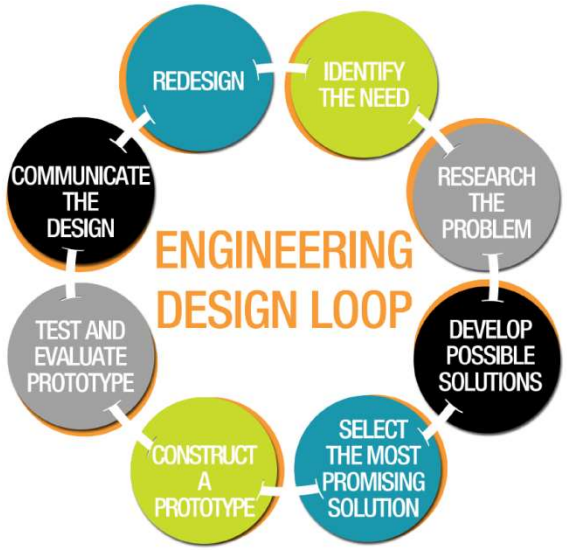
Mini-Lecture Series

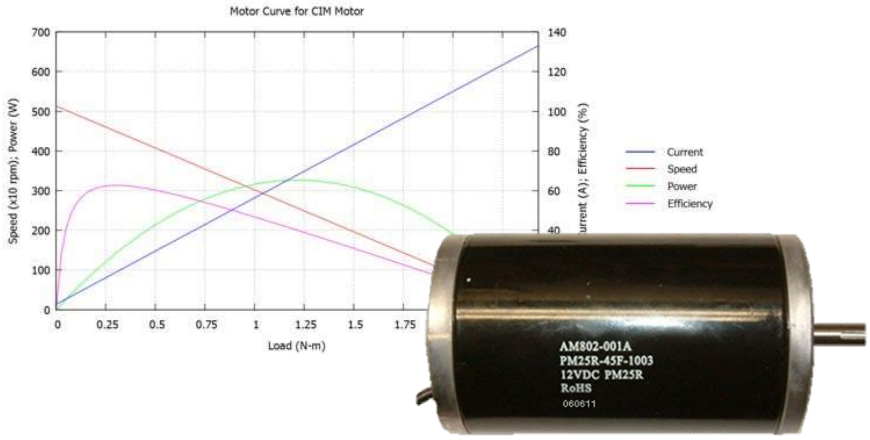
Team 3176 Off-Season
Engineering Orientation

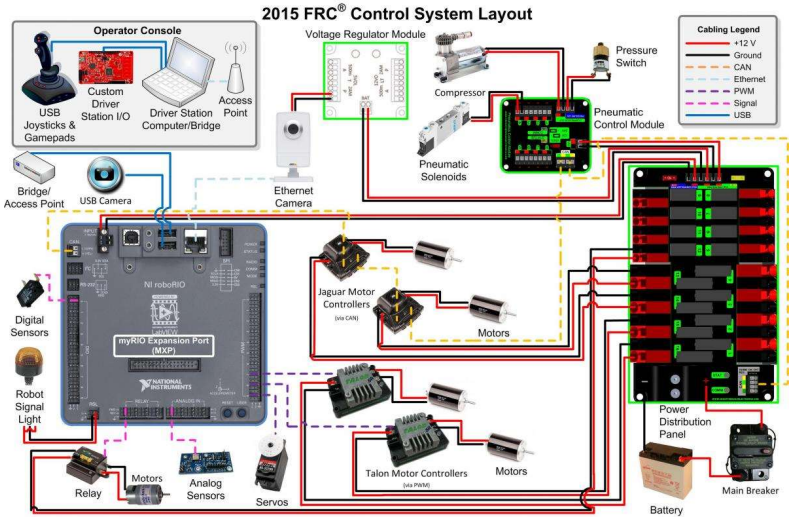
Pneumatics

TEAM 3176 PURPLE PRECISION

Previous Lectures…



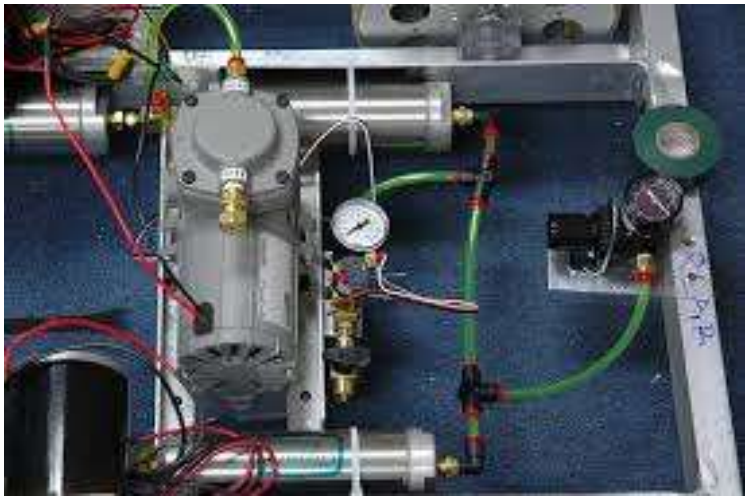




TEAM 3176 PURPLE PRECISION

Pneumatics

- Robots can use pneumatic components to provide a complement to the motors and gearboxes for various actuations. It is key to understand how to use and control it safely.
- In this mini-lecture, we'll cover
  - Some basic pneumatic concepts
  - Review robot components
  - Safety concerns
  - Design considerations



TEAM 3176 PURPLE PRECISION

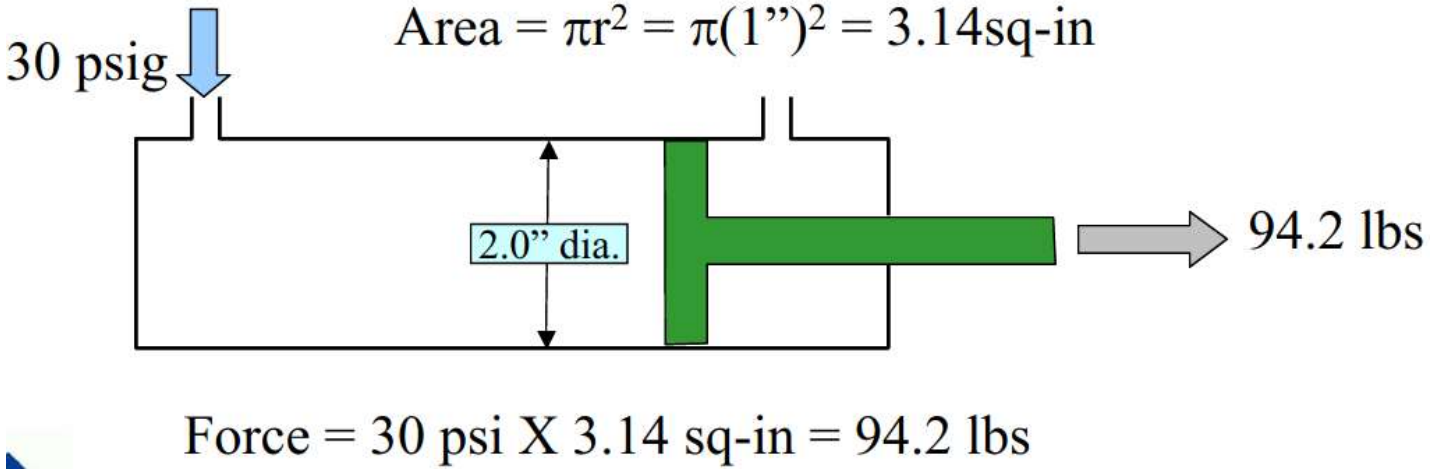
Fluid Power Basics

- **Hydraulics**
  - Incompressible working fluid
  - Typical Fluids: Synthetics, oils, fuel, water
  - 1,000 to 5,000 psi working pressure normal
  - Good at transmitting and multiplying force
  - Not used in FIRST
- **Pneumatics**
  - Compressible working fluid
  - Typical Fluids: Air, Nitrogen, CO2
  - 100 to 500 psi working pressure normal
  - Good at transmitting power
  - Can store energy
  - Used in FIRST!

TEAM 3176 PURPLE PRECISION

Basic Physics of Pneumatics

- Pressure = Force / Area (p = F / A)
- Force = Pressure x Area
- Example: 30 psig in 2” diameter cylinder



- How much force provided on retract? *(more, less, or same?)*
  - Force is reduced by the diameter of the rod
  - $A = \pi(r_1{}^2 - r_2{}^2)$ = π ($1^2 - 0.25^2$) = π (1 – 0.0625) = 2.94 sq-in
  - **F = 88.3 lbs**

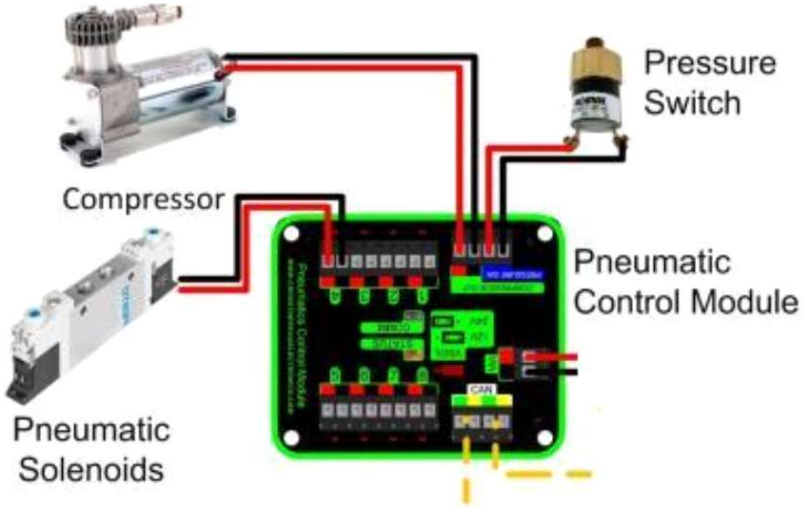
TEAM 3176 PURPLE PRECISION

Managing Pneumatic Energy

- **Store** Pneumatic Energy
  - Storage Tanks, Tubing, Fittings & Valves
- **Consume** Pneumatic Energy
  - Exhaust of actuators *and Leakage!*
- **Add** Pneumatic Energy
  - Compressor, Switch

TEAM 3176 PURPLE PRECISION

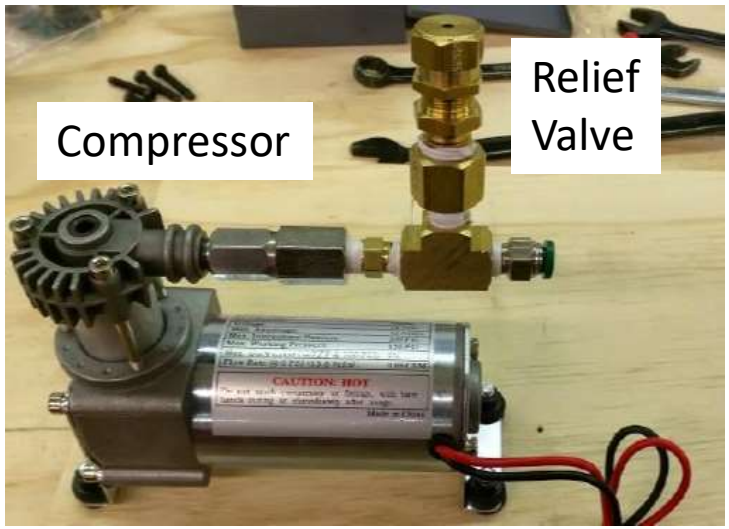
Pneumatic Control Module



- The PCM is used to control the compressor, solenoids, and pressure switch when wired into the RoboRIO control module.
- The PCM can control 8 single solenoid valves or 4 double solenoid valves.

TEAM 3176 PURPLE PRECISION

Compressor / Relief Valve / Regulator



Switch

Regulator

- The compressor provides a supply of pressurized air controlled by a pressure switch to automatically shut-off compressor to conserve battery power
- Relief valve provides a safety mechanism to protect from over-pressurization of the circuit
- Regulator valve sets the working pressure level of the circuit (max output of 60 psi)

TEAM 3176 PURPLE PRECISION

Pneumatics Safety

Pneumatics systems store sufficient energy in the form of compressed gas to cause severe injuries if improperly handled or constructed.

- **Always:**
  - Use components with the proper pressure rating
  - Ensure system has proper regulation and overpressure protection
  - Inspect for and discard damaged components
  - Ensure that system is fully depressurized before working on it
  - Watch for sudden movement, pinning, or puncture hazards
- **Never:**
  - Over-pressurize a system
  - Work on a pressurized system other than adjusting regulators and valves
  - Attempt to free a stuck actuator while pressurized
  - Direct shop air at other people
  - Use air tool attachments without the proper speed rating

TEAM 3176 PURPLE PRECISION

Design Considerations

- Pneumatics are best suited for **linear motion**
  - Motors are best suited for angular motion
- Motors have to be geared to produce the desired forces
  - Cylinder size can just be picked for the forces you need
- Ability to control position by cylinders is very limited
  - Ideal to 2 position situations (e.g., open/close)
- Cylinders absorb shock loads rather well and bounce back
  - Avoid side loads on cylinder rods
- Cylinders can be stalled without damage to the pneumatic system (unlike motors)
- Cylinders use up their power source rather quickly
  - Motors use up very little of the total capacity of the battery
  - Leaks in the system carry away critical stored energy

TEAM 3176 PURPLE PRECISION

Questions?

Sources:
http://www.instructables.com/id/How-to-Create-a-Pneumatic-System-for-FIRST-Robots/
http://www.firstinspires.org/resource-library/frc/pneumatics-manual
http://wpilib.screenstepslive.com/s/4485/m/24166/l/290495-wiring-pneumatics
http://www.mdfirst.org/images/stories/documents2013/2013_Educ_Day/Pneumatics_101.pdf

TEAM 3176 PURPLE PRECISION
TEAM 3176 PURPLE PRECISION