Pneumatics

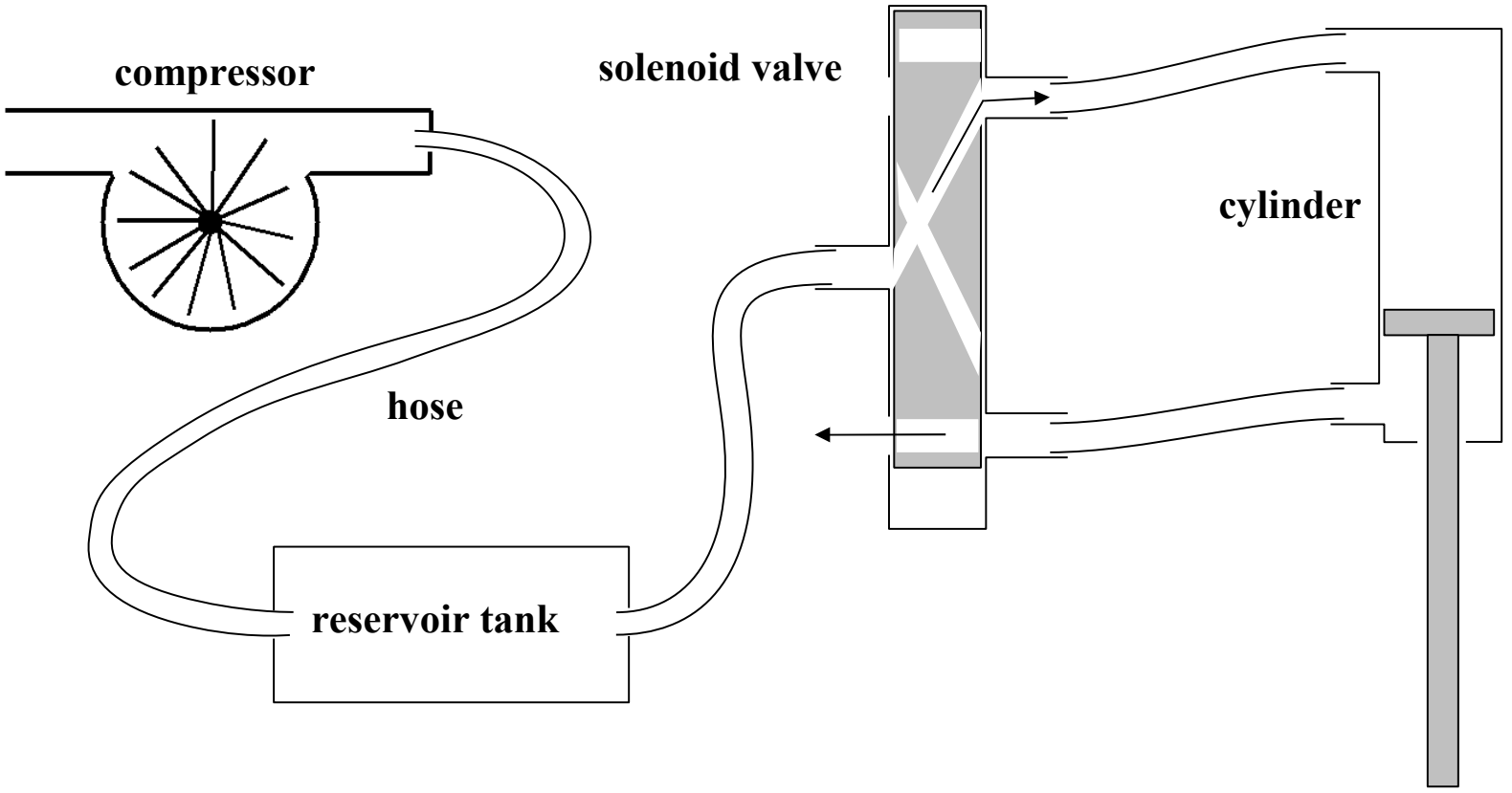
- Introduction to Pneumatics
- Pneumatic Components
- Pneumatic Mechanisms
- Resources

Ian Mackenzie

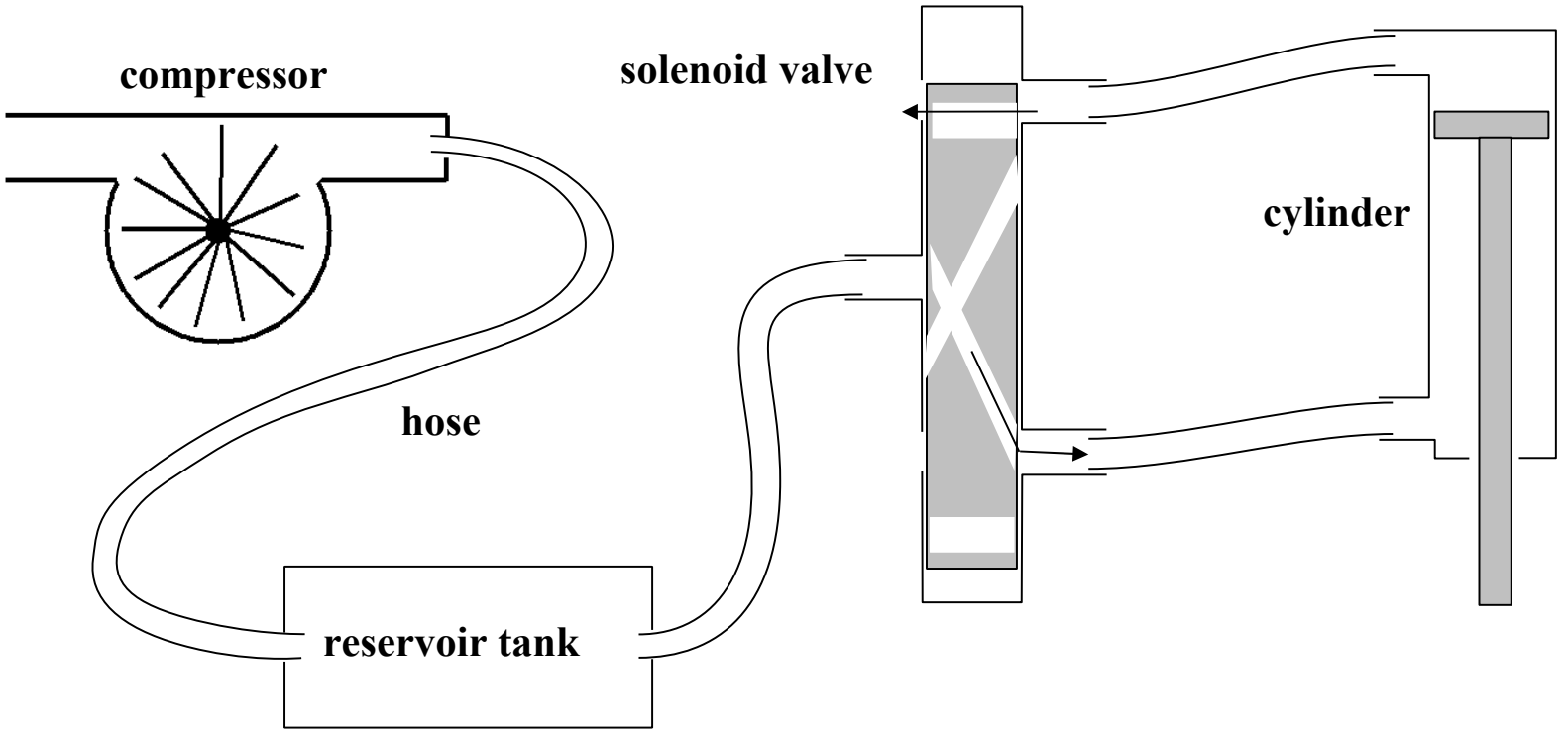
- 8 years FIRST experience
- Co-General Manager for Team 1114 in 2004, winning 8 FRC awards
- Lead designer for two revolutionary FIRST drive systems (Hexadrive 2002, SimSwerve 2004)
- Specific Areas of Mentorship
  - Mechanical Design, Competition Strategy
- 3rd year Systems Design Engineering student at the University of Waterloo
- Current member of the Waterloo Regional Planning Committee

Introduction to Pneumatics

Pneumatic Principles



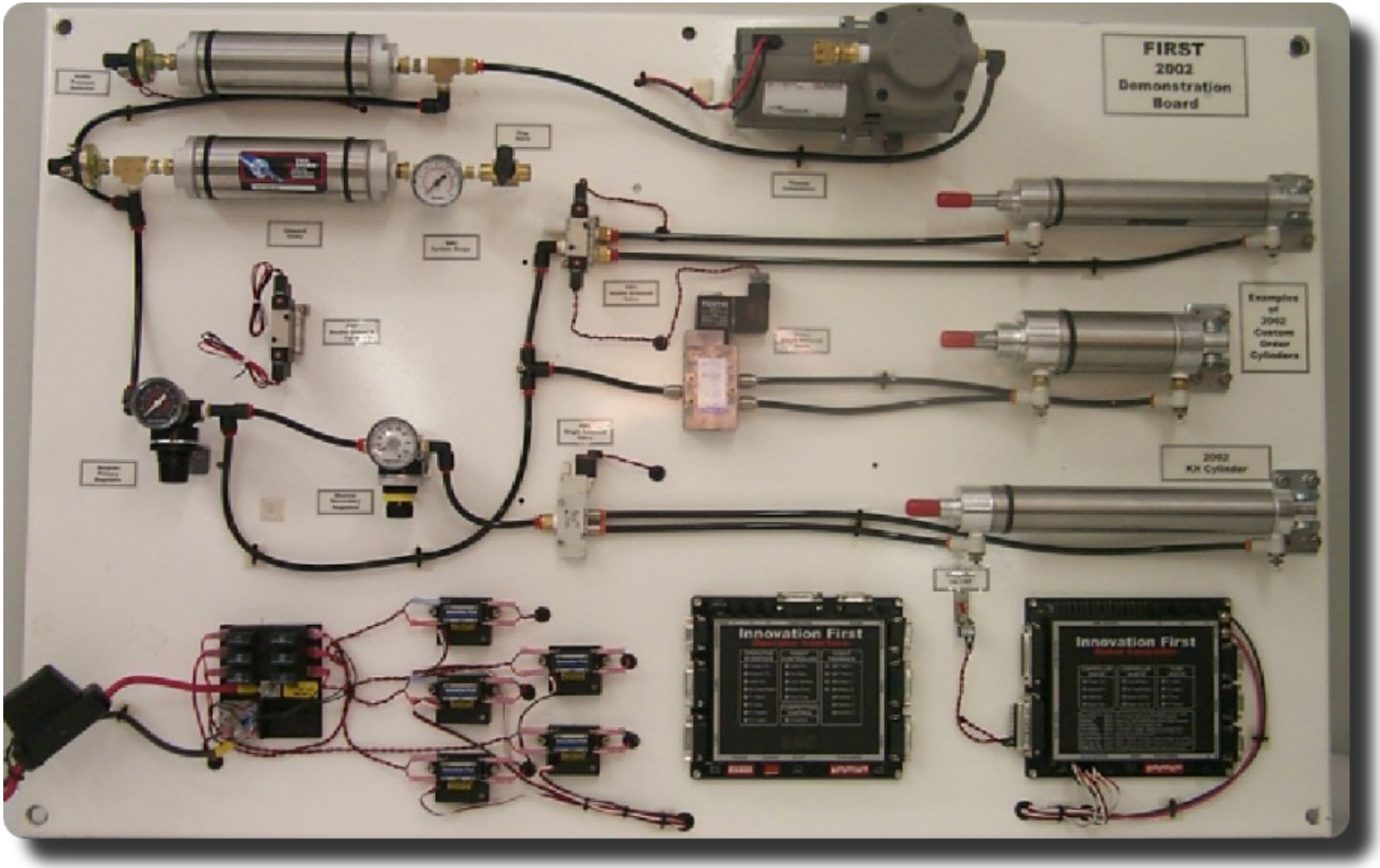
Pneumatic Principles



Why Use Pneumatics?

- Weight
  - Much lighter than motors (as long as several used)
- Simple
  - Much easier to mount than motors
  - Much simpler and more durable than rack and pinion
- More rugged
  - Cylinders can be stalled indefinitely without damage
  - Resistant to impacts
- Disadvantage: All the way in or all the way out

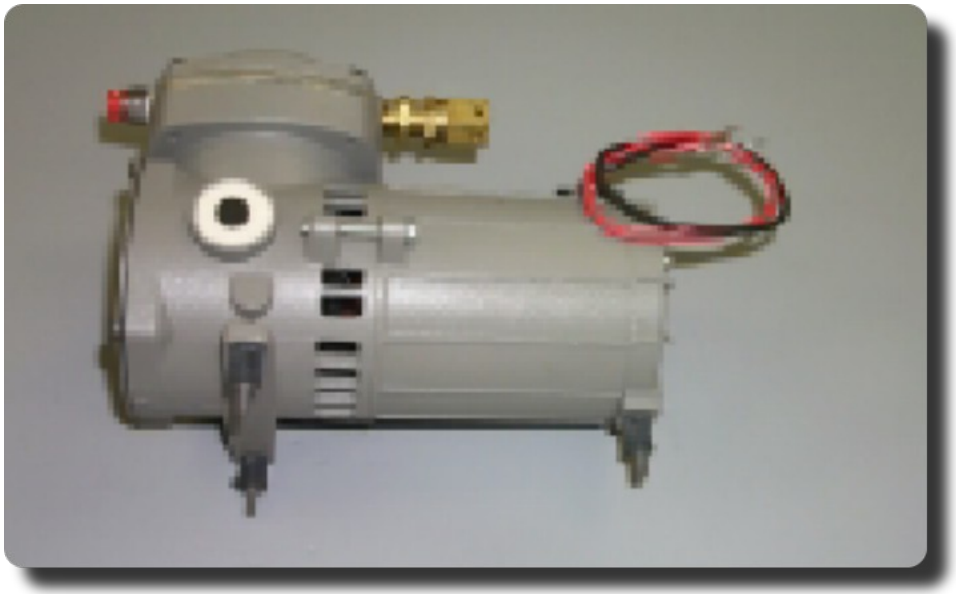
Pneumatics Board

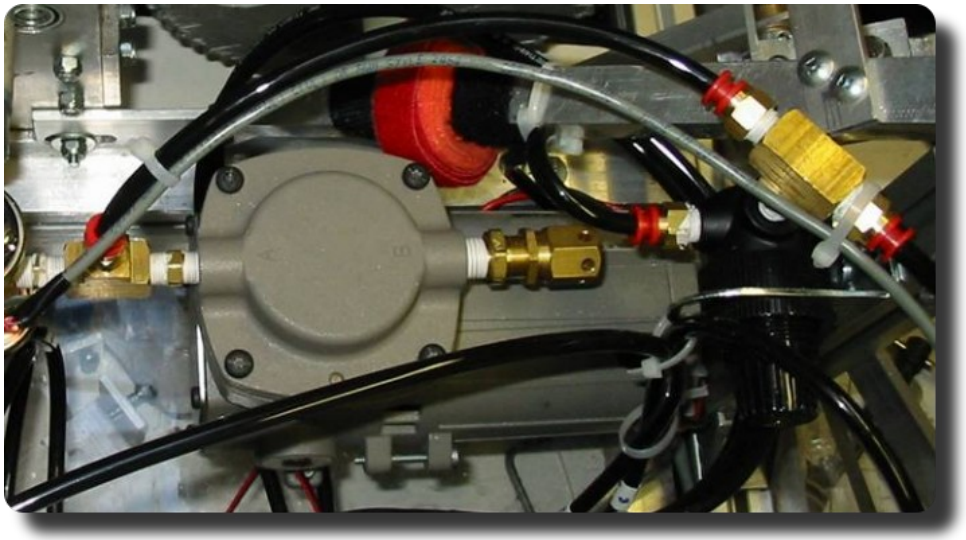


Pneumatic Components

Compressor

- Generates pressure of 120 psi
- Always run off relay module, in forward
  - Do not use to generate a vacuum!





Reservoir(s)

- Up to two
- Store compressed air at 120 psi
- Top up before each match
  - Slow leaks can decrease pressure between pit and field
  - Tether robot beside field to top up pneumatics

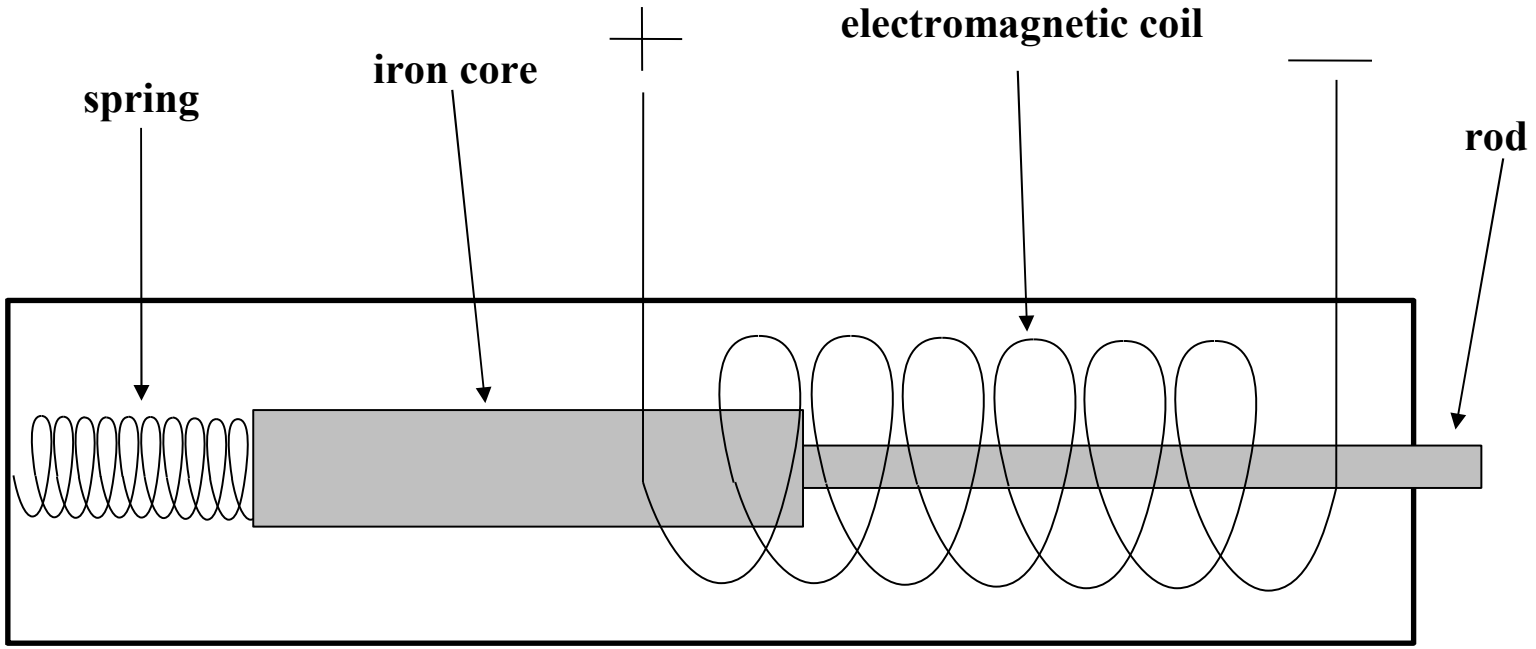
Regulator

- Allows air from reservoirs to flow to rest of pneumatic system
- Limits pressure in valves, cylinders to 60 psi

Pressure Sensor

- Detect pressure in pneumatic system
  - Indicate whether system is above or below a set pressure
  - Can be calibrated
- Usually two (one set for 115 psi, one set for 105 psi)
  - Pressure below 105 psi: compressor on
  - Pressure above 115 psi: compressor off

Solenoids



Single Solenoid Valve

- When energized, cylinder goes to one state
- When de-energized, cylinder always returns to rest state
  - When power is cut at the end of the match, cylinder will return to rest state
- Each valve powered by one relay module (only in forward)

Double Solenoid Valve

- One solenoid pulsed to move cylinder one way, other solenoid pulsed to move cylinder the other way
- Results unpredictable if both pulsed
- Valve will stay in either state when neither solenoid energized
- Can use one relay for each solenoid or one relay and two diodes

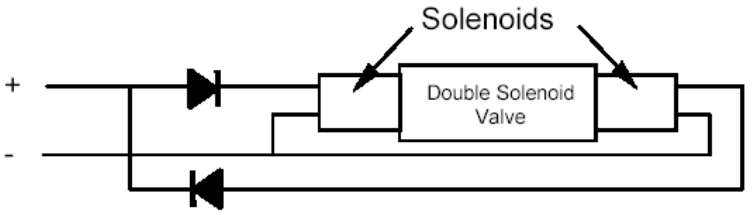
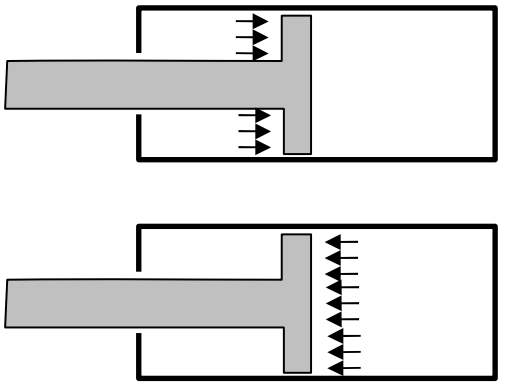


Figure 2.3: Use of Diodes with Double Solenoid Valve

Cylinders

- Force = Pressure × Area
  - 2” diameter piston
  - Area = $3.14 \times 1^2 = 3.14$ in^2
  - Pressure = 60 psi
  - 3.14 in$^2 \times 60$ psi = 188 lbs
  - Force while extending greater than while retracting



- Main decisions: Length and diameter
  - Diameter based on required force
  - Larger diameter: more force, but more air

Cylinder Tips

- If you need the piston to stay extended or retracted, add a mechanical latch
- Be careful to ensure the piston rod cannot get bent
- Hard to get locknuts/lock washers in large sizes, so nuts on pistons likely to come loose

Flow Controls

- Regulate flow of air into and out of a cylinder
- Used to control speed of a pneumatic cylinder
- If used, attach directly to cylinder (only one end needed)
- Seems to regulate air flowing in both directions, but one direction is restricted a little more

Fittings

- Put Teflon tape on all threads to ensure a good seal
  - Do not put tape on first two threads, as it may come loose and clog up a valve
- Tubing attached simply by pushing it into connector
  - If you have a leak, try cutting off the last couple centimeters of tubing; if it is damaged, it will not seal properly
  - To detect leaks, put soapy water on suspect connections and watch for bubbling

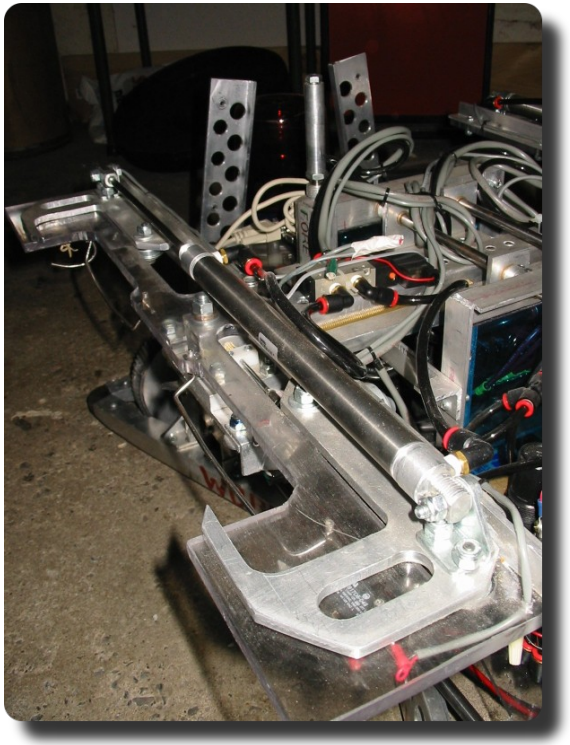
Exhaust Valve

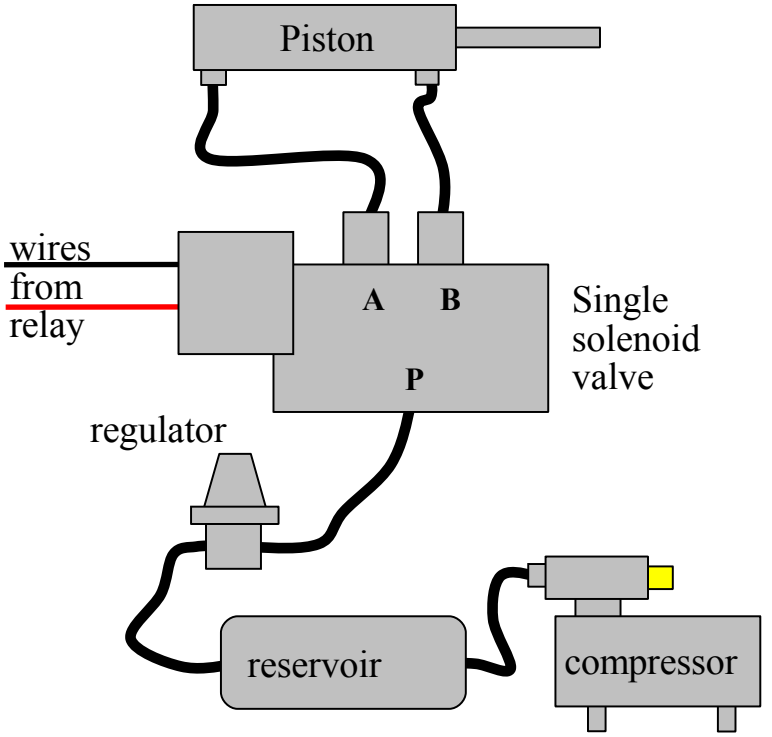
- Use to release pressure (especially at the end of a match)
- Useful if you need to be able to release a grabber after a match is over

Pneumatic Mechanisms

Linear Motion

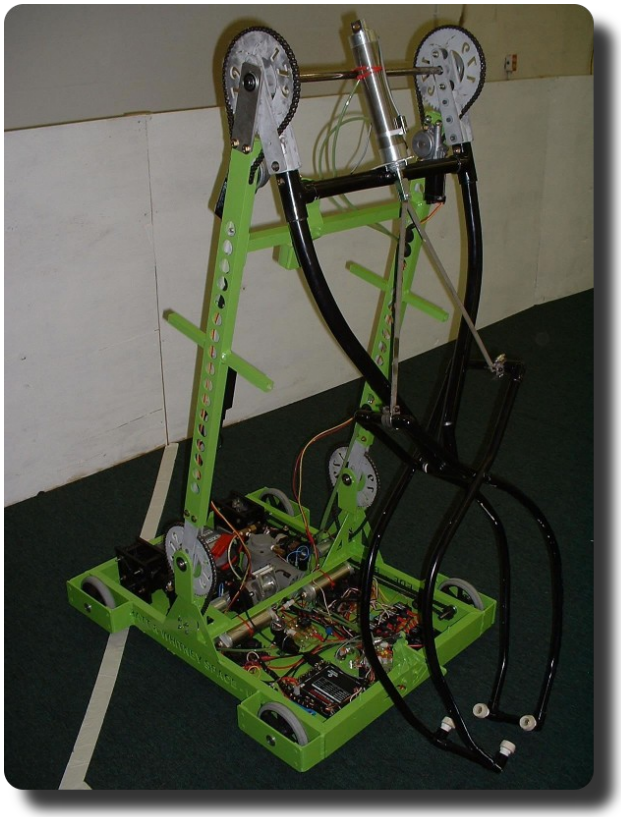
- Much simpler, easier, more durable than rack and pinion
- Can maintain constant force





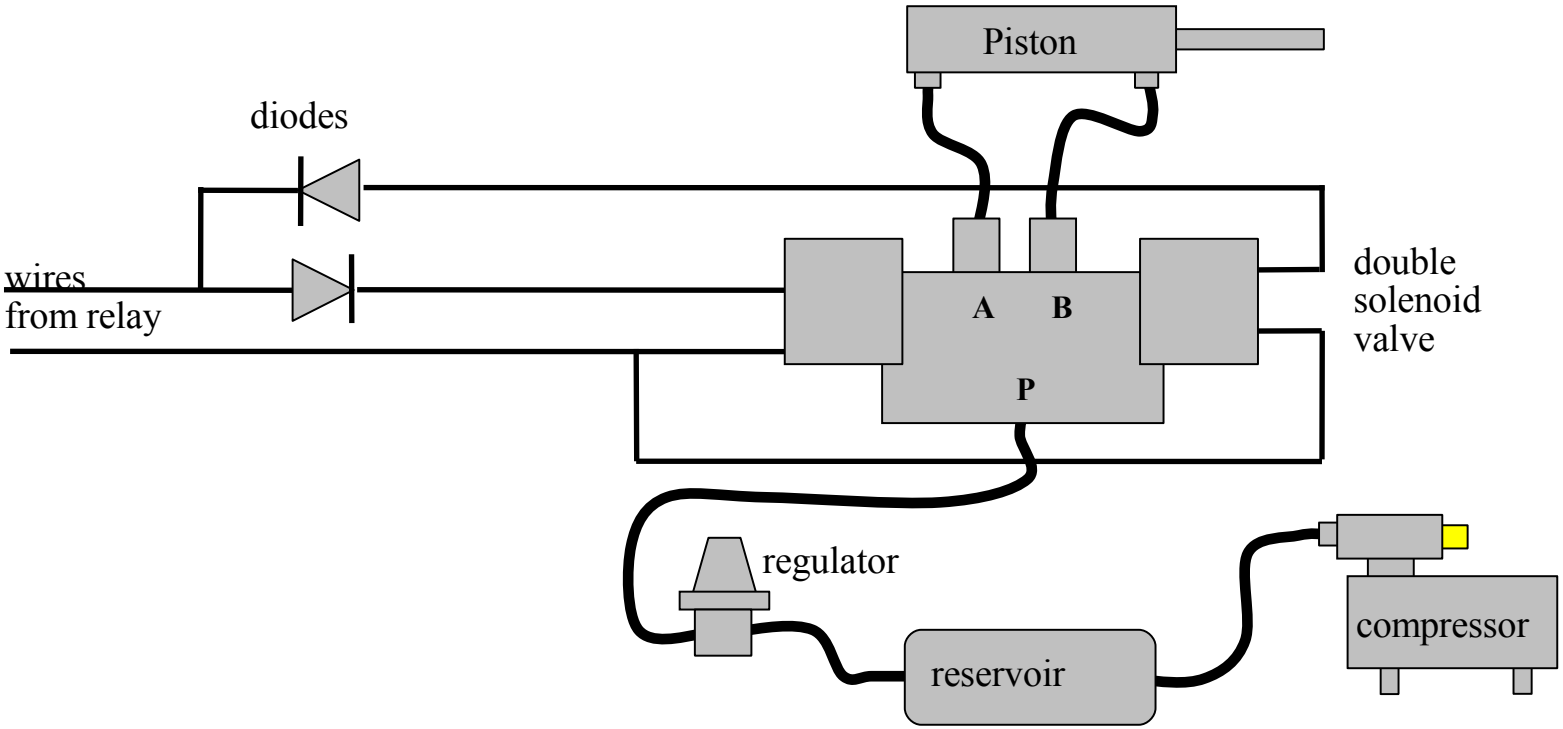
Short Rotation

- Arm joints
- Grabbers



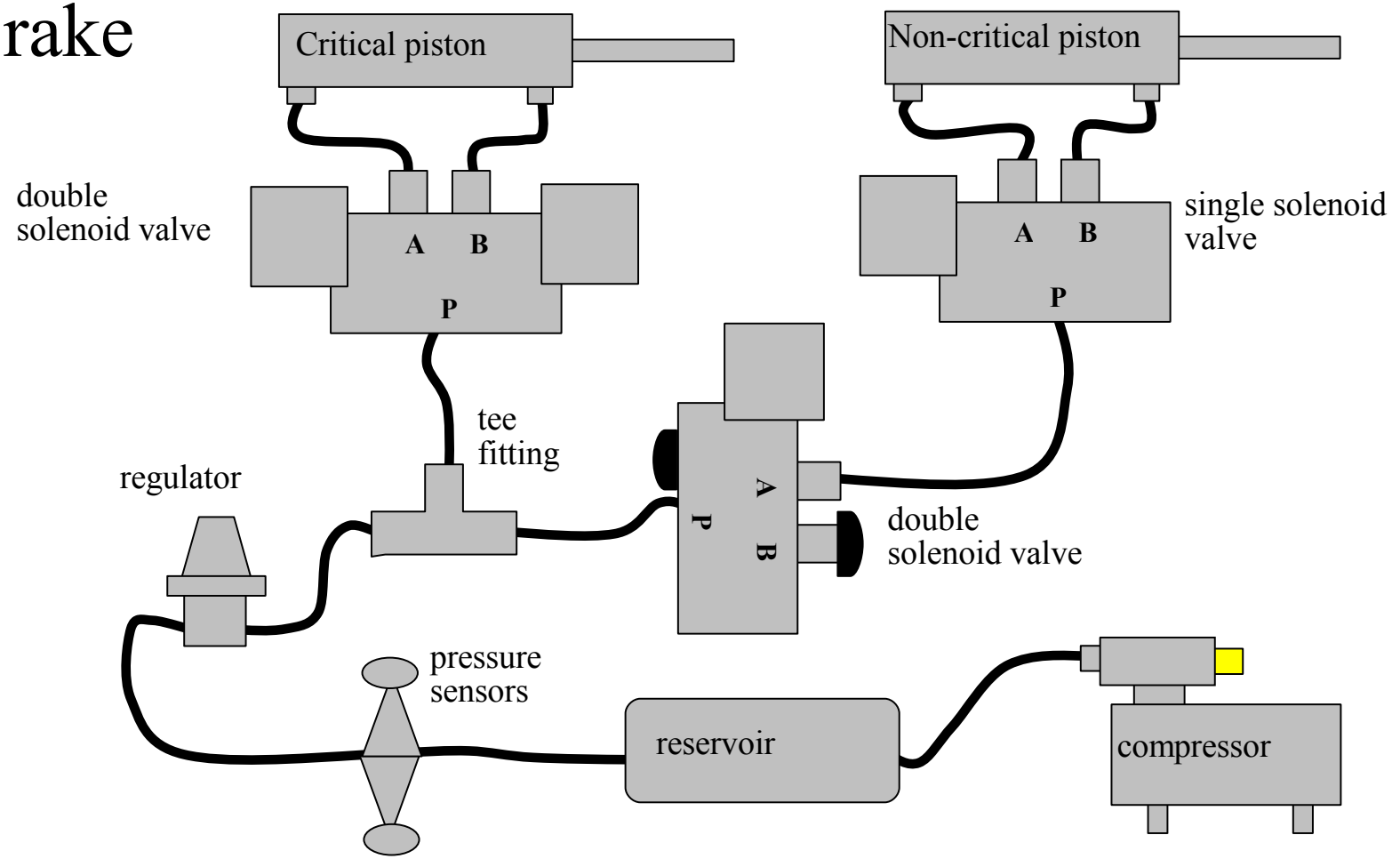
Short Rotation

- May want to keep joint in position at end of match (whatever position it's in)



Constant Force

- Gear shift
- Brake



Resources

Resources

- www.firstroboticscanada.org
  - Grippers, Joints galleries in 'Resources' section
- www.chiefdelphi.com/forums/papers.php
  - White papers on many topics
- www.chiefdelphi.com
  - Very active and helpful FIRST forums

Questions?

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