Pneumatics

Team 1732

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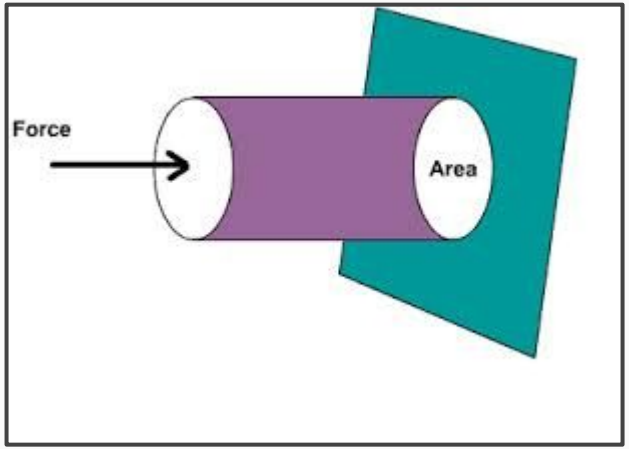
Agenda

- Intro
- FRC System Overview
- Components
- Example Mechanisms
- System Design Tips

Under Pressure

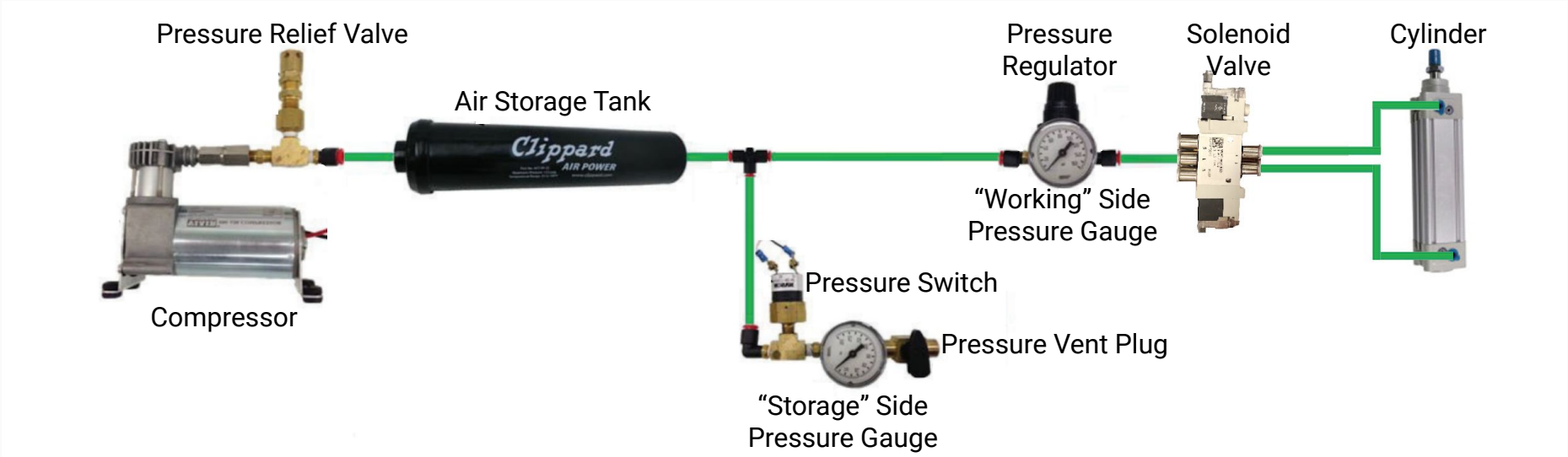
- Pressure is [force] per [area]
  - Typically pounds per square inch, PSI
- A pneumatic system uses pressurized air to produce and transmit mechanical energy



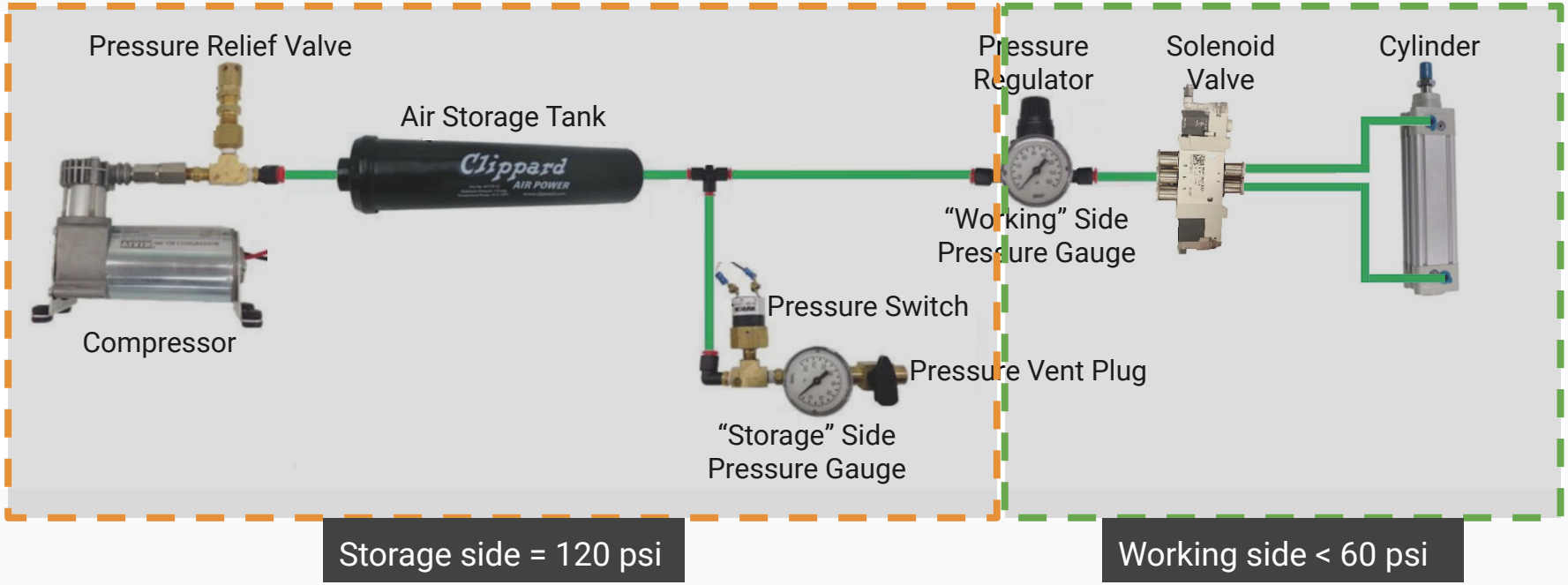
Pneumatics Advantages

- Simple to design
  - Compared to designing a mechanism with a motor, gearing, chains, belts, etc.
  - Just bolt a pneumatic cylinder onto two things
- Adjustable force
- Strong
  - Get hundreds of pounds of force
- Easy to add later
  - Adding a mechanism with pneumatics is easier than with motors

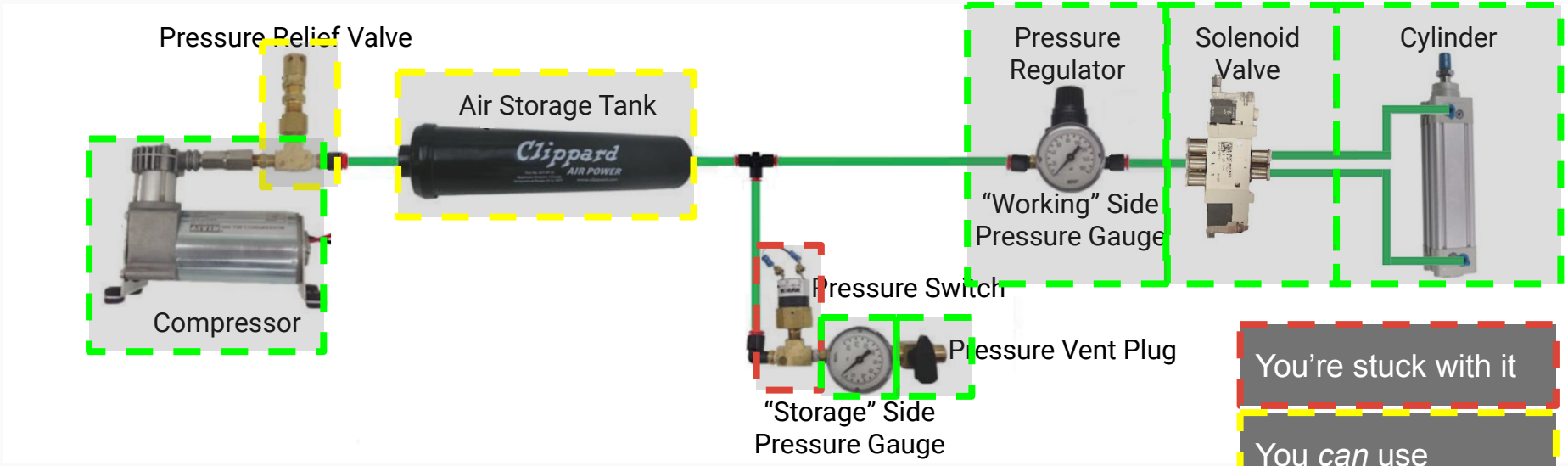
FRC System Overview



FRC System Overview



FRC System Overview



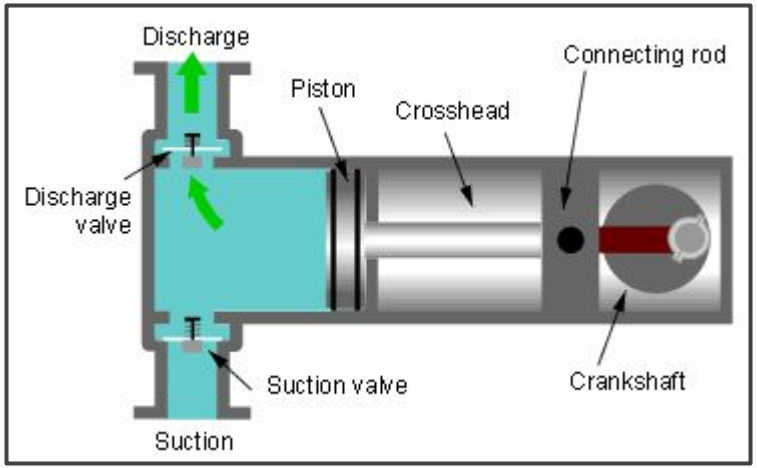
You're stuck with it

You *can* use different ones

There are many options

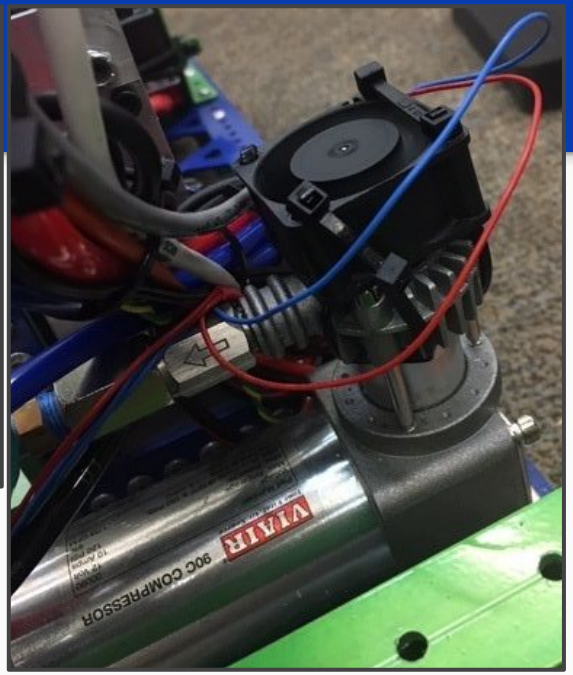
Air Compressor

- Converts electric motor rotation into pressurized air
- Pictured is a single-stage reciprocating compressor, which is common in FRC



FRC Compressors

- Viair 90c
  - Lower weight, pretty good
- Put a fan on it
  - Prevents your tubes from melting

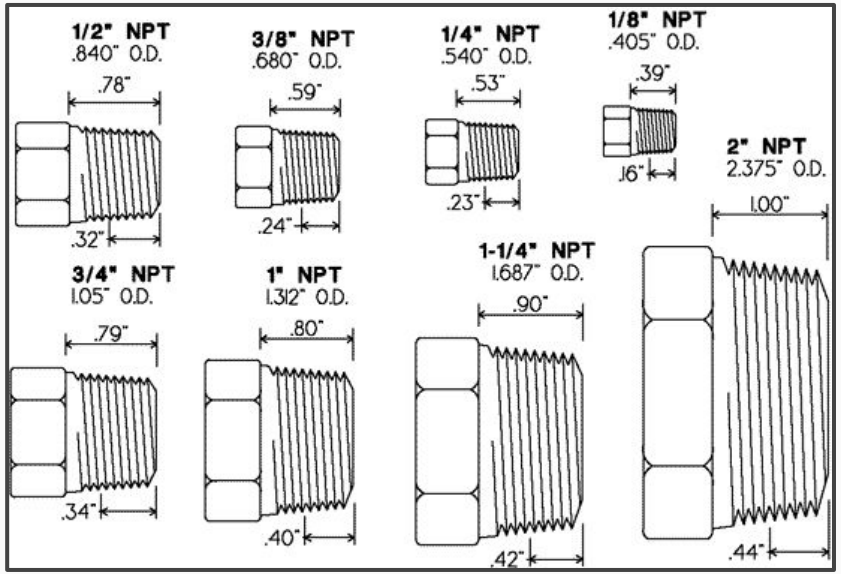


R79. Throughout an event, compressed air on the ROBOT must be provided by its one onboard compressor only. Compressor specifications must not exceed nominal 1.1 cfm (~519 cm3/s) flow rate @ 12VDC at any pressure.

A ROBOT'S compressor may be substituted by another compressor, but a ROBOT may only have one designated compressor at a time, and all compressed air on the ROBOT must be sourced from a single compressor.

Note: Viair C-series compressors, which have a max working pressure of 120 PSI, are rated for intermittent pressures greater than 125 PSI and therefore meet the requirements of R75.

Pipe Thread



- Used on many fittings
  - Threads vary on components, so check that you have the right fittings
  - 10-32 is also common
  - Small fittings, especially in brass, are prone to breaking
- National Pipe Taper (NPT) sizing isn't immediately obvious, so double check before buying!
- Tapered fittings form a tight seal
- Use with teflon tape or thread sealer

Teflon Tape

FRC Fittings

- Minimize number of connections to reduce points of failure
- Stock up on standard sizes
  - Recommended 1/4” and 5/32” tubing
  - Recommended 1/4” NPT and 10-32 threads

Automation Direct - UY14

Automation Direct - MS14-14N

McMaster - 5779K265

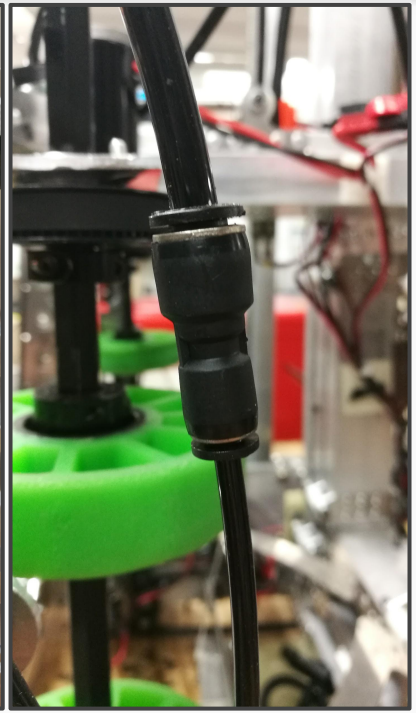
McMaster - 5779K167

Air tanks

- Just use the Clippard ones from Andymark
  - They can have problems with their built-in tube connections, but other than that are pretty good and light
  - You can use properly rated large metal air tanks, but expect to have a problematic robot inspection process at competitions

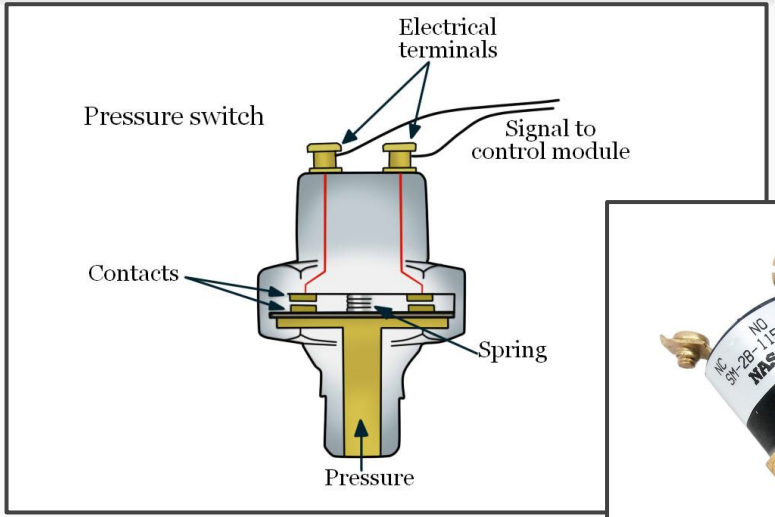
Tubing

- Tubing size limit is 1/4” OD
  - To maximize flow to compressor, air tanks, solenoids, large-bore cylinders
- Smaller tubing, 5/32” OD
  - Easier to route
    - Smaller
    - Tighter bend radius
  - Lighter
  - Meets most flow needs for smaller cylinders
    - Has roughly 1/3 of the inner cross sectional area of 1/4“ OD tubing
  - Automation Direct sells reducers



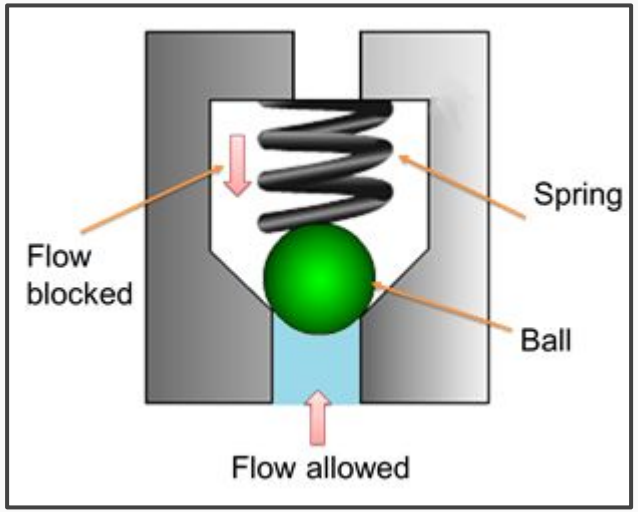
Pressure Switch

- Pressure overcomes a spring force to close contacts
  - This completes a circuit, sending a signal back to the controller, which turns off the compressor
- FRC uses Nason SM-2B-115R/443
  - Sold by Andymark
  - Preset to 115-120 PSI



Check Valve

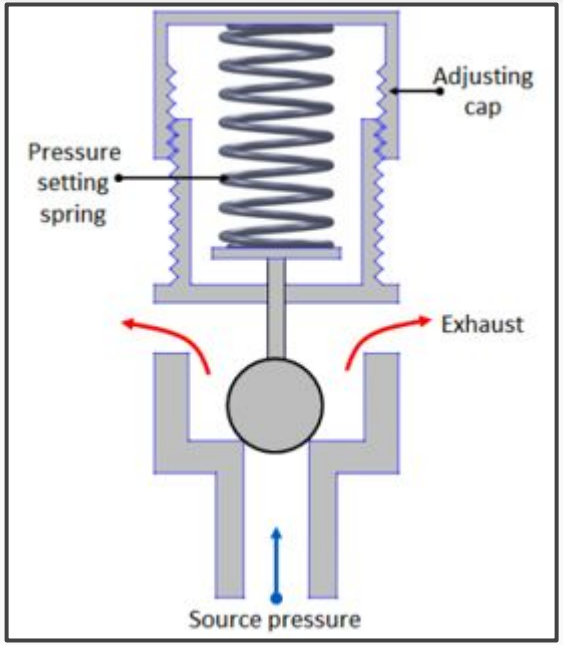
- One-direction valve, that allows free flow only in one direction
- Pressure coming from the bottom overcomes the spring and pushes the ball out of the way, allowing flow
- Pressure coming from the top pushes the ball down, preventing flow



Automation Direct - CVU14

Pressure Relief Valve

- An adjustable check valve
- Twist the cap to adjust the spring compression to set the force for the source pressure to overcome

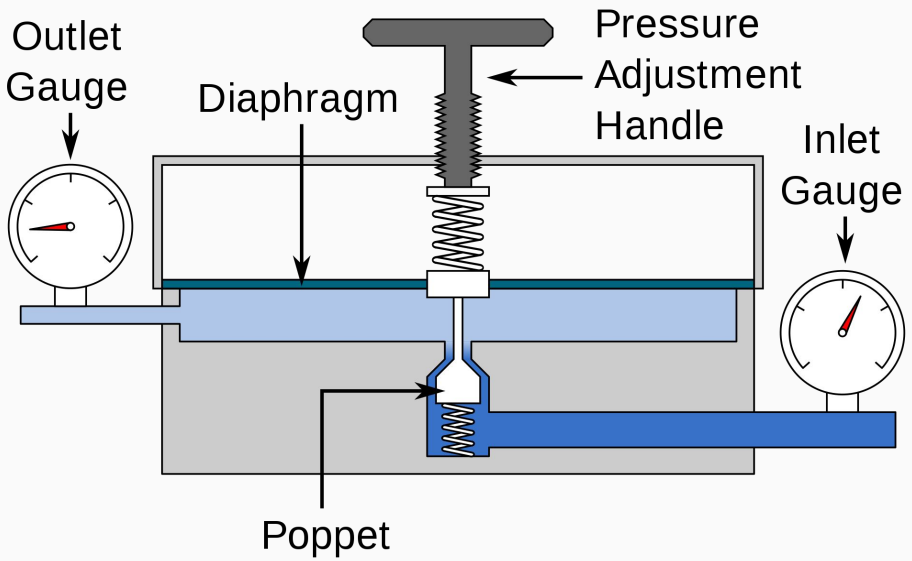


FRC Pressure Relief Valves

- Adjustable valves
  - Norgren 16-004-011, 16-004-003
- Preset valves
  - McMaster 5784T12, 125 PSI
  - Some of these open and stay open, so check extensively before using them at a competition. Also, make sure you buy a 125 PSI, not 120.
- Other equivalent adjustable and preset valves are legal

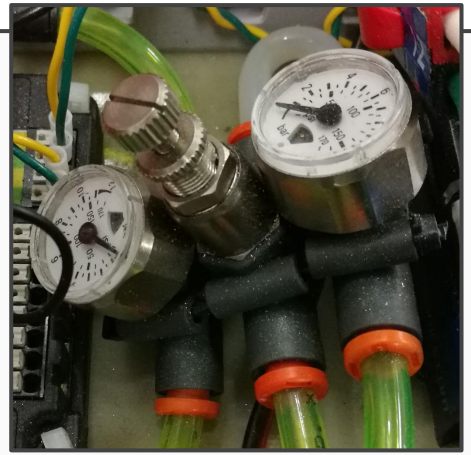
Pressure Regulators

- Pressure entering the body increases and pushes the diaphragm up, which closes the poppet
- Adjusting the handle changes the spring compression, changing the force that the pressure has to overcome to raise and lower the poppet
- This gives you a mechanism to set a fixed output pressure for a range of input pressures



FRC Gauges and Regulators

- Norgren regulator and gauge are common
  - Sold via Andymark
  - Nothing wrong with them, but they aren't the best
- Mini components
  - Save weight and space
  - AutomationDirect
  - Andymark



Solenoid Valve

- Energizing a solenoid coil moves a plunger to open a valve
- Single acting solenoid valve
  - A single solenoid coil pushes the valve in one direction, a spring returns it
  - Has a default position because of the spring
- Double acting solenoid valve
  - Has 2 solenoid coils, one to open and one to close the valve
  - Has no default position

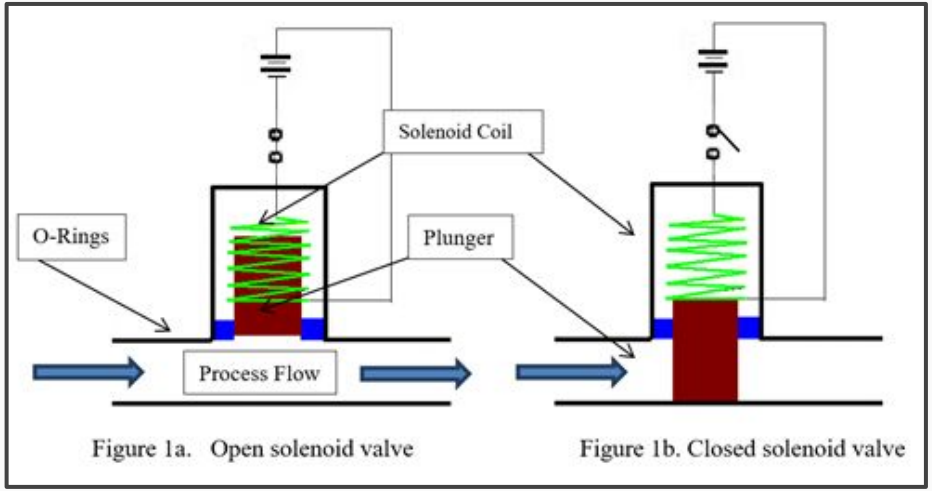


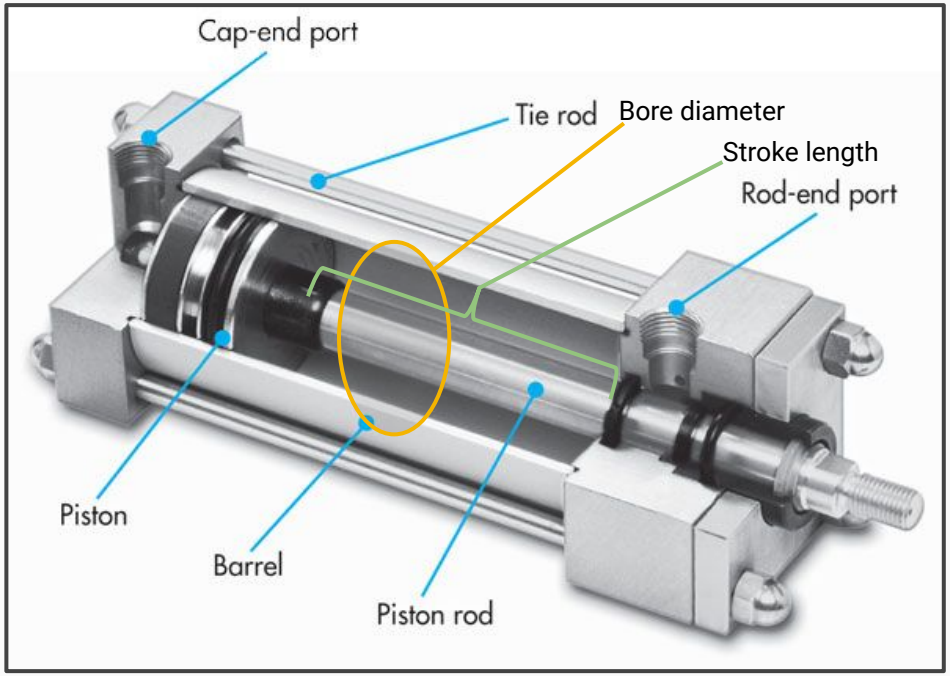
Figure 1a. Open solenoid valve

Figure 1b. Closed solenoid valve

FRC Solenoid Valves

- SMC Solenoids and manifolds
  - Via VexPro
  - Compact
  - Simplifies input plumbing
    - Single point of entry
      - Lower possible flow per valve, because of single entry
  - Plug extra holes
    - Via Automation Direct

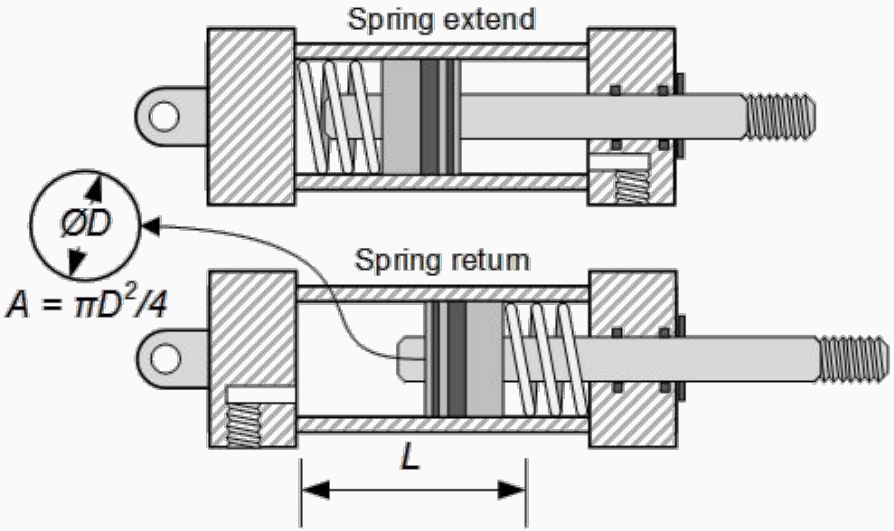
Pneumatic Cylinders



- The whole assembly is a “pneumatic cylinder”
  - Just that one part is a “piston”. Don’t call the whole thing a piston.
- Force:
  - Surface area of the back of the piston X pressure
    - 1” bore cylinder @ 60 psi
      - 0.79 in^2 x 60 pounds/inch^2 = 47.4 lbs
  - Pulling force is slightly lower because of the piston rod taking up area on the piston

Single Acting Cylinder

- The previous slide shows a “double acting” cylinder, which both pushes and pulls with air
- A single acting cylinder uses air to *either* push (extend) *or* pull (retract)
  - In some applications where force is only needed in one direction, using a single acting cylinder will save air
  - Single acting cylinders are typically longer for the same stroke length

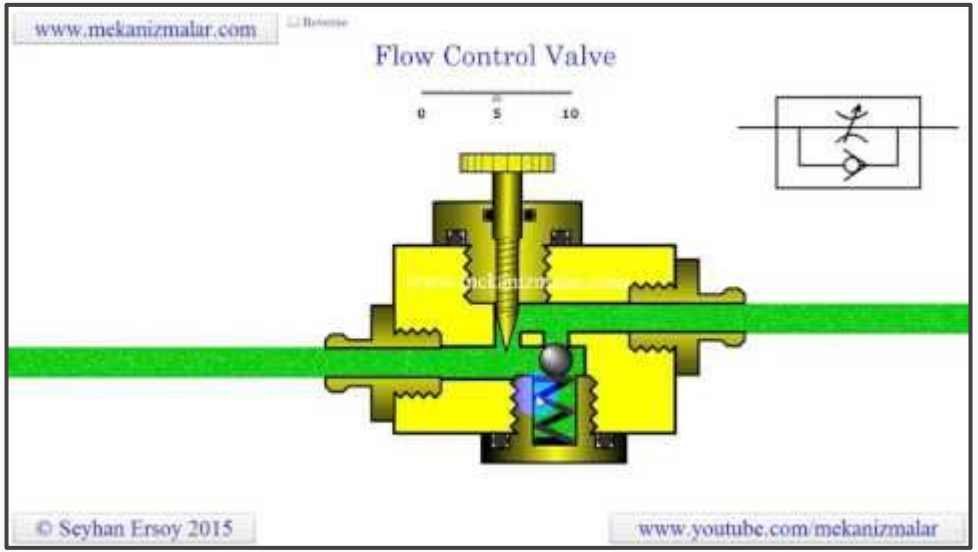


FRC Pneumatic Cylinders

- McMaster
  - Many options, typically expensive
- Bimba
  - Cheaper than McMaster
- AutomationDirect
  - I mean, if you're already buying fittings and gauges there...

Flow Control Valve

- Uses a screw to adjust how open a connection is
  - Like kinking a hose
  - Lets you slow down air flow by a controllable amount, without reducing pressure
- Can have a check valve, so flow is only reduced in one direction, but free in the other



FRC Flow Control Valves

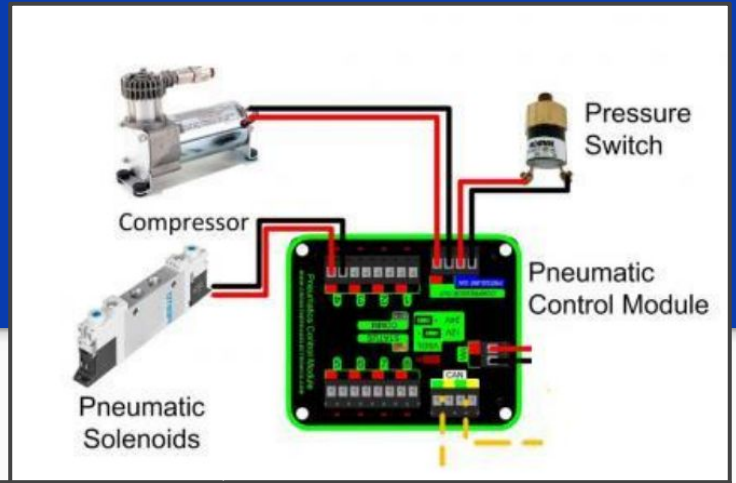
- Slow down pneumatic cylinder actuation
  - Make moving a mechanism less violent
- Can be attached directly to a cylinder, or in-line on tubing


Automation Direct - FVS14-14N


Automation Direct - FVU14

Pneumatic Controls

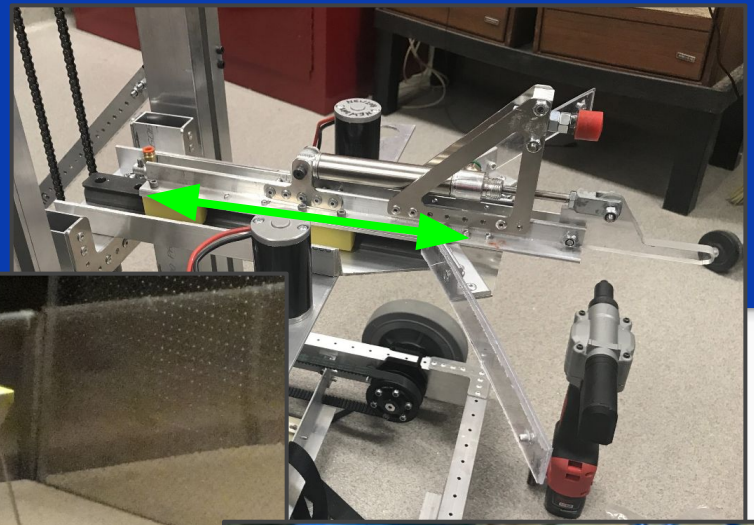
- Powered by Power Distribution Panel/Hub
- Communicates over CAN
- Powers air compressor
- Gets pressure switch signal
- Powers solenoid valves
- Important to set jumper for 12 or 24V solenoids
- Pneumatic Control Module
  - Sold by CTR Electronics, Andymark, Vexpro
- Pneumatic Hub (New)
  - Sold by Rev

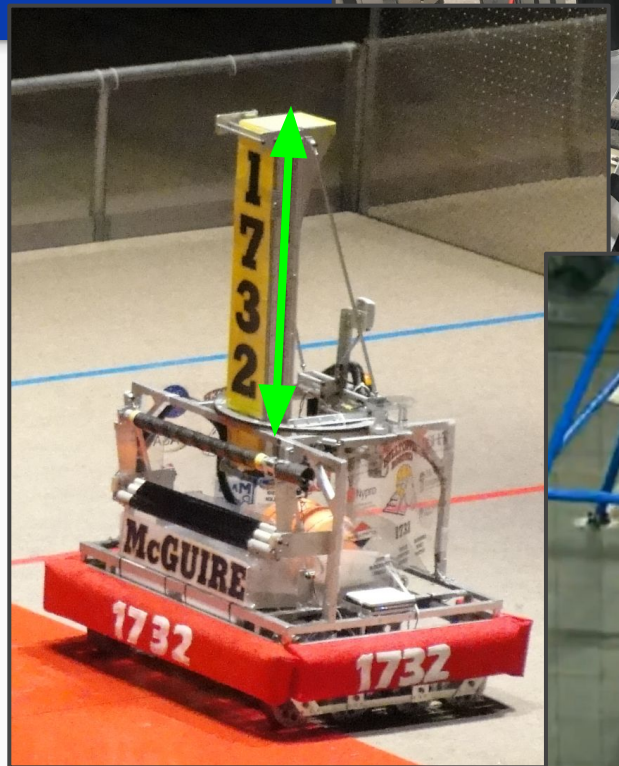


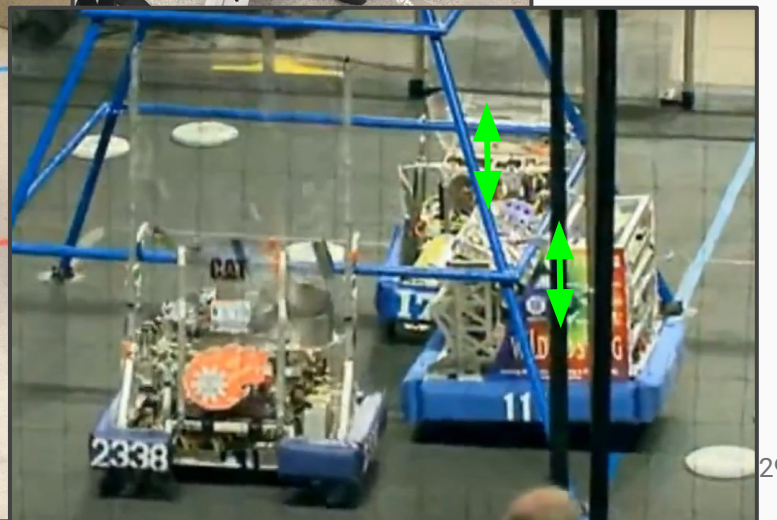
Pneumatic Mechanisms

Linear Motion

- Much easier to implement than a rack and pinion
- Sliders can be finicky, but try drawer sliders or linear bearings on smooth rods
- Examples:
  - 2012 - hood extension
  - 2019 - hatch panel grabber extension
  - 2013 - pull-up climbers

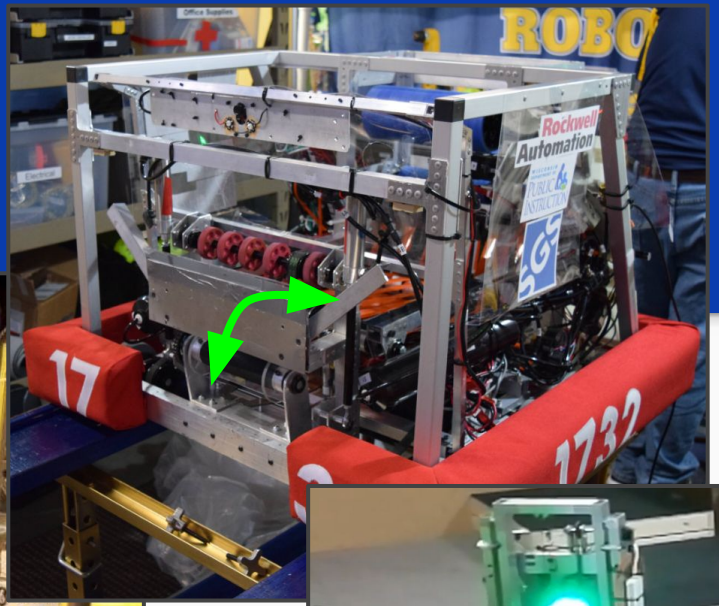


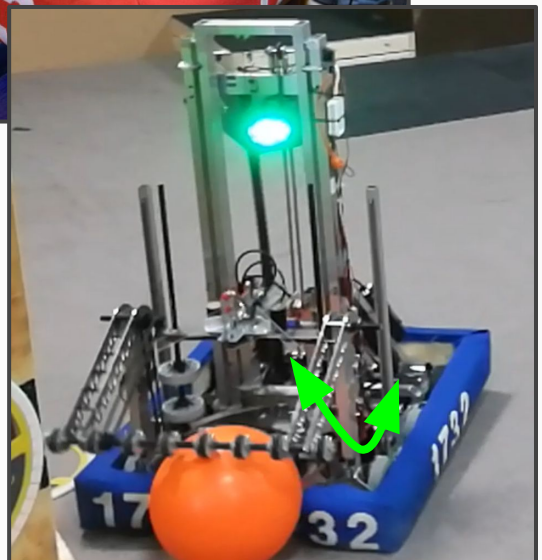




Short Rotation

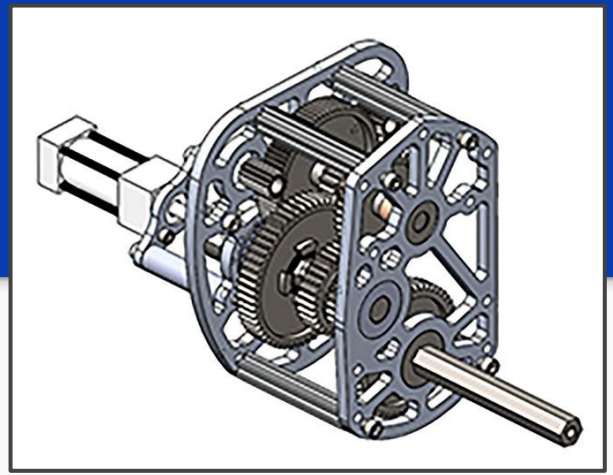
- For mechanisms with 2 positions, consider pneumatics instead of motors
- Examples
  - 2011 - Tube claw
  - 2017 - Gear intake
  - 2019 - Ball intake

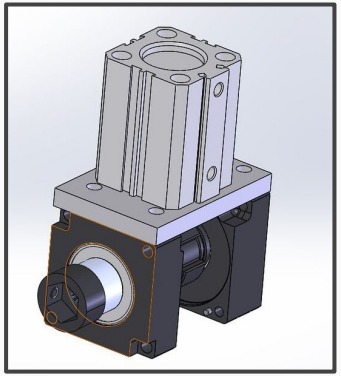




Constant Force

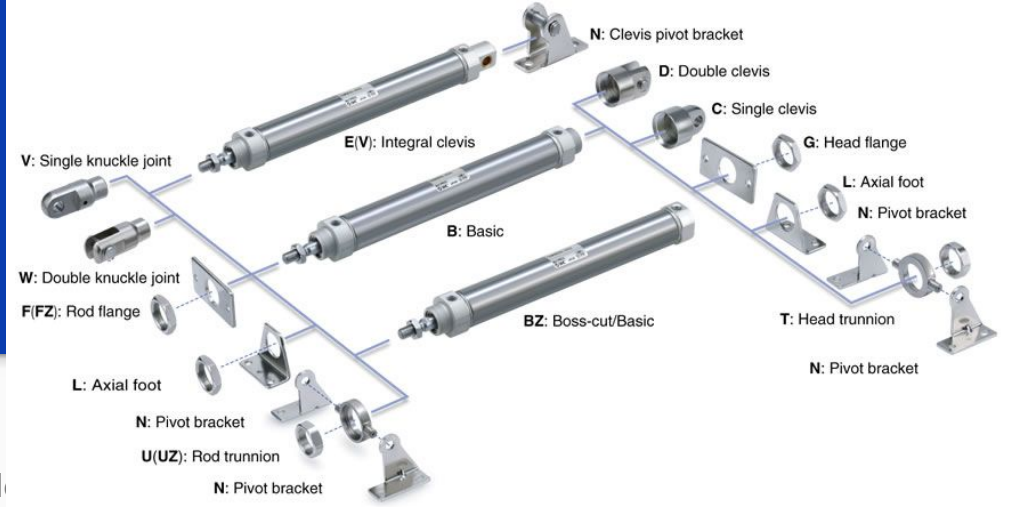
- Gear shifter
  - Losing pressure can cause a “neutral” position between gears
- Brake
  - What’s the default position? What happens if you lose pressure?

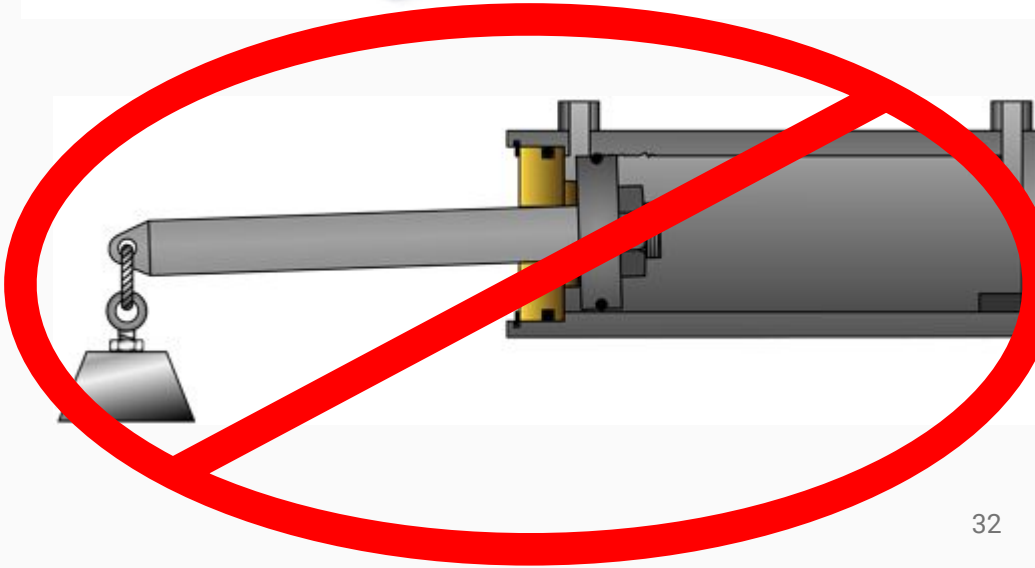




Cylinder Tips

- Don’t bend the rod
  - It’ll mess up the shaft seal
  - Forces should follow a direct line down the middl
  - Provide load support with smooth rods + linear bearings, drawer sliders, “elevator kits”
- Use the jam nut
  - Otherwise your spacing will change over time
- Don’t break the seal
  - If you use vice grips on the piston rod I’ll cry





Managing Capacity

- The small compressor won't do much during the match. Plan for enough capacity and fill the tanks ahead of time.
- How often will a function happen during a match?
  - If the answer is [a huge number], pneumatics might not be the right solution
  - Run a "match+" of cycling all of your pneumatics to test your capacity
- Periodically check the system for leaks
  - Pressurize the robot and let it sit for several minutes. Check if the pressure dropped.
    - Check both positions of each function!

Troubleshooting Leaks

- If you can’t hear or feel a small leak, try using water with a bit of soap and watch for bubbles
- Work through different parts of the system and isolate them from others
  - For example, cap the output of an air tank and check that just the compressor+tanks hold air. Then add in just the plugged manifold. Then one circuit at a time.
- Common causes of leaks:
  - Badly done teflon tape
  - A tube that isn’t seated correctly
    - Get and use a tube cutter for square cuts

Get Free Stuff!

- Kit of Parts vouchers
  - Clippard - air tanks
  - Bimba - cylinders
  - Automation Direct - fittings
  - Andymark - everything

Questions?

Email: Team@team1732.com