Lightning Robotics
Fabrication Basic Training

Familiarization with Shop
- Identify all areas
- Identify all equipment

Tool Storage / Cleanup
- Tool Box Labeled Drawers
- Pit Carts/Robot Cart Tool Boxes are off limits.
- Parts/Tool Cage.
- Must sign out tools, Calipers, stock
- Must clean up your own mess before you leave, Time cards will not be signed. If work is still in progress clean up what you can. Return anything signed out to the cage.
- Bins for Sub-Assemblies

CAD Drawings
- Safety – Watch out for paper cuts ☺
- Identify Zero Point
- Check for missing dimensions – All holes have diameter? And X – Y dimension?
- Stock Material (different thickness)
- Is this a one off piece or will multiples of the same be needed? If many identical pieces are needed consider the use of a template (gussets).
- Will multiple somewhat similar pieces be needed? Make them all to the same size first. Clamp the pieces together and drill holes at the same time. Why easiest way to make sure holes line up. Measuring/Marking/Drilling holes on separate pieces, the holes will be a little bit off.
- Making Left/Right Pieces, make them together, but watch the orientation

Measuring
- Standard vs. Metric
  - We don't normally use Metric. Sometime something we purchase will have metric parts.
- Measure Twice – Cut Once
- Can always make it shorter
- Tape Measure
  - Do not use clip at end – start at the one inch mark
  - Clamp end in place for long measurements
- T-Square

    - Do not take them apart
    - Has built in scribe, put it back do not lose them.
- Calipers
    - Most accurate – Make sure to zero
    - Use lock knob to lock measurement to make multiple identical measurements
    - Can also be used to scribe marks
- Marking
    - Scribes – pointy tools used to "scratch" mark into stock
    - Center Punch – use to make an indentation to start a drill bit. Need to be precise.
    - Markers, Fine Point, Regular, normally not used for making, but maybe in some cases.
        - Use to enhance scribe marks
- Measuring Process
    - Square up one end of stock
    - Measure length, Scribe.
    - Check Drawing, measure again… why Measure Twice Cut Once.
    - Cut to length, leaving a bit long… why can always make it shorter.
    - Use Belt Sander to square up cut end and get to exact dimension.
    - Only after piece is the correct dimensions, do you proceed with additional markup.
    - Identify the 0, 0 point on the piece and mark it, could also mark top/bottom/left/right if needed.
    - Note on drawing which markings are on the same lines.
    - Layout additional marks all measured from the 0, 0

Stock Material

- Types
    - Steel – Heavy, hard to machine, easy to weld, we have only used rarely.
    - Aluminum – Different Classifications
        - 7075- It is strong, with a strength comparable to many steels, and has good fatigue strength and average machinability. It is expensive – we have not used.
        - 6061- It has good mechanical properties and exhibits good weld ability. It is one of the most common alloys of aluminum for general purpose use.
        - 5052- It has good workability, medium static strength, high fatigue strength, good weld ability, bit easier to bend than 6061 – We have not used
        - 2024 - It is used in applications requiring high strength to weight ratio, as well as good fatigue resistance. It is weld

able only through friction welding, and has average machinability. We have not used.

- Brass – Softer metal – used in a lot of bushings (what is a bushing?) Only tried to use a brass gear once.
- Plastic
  - Acrylic – Fractures (Shatters) easily (rarely used)
  - Plexiglas – Not used
  - Polycarbonate (Lexan) Can still fracture, but is more resilient- Used a Lot
  - UHMW Ultra High Molecular Weight – Fairly soft, easy to machine, though messy, low friction – Starting to be used more
  - Delrin, harder plastic, expensive, very low friction (not used recently)
  - Red Stuff, falls in between UHMW and Delrin. Used last year
  - PVC – Plumbing tube, Schedule 40, Schedule 80 – Used a lot.
    - Pipe - The purpose with a pipe is the transport of a fluid like water, oil or similar, and the most import property is the capacity or **the inside diameter**.
    - Tube - The nominal dimensions of tubes are based on the outside diameter.

Profile – Flat, Angle, Box (square – rectangle), Tube, C

Thickness

.062, .08, .09, .125, .18, .25 (What are those in fractions)

Fasteners

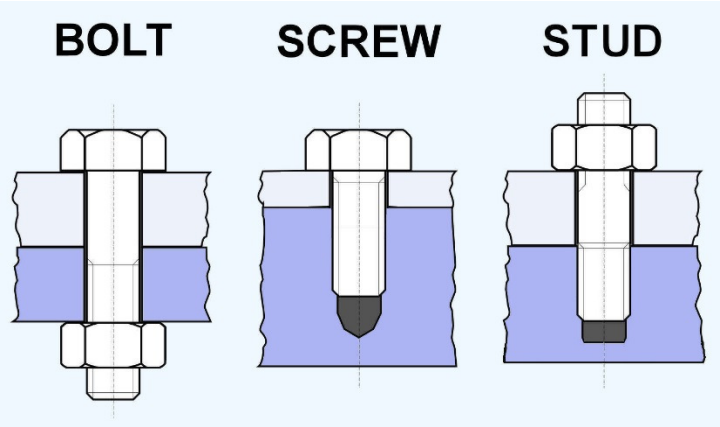
- Bolts / Machine Screws
  - Where Used
    - Stronger connection is required.
  - What's the difference? Some bolts can be used as screws; some screws can be used as bolts.
    - 

Figure 1 http://engineerexplains.com/answr/Screw-vs-Bolt1.html

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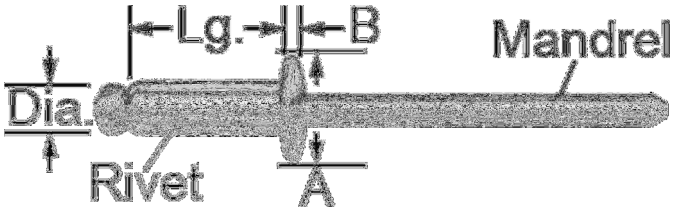
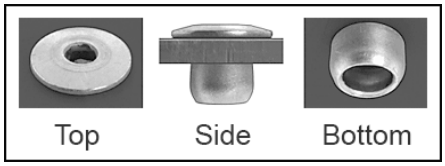
http://store.curiousinventor.com

  - Sizes (Length varies)
    - Diameter x threads per inch
    - 3/8 x 16
    - 1/4 x 20
    - #10 x 32
    - #8 x 32
    - #6 x 32
    - #4 x 40
  - Heads
    - Hex head
    - Flat Head
    - Allen Head
      - Button
      - Cap
      - Flat
  - Grading – Standard / Grade 8
  - Material Steel, Aluminum, Stainless Steel
  - Nuts
    - Standard 

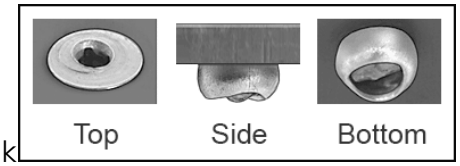
        - Nylock

        - Kep
- Rivets (Blind Rivets / Pop Rivets)
    - Where used
        - Good were access to both sides is restricted
        - Eazy to drill out an replace
        - Lighter than bolts
    - Material
        - Aluminum Rivet - Steel/Aluminum Mandrel
        - Steel
        - Stainless Steel
        - 

    - Sizing
        - Diameter 1/8 – 3/16 – 1/4
        - Grip Length 1/8 – 5/16
    - Head – Diameter
        - Domed



        - Counter Sunk



    - Mandrel
    - Shear Strength – Pieces rotating can shear the rivets

Screwdrivers

- Types
    - Flat / Straight
    - Phillips
    - Square
    - Torque

- Get the right size for the head
- Righty Tighty / Lefty Loosey
- How to hold to apply torque
- Do not let end slip
- Don't use as pry bar
- Don't use as center punch

Wrenches

- Safety – watch your knuckles in close spaces and tight bolts
- Righty tighty – lefty loosey
- Types – Generally used for hex head bolts and hex nuts
    - Combination
    - Box End
    - Open End
    - New Styles - Ratchet

Sockets

- Generally used on Hex Bolts
- Drive Size ¼" 3/8" ½"
- Socket Length – Standard length / Deep Well
- Driver direction selection
- Socket design – Star – Square – hex
- Attachments for Allen head bolts

Allen Wrenches

- T-Handle
- L-Handle – Long end more torque, Short End easier to fit some spaces
- Combination Set
- Ball End
- Different Sizes

Deburrer

- Purpose is to remove burr on metal after cutting
- How to use properly.
- Don't just go around in circles
- Should be able to remove burr in one motion

Files/Rasps

- Also used for deburring, smoothing edges, and removing material
- How to use properly
- http://www.wikihow.com/File-Metal
- **Select a file that is best for the job.** There are many types of files, coming in various sizes, shapes, degrees of coarseness, and tooth geometries.

- **Clean the file.** There should not be any pins (bits of filed metal) stuck in the teeth; if there are, clean them out with a stiff wire brush or, if necessary, a piece of skinny wire or sheet metal.
- **Lubricate the file**: Lubricate the teeth of the file or a small amount of oil. This makes the file less likely to become clogged with pins in the future.
- **Clamp the work in the vice.** It should protrude far enough that you are not likely to rub the file on the hardened steel jaws of the vice, but not any more than this - if the work extends too far from the jaws of the file, it will vibrate ("chatter") during the filing, making the work take longer and the finish of the work poor.
- **Now, for the actual filing, (the following 3 steps are not to be taken in order - you may indeed only do one of them)**:

    - **For heavy cross filing**, to remove material, grab the handle of the file with the dominant hand and place the palm of the other hand on the end of the file. Orienting the file so that it points away from you, press down firmly (so that the file digs in and cuts the metal) and make long, slow strokes away from your body, removing downward pressure on the return stroke to prevent dulling the file.
    - **For light cross filing, to remove material with a small file (as for detail work)**, grab the handle of the file with the dominant hand and place the fingers of the other hand on the end of the file. Orienting the file so that it points away from you, press down firmly (so that the file digs in and cuts the metal) and make long, slow strokes away from your body, removing downward pressure on the return stroke to prevent dulling the file.
    - **For draw filing, to make a highly finished surface**, grab each side of the file with your hands only somewhat further apart than your work piece. Orienting the file so that it points to your side, press down firmly (so that the file digs in and cuts the metal) and make long, slow strokes away from your body, removing downward pressure on the return stroke to prevent dulling the file.

Cutting – Tin Snips/Box Cutters

- Tin Snips – only used rarely
  - Safety – USE GLOVES, this cutters leave razor sharp edges
  - Use only for soft and thin material (not for steel or anything larger than 1/16" aluminum)
  - Use only one hand for cutting, if you cannot cut with one hand, material is probably too thick or hard.
  - Unlike sissors… When cutting the bottom blade will come up instead of pushing the top blade down. This is just the opposite of the motion you are familiar to using when cutting with scissors. Keep the top blade aligned over the metal sheet and bring the bottom blade upwards, cutting from the bottom side up.
  - Do not try to cut sharp curve with the straight cutting yellow cutters.
  - Use the red snips in your right hand to cut counter clockwise
  - Use the green snips in your left to cut clockwise.
  - When you are cutting with snips, don't cut all the way through.
  - When you are cutting watch the jaws on the snips and only cut about 3/4 of the way then release and move the snips ahead, this way you do not leave those sharp bends.
  - When you are cutting with the red snips in your right hand, the metal on your right will lay flat, if you take the metal on the left and hold it up about 20 degrees, then it will not bend, and both pieces of metal will be good
- Box Cutters
  - SAFETY use Gloves
  - Have stock being cut clamped securely
  - Do not try to cut all the way though at once.
  - Take a bunch of light, small cuts

Hack Saw

- Used to cut Metal, Aluminum and Steel, Plastics, could be used for wood, but going to take a while.
- How to load Blade
  - Blade direction
    - Look at teeth, (some have arrow) teeth point forward.
    - Hack saw only cuts on forward stroke, does not cut on backward stroke.
  - Tension – Need to be tight, loosely tensioned blades will not cut as straight
  - Sometimes mount blade on able to fight tight spots
- Different Blade Material and number of teeth
  - We usually only have one type of blade
  - The thinner the stock being cut the more teeth per inch are needed.
- Cutting

- Stock needs to be securely clamped
- Clam should be as close to the cutting location as possible.
- Take advantage of any right angle surfaces in clamping devise to make a straight cut
- Hold hack saw with two hands on either end when possible.
- Want big, long, slow strokes, do not want a bunch of little ones until the very end.
  - Evens out wear on blade
- Start by applying pressure and pushing forwards.
- Ease off pressure on back stroke.
- Lubricate blade when cutting.
- When almost though material can start using shorter strokes for more control
- The cutting angle is susceptible to changes in how the handle is being held
- SAFETY: Parts are generally very hot after being cut, do not pick up with fingers.

Tap & Die

- Safety – Nothing Specific
- http://www.irwin.com/support-services/ask-irwin/1

- Be sure to select the right diameter and threads per inch.
- Tap and dies are metal threading tools. Taps make internal threads inside a hole and dies make external threads on a round rod.
- Tapping
  - To create new threads inside a hole you must first drill a hole. Refer to the tap / drill chart in your set to determine the correct drill bit size for the new hole. Drill your new hole.
  - Place the square of the tap into the tap holder and tighten. Place the tip of the tap into the hole. Keep the tap as perpendicular to the hole as possible. Press down and turn the tap in the hole. The tap should begin cutting threads into the wall of the hole. After making 2 - 3 full turns, turn the tap backwards 1/2 - 3/4 of a turn. This will break the chip loose.
  - Continue the above steps, lubricating as necessary, until finished.
  - Sometimes it is necessary to remove the tap from the hole and clean it out before starting to tap again.
  - Go slowly, constantly checking to make sure the tap is square to the material.
- Dies
  - Dies are used in the same manner except they are used on a round stock instead of in a drilled hole.
  - It will probably be necessary to put a bit of a bevel on the end of the rod to help get the die started.
  - The die size you select should be the same size as the rod. IE If you want a 3/8" rod, you would use a 3/8" die.
- We always recommend using a quality cutting fluid. This will extend the life of the tools and improves the quality of the threads.

Chain breaker

- Ehow.com
- Unwind the handle of the chain breaker tool until you have enough room to place one of the chain links on the outermost slot of the tool. It doesn't matter which link, because they are all the same. Back the handle out until the pin is out of the way.
- Turn the handle of the tool clockwise until the pin of the tool connects with the pin in the chain link. Continue twisting the handle to push the pin in the chain link out the other side. Stop twisting just before the chain link pin is completely pushed out. If you push it all the way out, you won't be able to reconnect the chain links. When you begin to feel resistance on the handle as you twist it, stop twisting.
- Remove the chain from the tool and twist it where you've pushed the pin. The links will separate as you twist. Twist one side of the link clockwise and the other side counterclockwise until they separate.
- Remove the chain from the sprockets. Make the necessary repairs and then replace the chain. Snap the links back together.
- Place the chain link back on the chain breaker tool's outermost slot with the link pin facing in toward the tool's pin. Twist the handle of the tool clockwise to push the pin back through the link plates until it's evenly protruding on both of the outer sides of the chain link plates.
- Back off the handle of the tool and move the tool so that the chain link sits on its innermost slot. Twist the handle of the tool until the tool's pin gently taps the chain link pin. This will loosen any compression that has caused the sides of the chain link to bind and get stiff.

Wood Saws

- Back Saw / Miter Saw
    - A **backsaw** is any hand saw which has a stiffening rib on the edge opposite the cutting edge, allowing for better control and more precise cutting than with other types of saws. Backsaws are normally used in woodworking for precise work, such as cutting dovetails, mitres, or tenons in cabinetry and joinery. Because of the stiffening rib, the backsaws are limited in the depth to which they can cut. Backsaws usually have relatively closely spaced teeth, often with little or no set.
- Crosscut Saw – Wikipedia
    - A **crosscut saw** is a general term for any saw blade for cutting wood perpendicular (across) the wood grain. Crosscut saws may be small or large, with small teeth close together for fine work like woodworking or large for course work like log bucking, and can be a hand tool or power tool.

- The cutting edge of each tooth is angled in an alternating pattern. This design allows each tooth to act like a knife edge and slice through the wood in contrast to a rip saw, which tears along the grain, acting like a miniature chisel. Some crosscut saws use special teeth called "rakers" designed to clean out the cut strips of wood from the *kerf*. Crosscut saws generally have smaller teeth than rip saws.

- Rip Saw - Wikipedia
  - In woodworking, a cut made parallel to the direction of the grain of the workpiece is known as a rip cut. If one were to cut a tree trunk in half from top to bottom, this would be a rip cut — but the term also applies to cutting free lumber.
  - A **rip saw** is a saw that is specially designed for making rip cuts. The cutting edge of each tooth has a flat front edge and it is not angled forward or backward.[1] This design allows each tooth to act like a chisel (rather than being knife-like, as with a crosscut saw), preventing the saw from following grain lines, which could curve the path of the saw. By acting like a chisel, the saw can more easily cut across deviating grain lines, which is necessary if a straight cut is to be achieved.