Mechanical Issues

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Agenda

- The Maslab Workshop
  - Raw Materials
  - Other Materials
  - Fasteners
  - Tools
  - Safety & Maintenance
- Mechanical issues
  - Motors
  - Techniques
  - Design Principles
  - Other resources

The Maslab Workshop

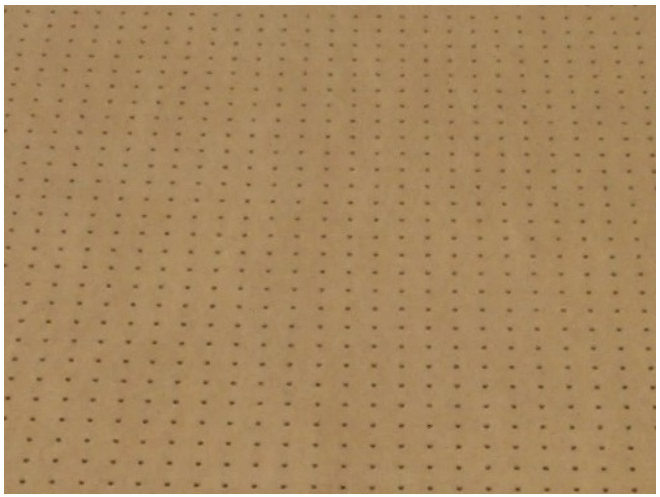
- Goal: Be able to build a simple robot with the tools and materials provided in the Maslab Workshop

Raw Materials

- Pegboard
- Hardboard
- Baltic Birch Plywood
- Sheet Aluminum
- Polycarbonate
- Prototyping Foam

Raw Materials

- Pegboard (1/4” thick)
  - Great for initial testing – already has ¼” holes on 1 inch spacing
  - Useful in some specific applications, generally limited
  - Can be cut with anything sharper than a butter knife



Raw Materials

- Hardboard (1/4” thick)
  - Pegboard, without the holes
  - Better for intermediate designs (cheap!)
  - Hardboard used during development can be replaced with better quality plywood for final version

Raw Materials

- Baltic Birch Plywood (1/4”, 3/8”)
  - The good stuff – strong, looks nice
  - A bit slower to cut
  - Pre-drill holes for wood screws to avoid cracking

Raw Materials

- Sheet Aluminum (1/16”)
  - Great for smaller structural members like L-brackets
  - Bending can increase strength
  - Easy holes with hand punch →
  - Quick cuts on shear

↘

Raw Materials

- Polycarbonate (1/8”, 1/4”)
  - Looks really cool
  - Not too hard to machine, unless it gets hot and softens
  - 1/8” can be sheared and hand punched
  - 1/4” can be cut using scroll saw and drilled
  - Good for mounting gears

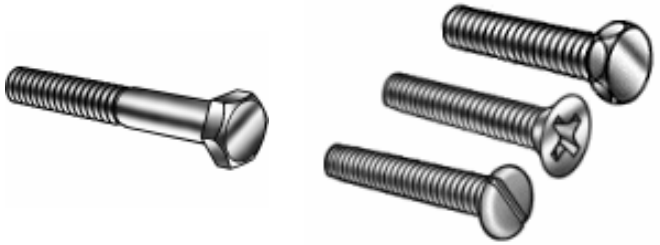
Raw Materials

- Prototyping foam (2” blue foam)
  - Large sheets available
  - Good for bulky parts
  - Cuts easily with hot knife
  - Also can be sculpted with hot knife for interesting / irregular shapes

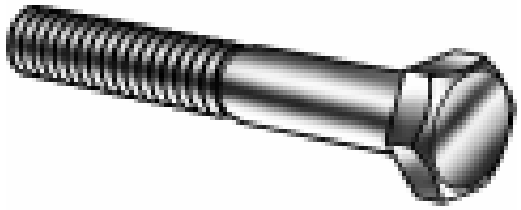
Other materials

- Wooden dowels
- Hollow metal tubing
- Springs
- PVC pipe
- Foam pipe insulation
- Gears
- Others…

Fasteners

- Bolts and machine screws 
  - sizes from ¼” down
- Wood screws 
- Glue (hot glue, superglue, wood glue)
- Tape

Fasteners



- Use the bolts! We have plenty
  - Washers protect softer materials like wood (one each at top, bottom)
  - Many ¼”-20 bolts, but also from #10-#2
  - Try to pick most appropriate size. Sometimes longer bolts can eliminate need for additional pieces
  - For loose but permanent connection, tighten 2 nuts against each other

Fasteners

- Bolts continued
  - Bolts are great for temporary fasteners, as well as permanent ones
  - Use lock washers to prevent loosening from vibrations – teeth bite into surface of material and nut

Fasteners

- Wood glue – best with wood screws for permanent joints.
  - Make a solid piece out of multiple pieces
  - When glue dries, stronger than the wood around it. Dry time is long, though
- Superglue – quick and dirty, or use with other fasteners for permanence

Fasteners

- If you’re not sure how well a joint will work, use scrap and test it
- Testing mechanical parts is a good idea in general, just like software
- Design for assembly and re-assembly

Tools

- Scroll Saw
  - Thin (1/4”) wood and polycarbonate only
  - Makes curved cuts
  - Don’t force the blade in any direction, medium pressure will cut
  - No metal allowed!

Tools

- Hacksaws, wood saw
  - Cut wood, PVC, cardboard
- Pipe cutter (small red gadget)
  - Cuts brass tubing – turn and tighten gradually
- Rotary cutting tool
  - Quick, but inaccurate

Tools

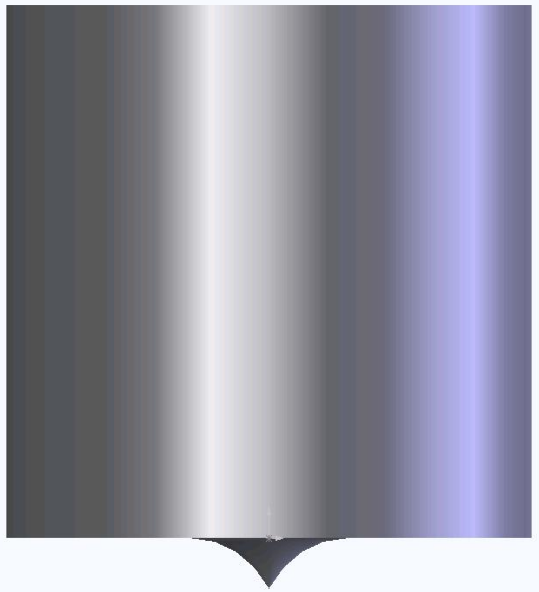
- Mitre saw
  - More accurate wood cuts, any angle
  - Use clamps for best result
- Drill press
  - Wood, plastic, metal (carefully)
  - Clamp small or light pieces
  - Punch is preferable for sheet metal – if you have to drill, make sure the piece will not cut you if it binds
  - Make sure to use harder drill bits for metal

Tools

- Shear / Brake
  - Cuts thin materials only (1/16 sheet aluminum and polycarbonate)
  - Use stop (in back) for repeated cuts
  - Makes right-angle bends in metal
  - Use to make L-brackets

Tools

- Punch
  - Use the centerpunch (pointy thing) and hammer to make dents where you want holes
  - Punch tip will be easier to position



Safety

- Wear goggles when in shop area
  - You may not be using a dangerous tool, but someone else might
- If you’re unsure about a tool’s use, ask!
- Use fan when soldering
- Be nice to the benches

Maintenance

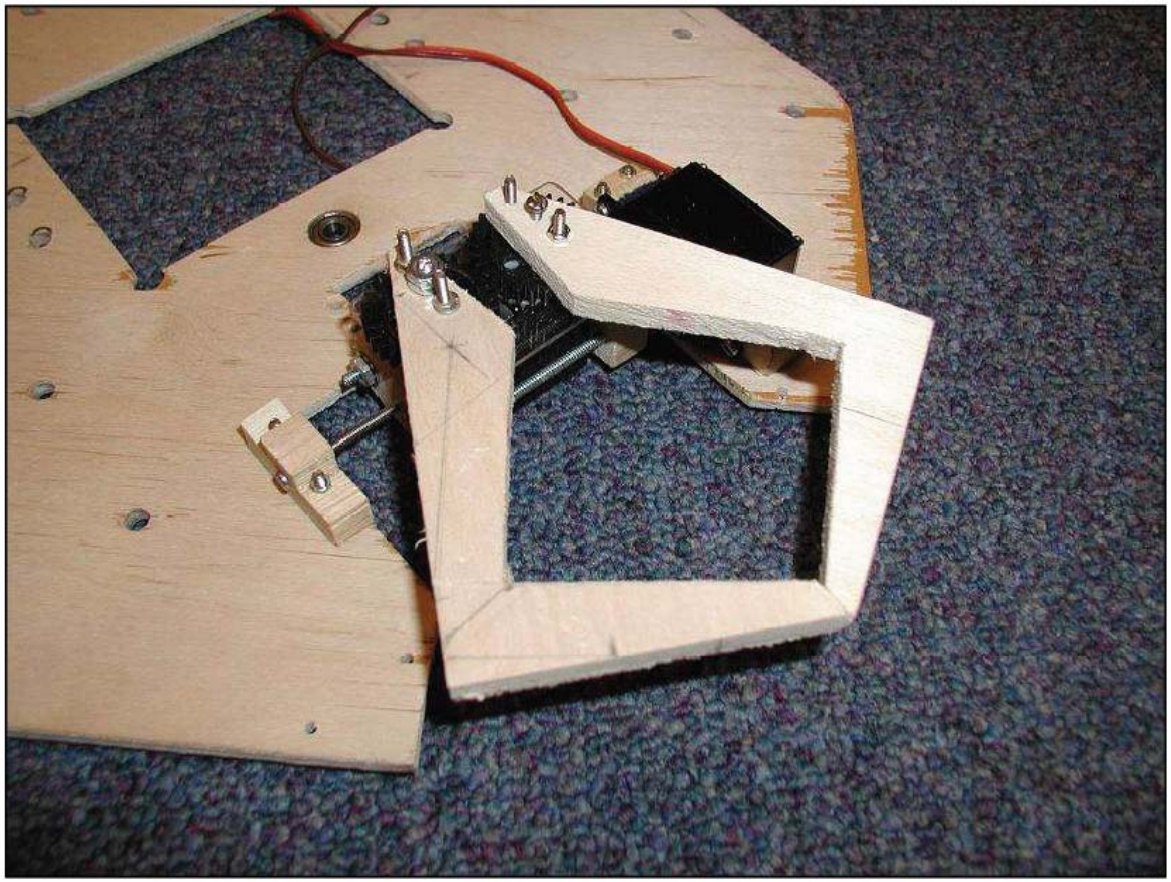
- Be nice to your labmates
  - Bring tools back as soon as you are done
  - Put bolts into correct bin, or the mix bin to be sorted later. Just not into the wrong bin
  - Drill bits have nice racks. Use them!
  - Again, be nice to the benches! Take care when soldering, use scrap under workpiece when drilling

Motors

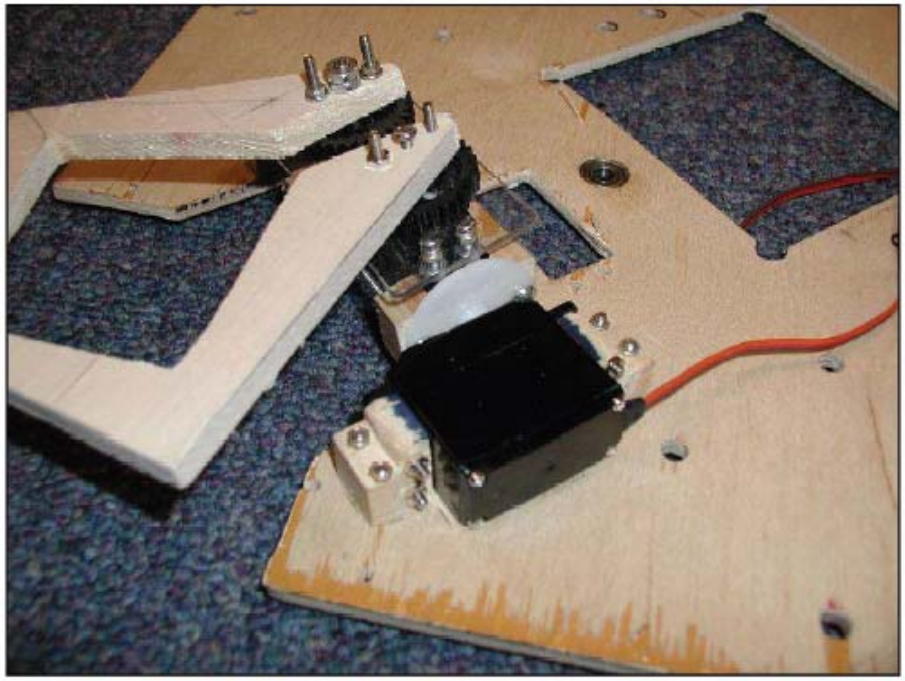
- Be careful of side loading, axial loading
- Use appropriate motors – servos have a limited range of motion, and cannot bear the load of metal motors
- Extra high speed and extra high torque motors available
- Servos can be modified for larger range of motion

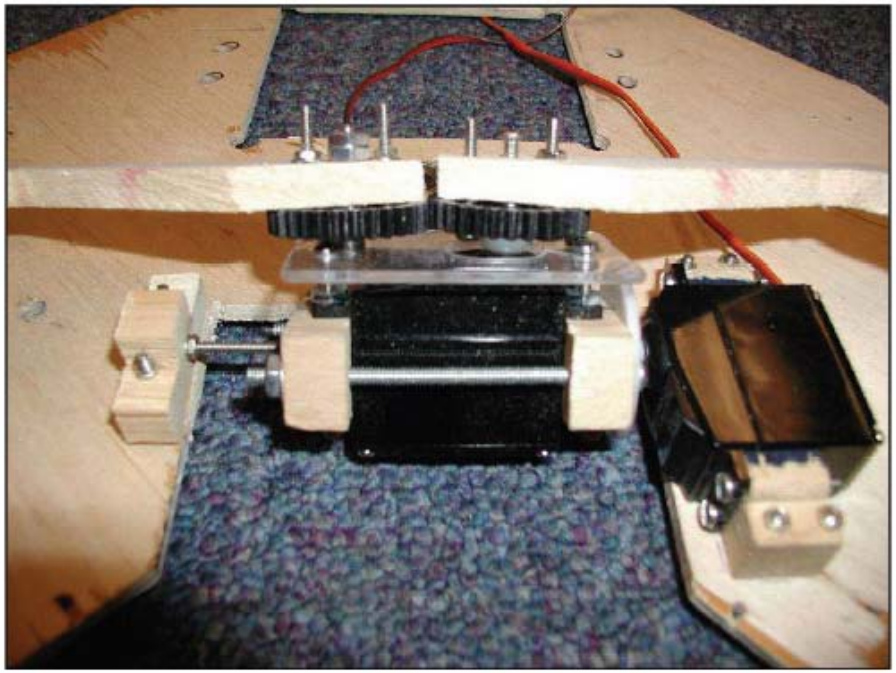
Techniques

- Many possibilities with wood and bolts



Simple Rotating Gripper





Techniques: Mounting IR and Servos

IR range finder

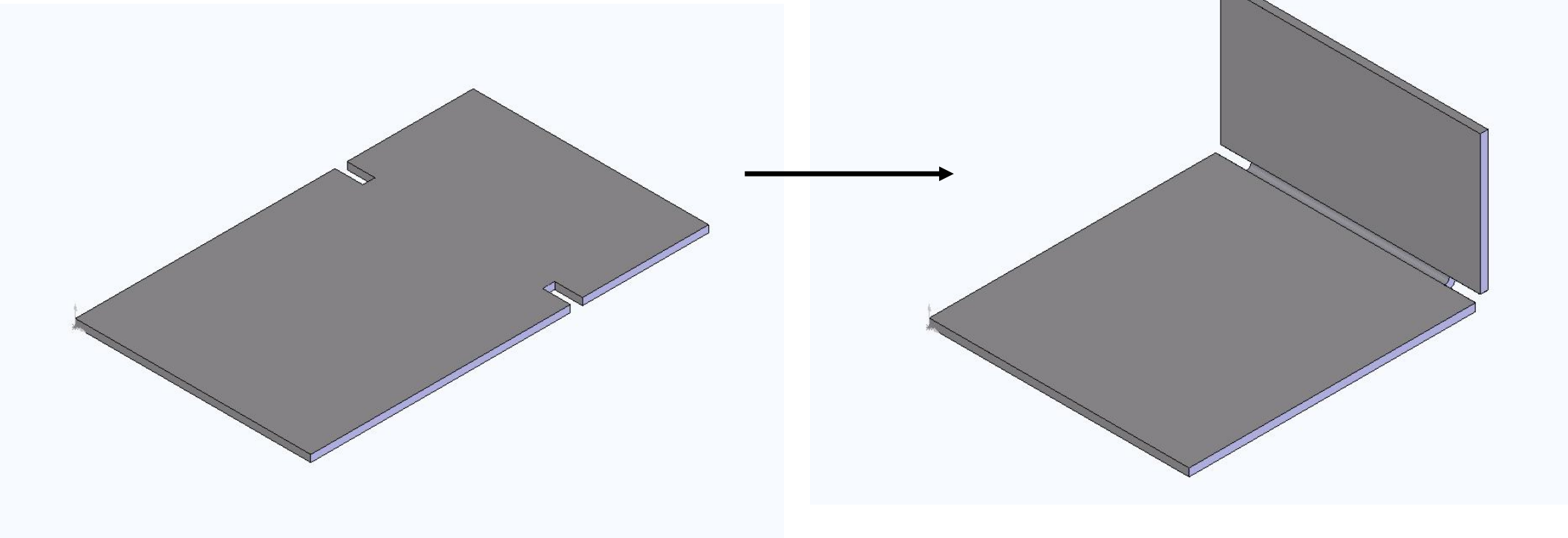
Servomotor

Techniques: Metal bending

To bend without the brake, make guide cuts using snips

(and holes along bend line for wide pieces)

This makes it bend where you want it to

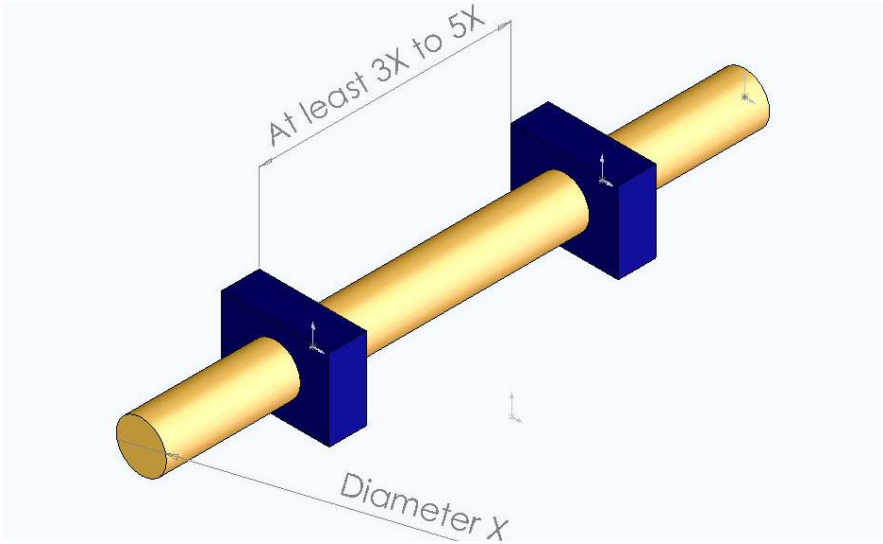


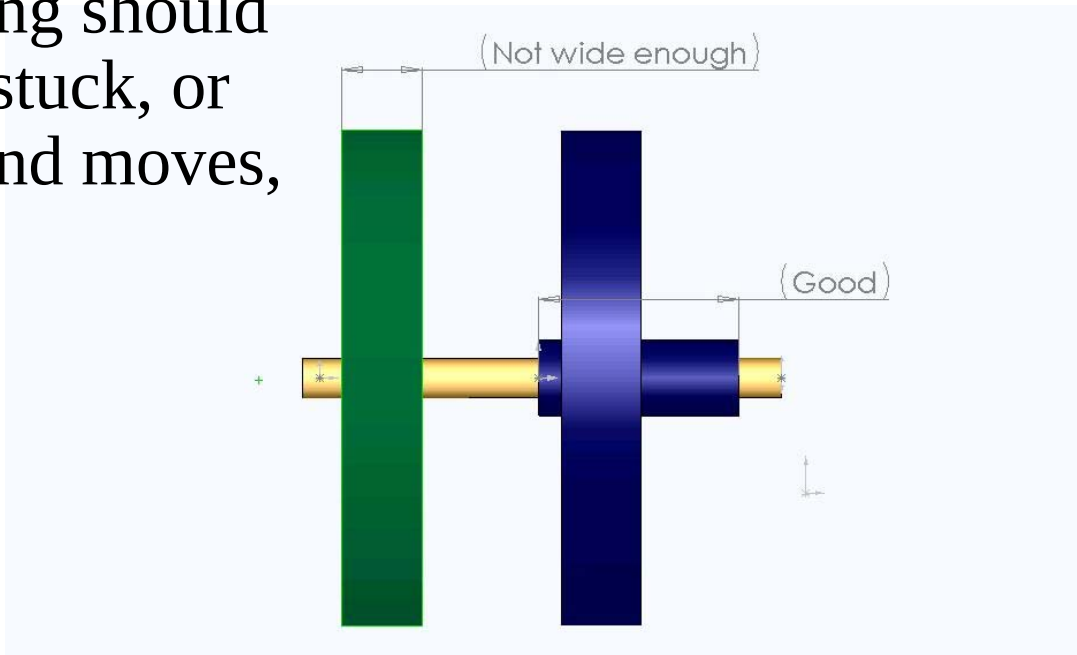
Design Principles

- Rule of 3-5

(Saint Venant's principle)

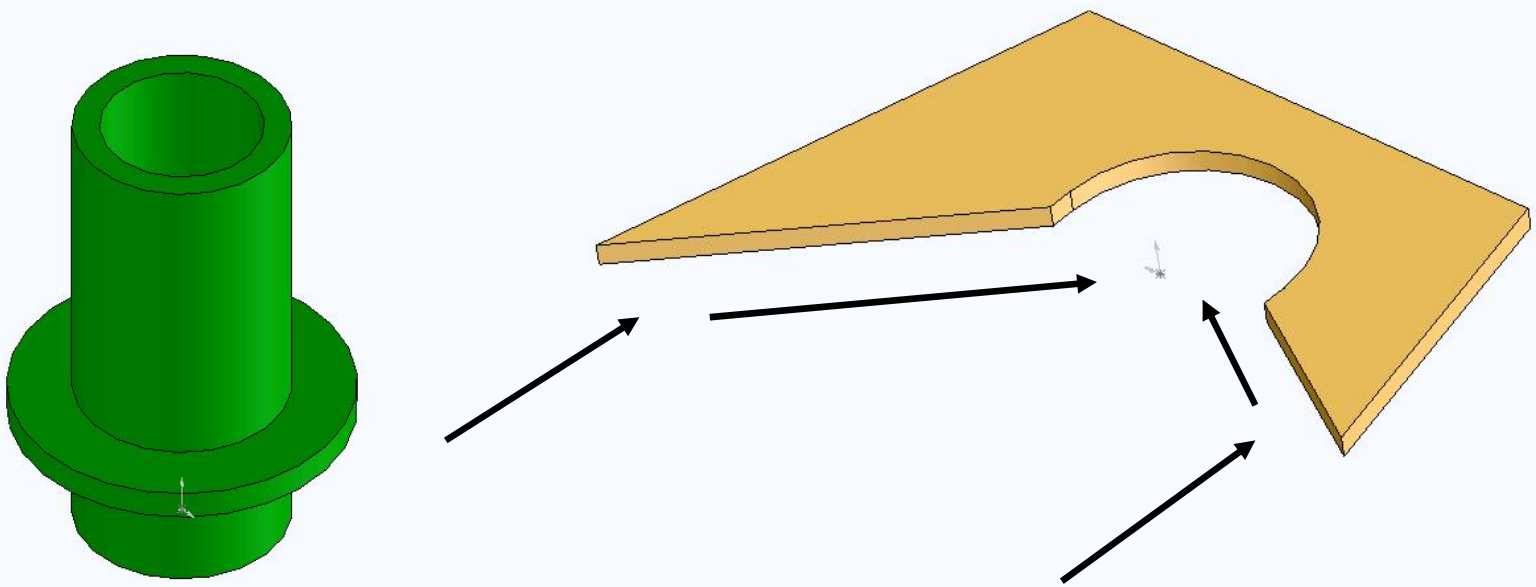
- Applies to shafts (rotary and linear motion) wheel hubs, others
- Anytime something should move and it gets stuck, or should be stuck and moves, check this rule





Design Principles

- Sometimes a mechanical solution can save software design time
- Compensate for lack of precision mechanically



Other Mechanical Engineering Resources

- Central machine shop
  - Basement of Building 38
  - All kinds of metal and plastic stock
- Edgerton Shop
  - Across Vassar Street
  - Training required, safety lecture

Parts Resources

- Mcmaster.com
  - Raw materials, fasteners, and almost infinitely more
- Sdp-si.com
  - Gears, shafts, bearings, pulleys, chains
- Allelectronics.com
  - Surplus – limited selection, but cheap
  - Browse and order interesting parts ahead of time, even if you're not sure you'll use them