spacers and shafts. Cut snap ring grooves. Drill center holes in round-stock and many other tasks.
 - A mini lathe (7") is often a good way to get started while a 10" lathe is enough for most *FIRST* Robotics Competition tasks.
 - A DRO (Digital Read-Out) will increase the ease of use of a lathe.
 - Some commonly recommended brands include
 - Precision Matthews
 - Grizzly
 - Harbor Freight
- Arbor Press (~\$60 to \$400) and Hex Broach (~\$250)
 - We recommend the 1 Ton version at a minimum. This is the proper way to press in bearings, pinions, and many other robot tasks. You may not know what else you will use this for until you get one.
 - A 3 Ton Arbor Press can be combined with a ½" hex broach to make hex holes in parts.
- CNC Router
 - A CNC router is one of the most useful tools a *FIRST* Robotics Competition team can acquire. It allows you to cut parts from flat materials such as aluminum, polycarbonate, and wood.
 - Some commonly recommended brands include
 - Omio X8 (\$3000 to \$4000)
 - ShopSabre (\$10000 to \$20000)
- Woodcutting saws
 - Circular Saw (~\$50) or Table Saw (\$400 to \$1500)

- These are mostly used for cutting large sheets of plywood.
 - Very helpful for building the team versions of the *FIRST* Robotics Competition playing field.
- Manual Mill or CNC Mill
 - Used for creating precision parts
 - Most useful when a mentor on your team has experience machining with a mill
- Compressor and Air Tools
 - Air Powered tools are useful for many applications.
 - Pneumatic rivet guns are more convenient than manual ones.
 - Pneumatic staple and nail guns are useful for making *FIRST* Robotics Competition bumpers.
- Laser Cutter
 - A laser cutter (\$6000 to \$10000) is great for cutting wood and plastic. They cut parts very fast and require very little training to use.
 - An 80w to 130w Co2 laser is most commonly used by *FIRST* Robotics Competition teams.
 - Thunder Laser is a brand used by several *FIRST* Robotics Competition teams.
- Sheet Metal Brake
 - A sheet metal brake is used for bending flat material such as aluminum or polycarbonate.
 - There are a variety of options at various price points.