

Pneumatics



2008
FRC Kick-off Workshops
Ken Stafford



What's Wrong with Pneumatics?

- **Too Heavy!**
- **Too Springy!**
- **Too much demand on Battery!**
- **Too Fast**
- **Too Slow**
- **Too much Footprint/Space Req'd**
- **Others?**

Weight

- “Tare” weight: 7.5 lbs
 - Compressor
 - Accumulators (2)
 - Regulator/fittings
 - Spike relay
- Individual Systems: .5-2.0 lbs
 - Cylinder
 - Connections
 - Solenoid



Battery Problem

- **Motor current is a function of its speed and load**
- **Rapid starting and stopping at high set pressure uses max current (easily over 10 A for start)**
- **Existing pressure switch has very low latency**



Battery Help

- **Pre-2006 FRC kit pressure switches turned off at about 115 psi—turned back on at about 105 psi**
- **2006-7 switches better: 115 to 95 psi**
- **Still an unpredictable significant current**
 - **Use logic s/w to prevent turn on during critical non-pneumatic operations**
 - **Use delay logic to delay turn-on**

What's Right with Pneumatics

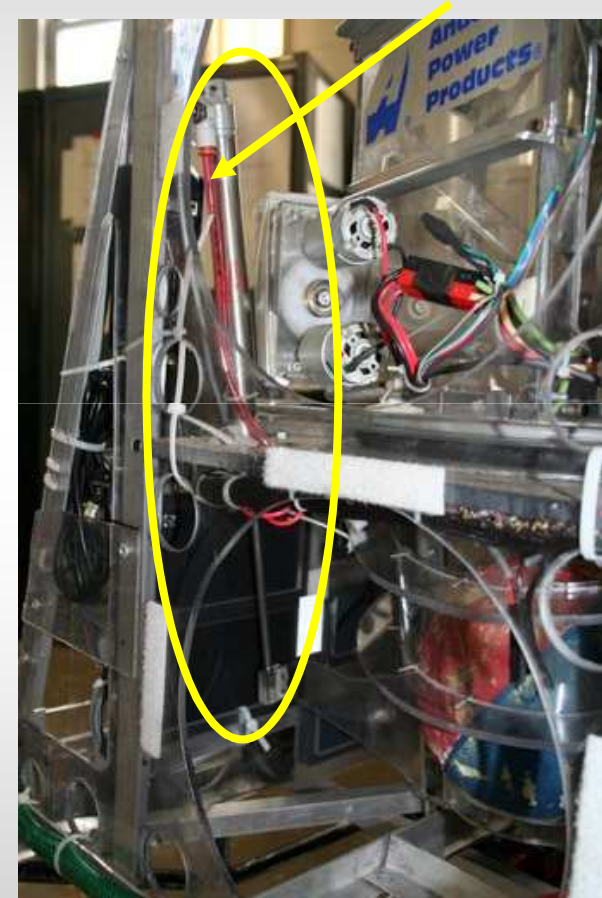
- **No “magic smoke”**
 - Do not overheat, even with overloads
- **Provide controlled force**
- **High speed combined with high force**
- **Accurate end position control**
- **Holds energy without additional power consumption**
 - An adjustable Spring
 - No backdrive at End-of-Match!

Where to use

- **Two-position linear applications**
 - A “lifter” or “gate”
- **Two-position with stored energy**
 - Transmission Shifter
- **Limited-arc rotary applications**
 - Gripper
 - Arm Elbow or Shoulder

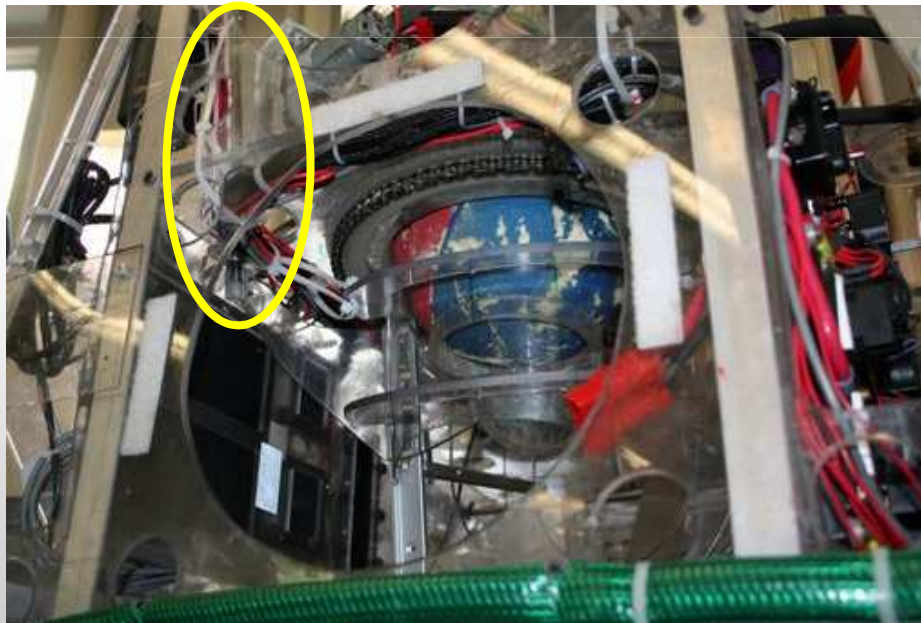
Example “Lifter”

- **2K6 FRC Robot: lifts balls to spinning shooter wheels**
 - $\frac{3}{4}$ x 6 cylinder
 - Magnetic switch-activated return stroke
 - Capable of feeding shooter at 3 balls per 2 secs



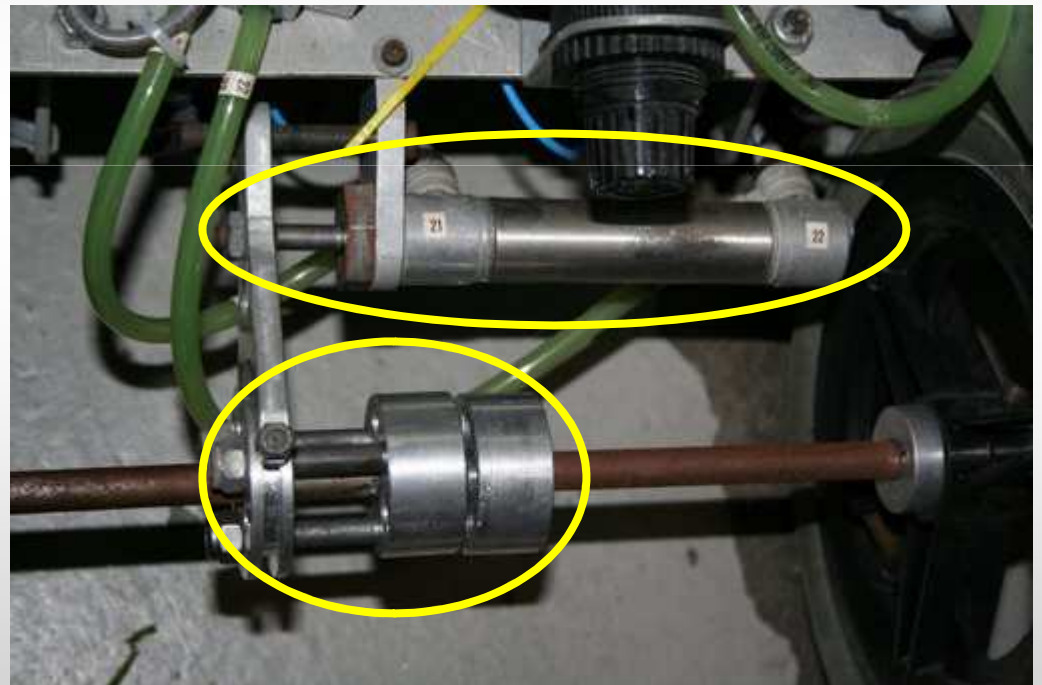
Lifter Design Considerations

- Force of pulling vs pushing (piston rod effect)
 - $F = P \times A$, $F = 60\text{psi} * \pi ((3/8)^2 - (1/8)^2) = 24 \text{ lbs}$



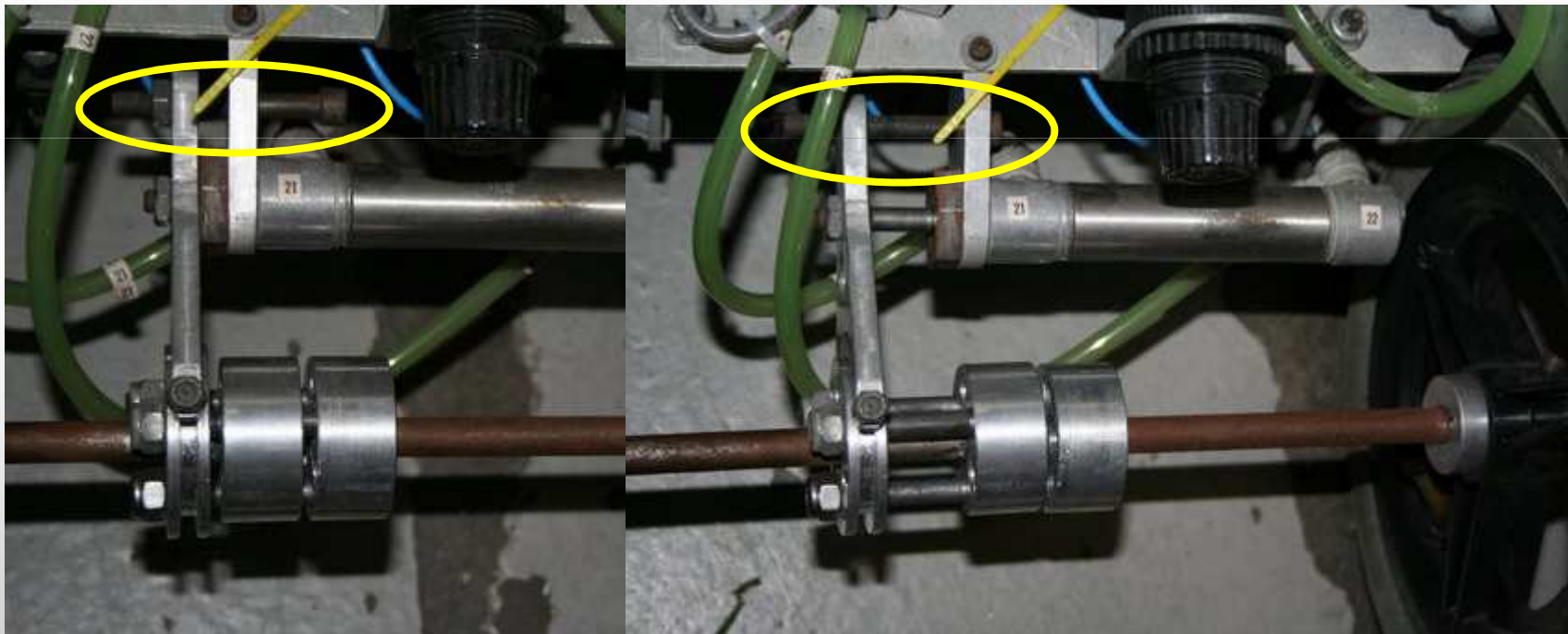
Example “Shifter”

- **2K4 FRC Robot: slides pins to lock/unlock “differential”**
 - $\frac{3}{4}$ x 2 cylinder
 - 3 pins to be locked into 3 of 6 holes



Shifter Design Considerations

- Only wanted $\frac{3}{4}$ in of motion
 - Used adjustable fixed stop



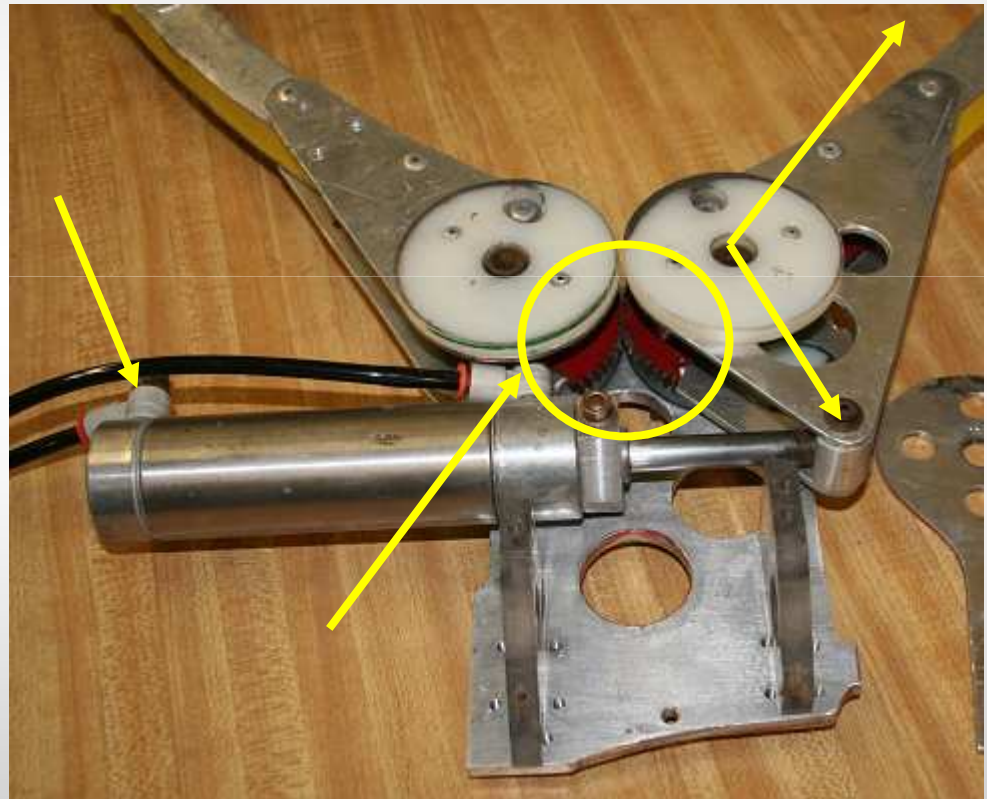
Example “Gripper”

- **2K1 FRC Robot: grab 30” ball from floor and place on high goal tower**
 - Needed secure 10 pound grip
 - Had to balance on tower
 - Nice to be able to grab 10” balls also



Gripper Design Considerations

- Geared joint insured symmetry, doubled rotation angle
- Effective radii
 - 3" for cylinder
 - 15" for gripper
- Used 1½ x 3 cylinder
 - $F = 60\text{psi} * \pi (3/4\text{'})^2$
= 106 lbs
 - At 3:15 ratio & 2 arms
 - Closing force = 10.6 lbs
- Used flow-controls
 - Quick grip
 - Slow release



Bits and Pieces

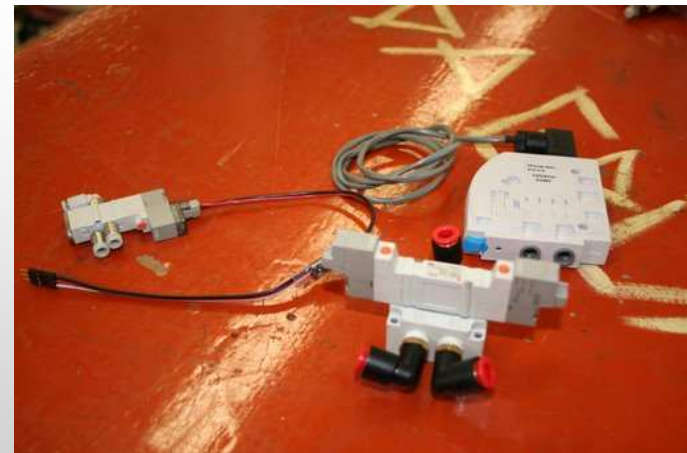
- **Adjustable Regulator**
 - Use minimum psi req'd
 - Saves air
 - Maintains force

- **Magnetic Switch**
 - Digital position



More Bits

- **Flow Controls**
 - Needle valve controls outflow only
 - DOES NOT control force, just speed
- **Solenoid Valves**
 - Very low current
 - Require 6-10 psi



General Suggestions

- **Do not use unless you have 2 or more systems that really benefit from pneumatics**
- **Unless...you can use accumulators only—no compressor**
 - **EG: you could shift a transmission (3/4 x 1 cylinder) ~70 times on two 2 X 6 tanks**
- **Do not tolerate leaks!**

Summary

- In 16 years of FIRST (only 14 with pneumatics?), Team 190 has used pneumatics in 10 robots—6 of the last 7
- The weight is manageable when multiple systems are used
- When used appropriately they are great
 - SHIFTERS!
 - GRABBERS!
 - LIFTERS!

Questions?

