

# 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
- 3<sup>rd</sup> year Systems Design Engineering student at the University of Waterloo
- Current member of the Waterloo Regional Planning Committee

# Introduction to Pneumatics

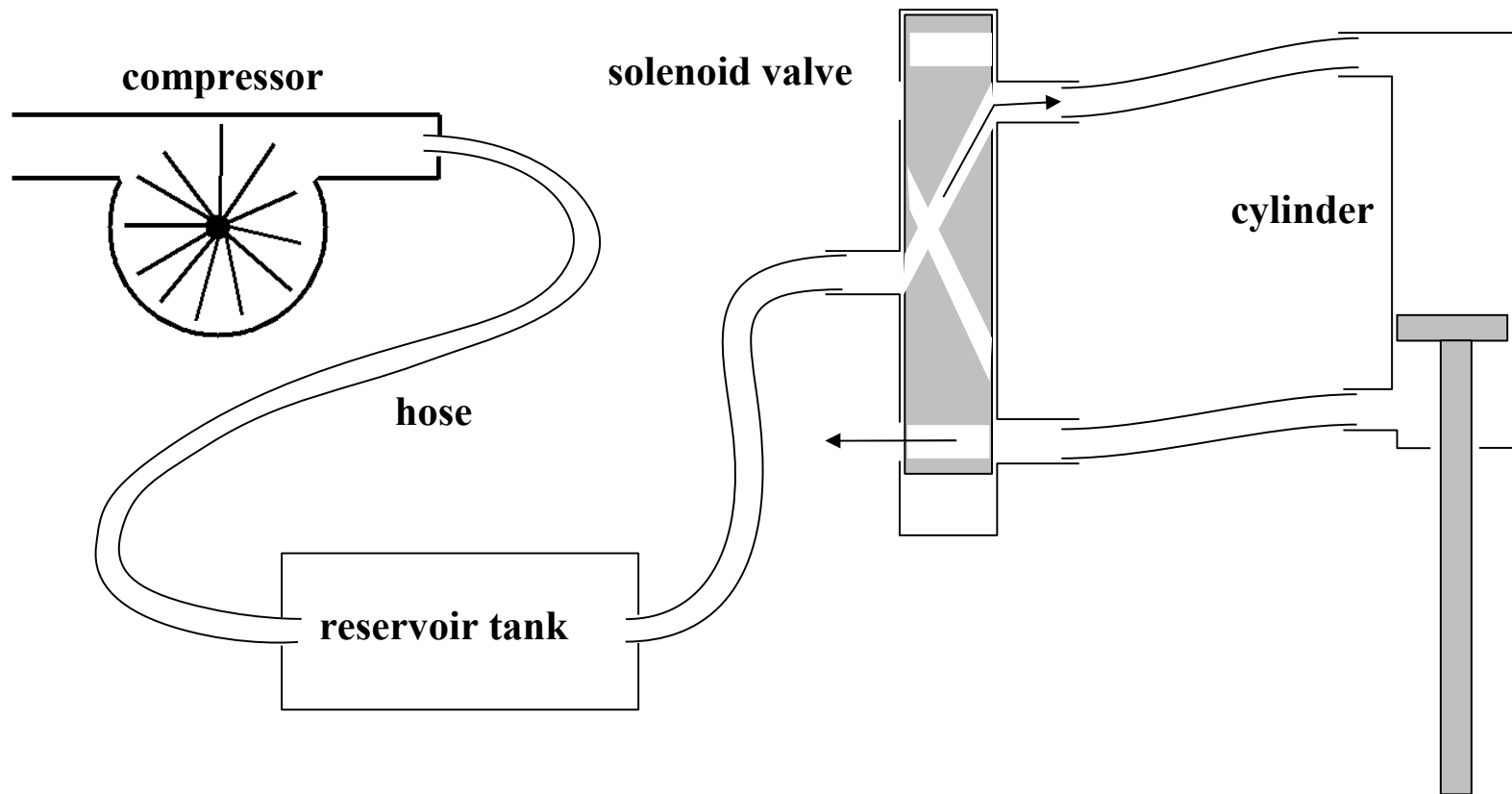
# Pneumatic Principles

Introduction

Components

Mechanisms

Resources



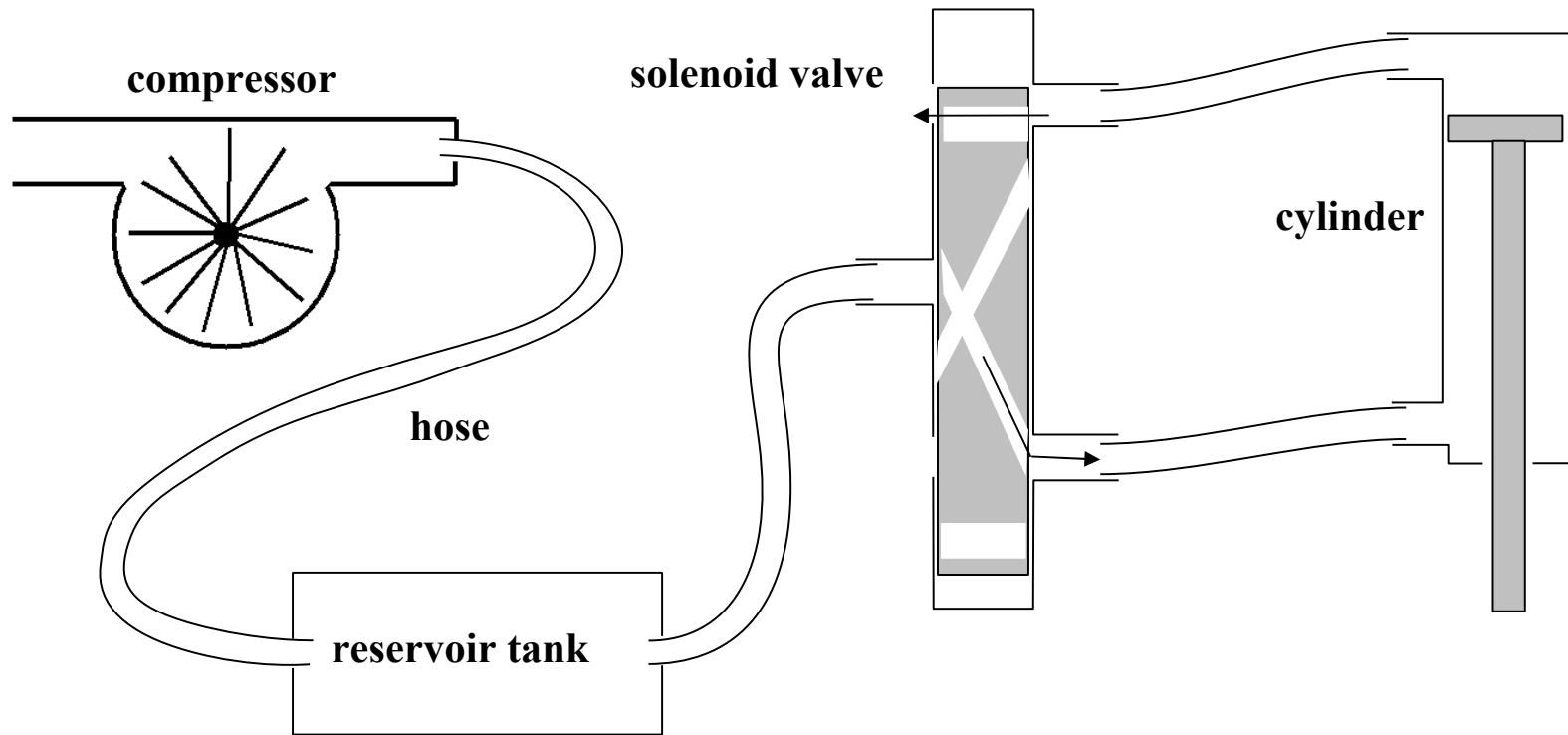
# Pneumatic Principles

Introduction

Components

Mechanisms

Resources



## Why Use Pneumatics?

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Introduction

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Components

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Mechanisms

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Resources

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- **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**

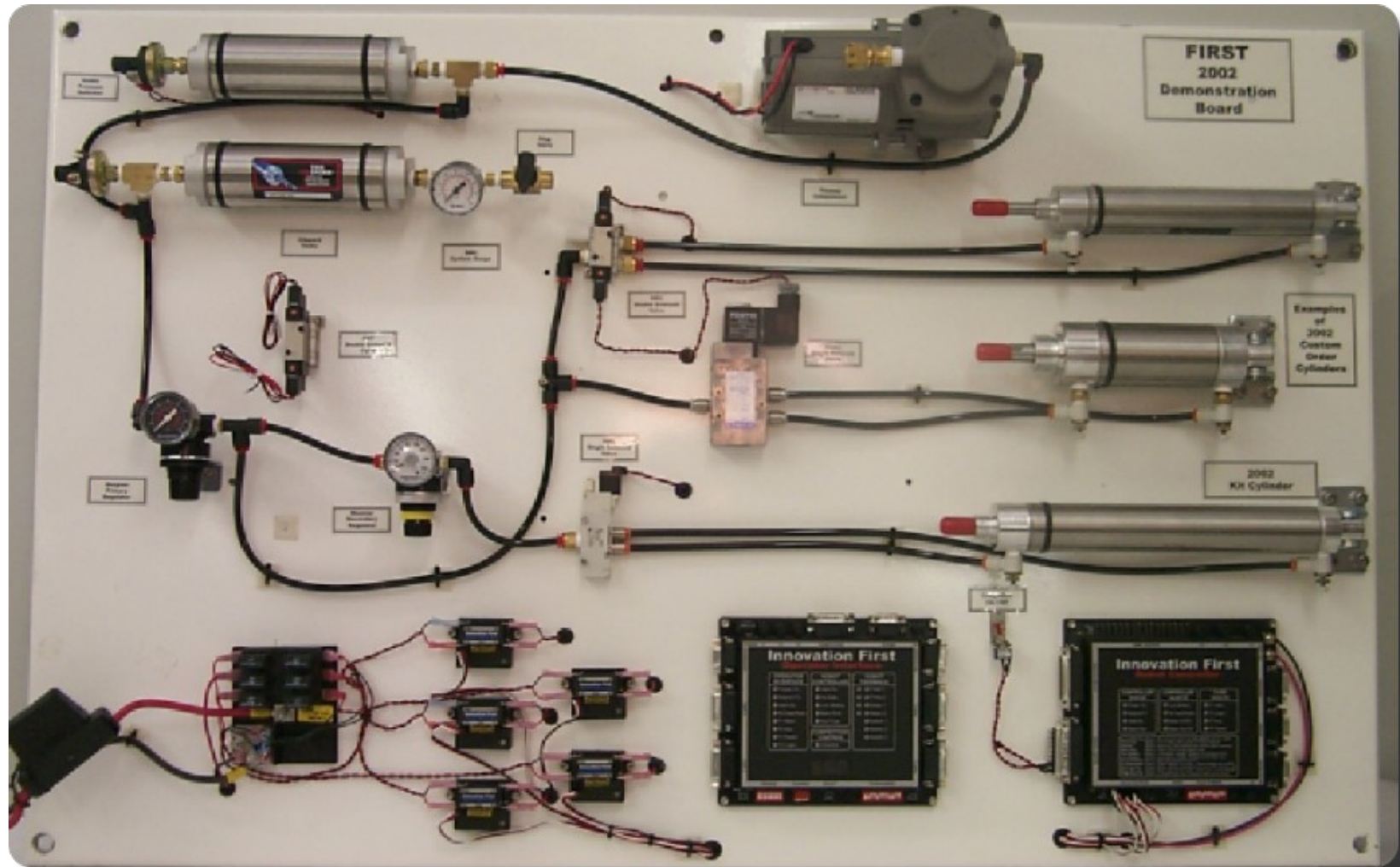
# Pneumatics Board

Introduction

Components

Mechanisms

Resources



# Pneumatic Components

# Compressor

Introduction

- Generates pressure of 120 psi

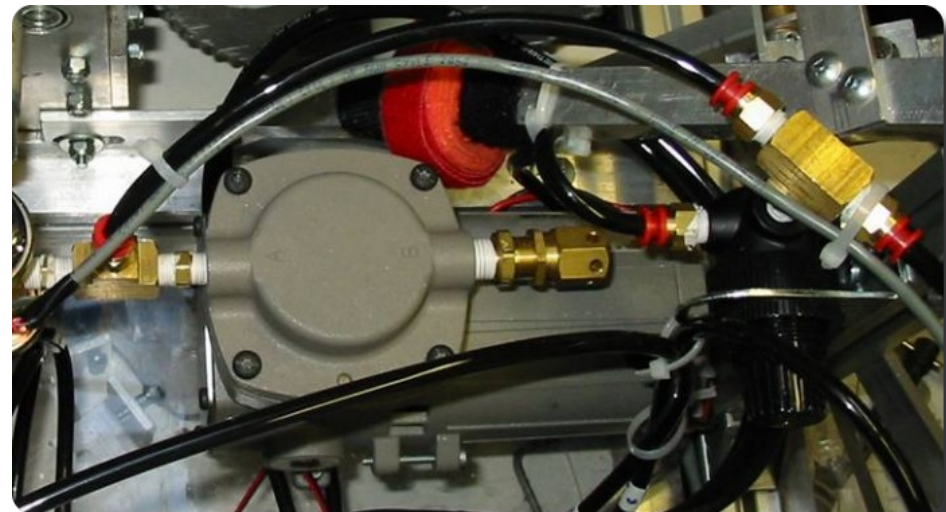
Components

- Always run off relay module, in forward

Mechanisms

- Do not use to generate a vacuum!

Resources



# Reservoir(s)

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Introduction

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Components

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Mechanisms

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Resources

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- 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

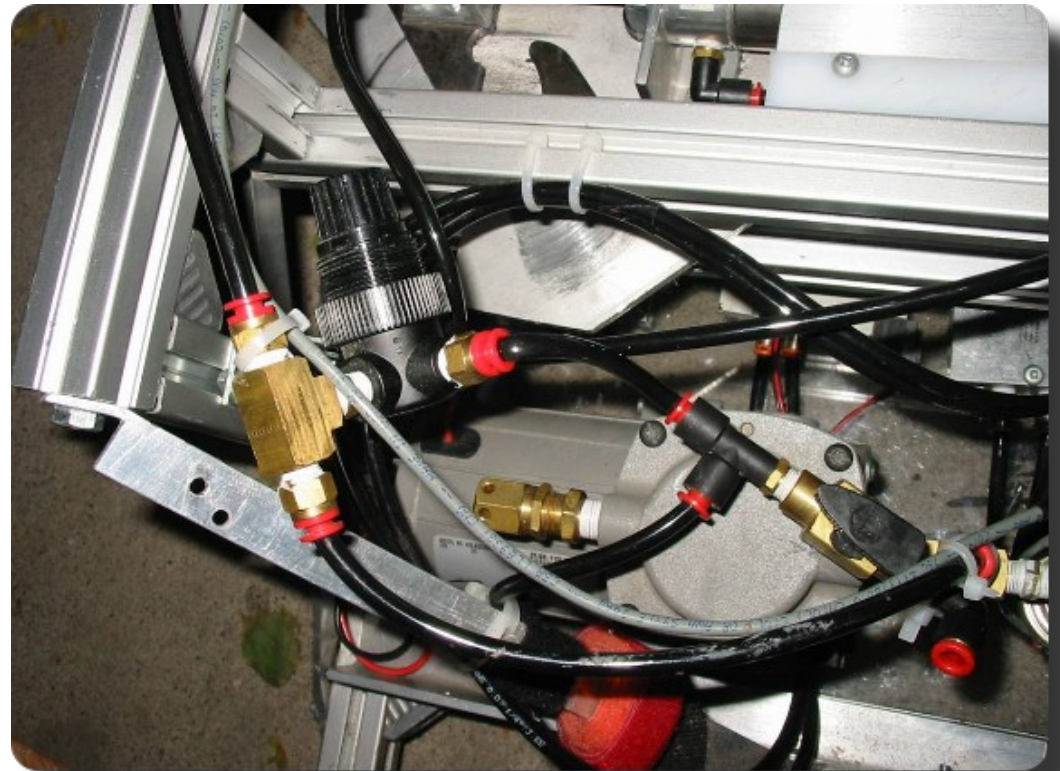
Introduction

Components

Mechanisms

Resources

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



# Pressure Sensor

Introduction

- Detect pressure in pneumatic system

Components

- Indicate whether system is above or below a set pressure
- Can be calibrated

Mechanisms

Resources

- Usually two (one set for 115 psi, one set for 105 psi)
  - Pressure below 105 psi: compressor on
  - Pressure above 115 psi: compressor off



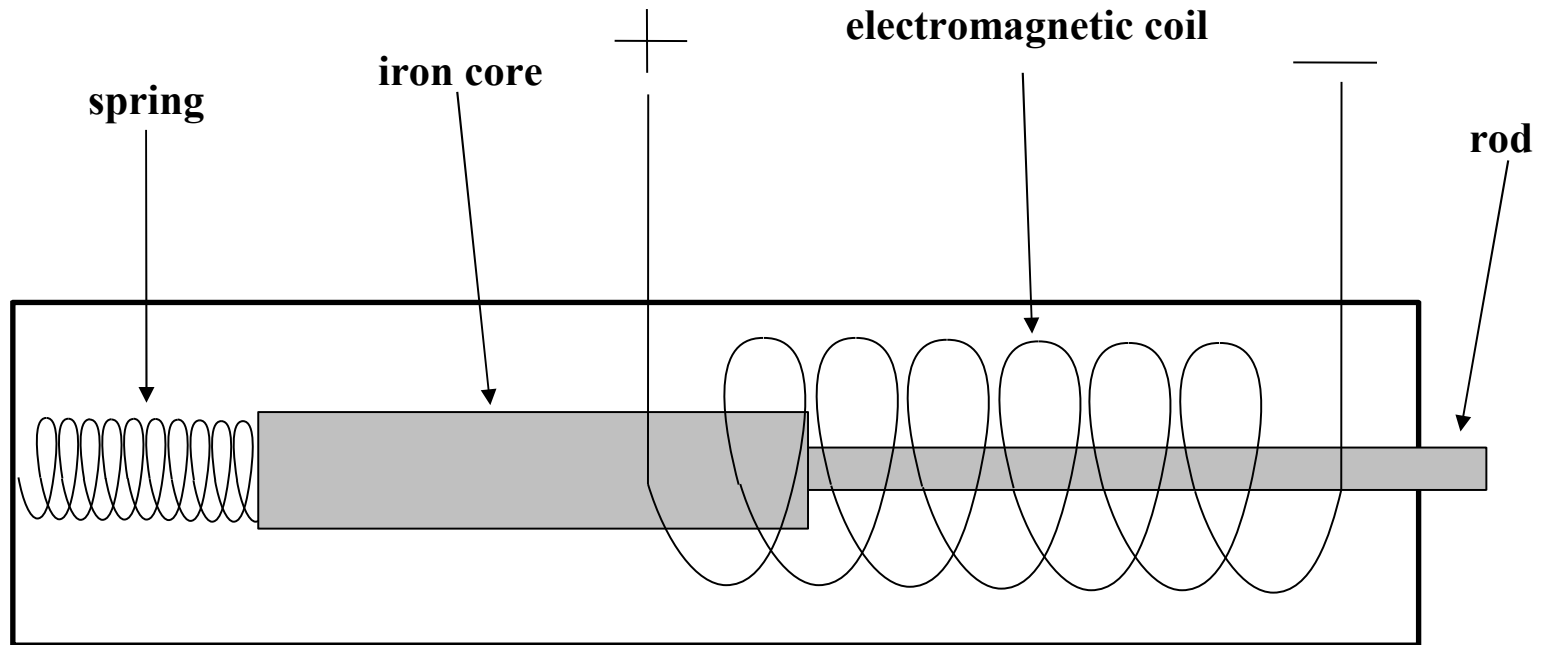
# Solenoids

Introduction

Components

Mechanisms

Resources



# Single Solenoid Valve

Introduction

- When energized, cylinder goes to one state

Components

- When de-energized, cylinder always returns to rest state

Mechanisms

- When power is cut at the end of the match, cylinder will return to rest state

Resources

- Each valve powered by one relay module (only in forward)



# Double Solenoid Valve

Introduction

Components

Mechanisms

Resources

- 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

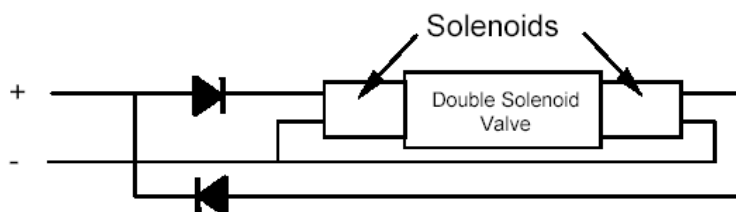


Figure 2.3: Use of Diodes with Double Solenoid Valve



# Cylinders

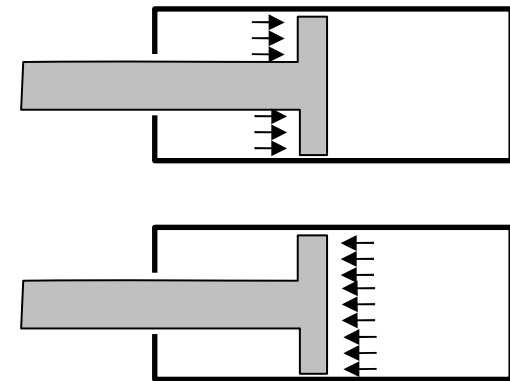
Introduction

Components

Mechanisms

Resources

- Force = Pressure  $\times$  Area
  - 2" diameter piston
  - Area =  $3.14 \times 1^2 = 3.14 \text{ in}^2$
  - Pressure = 60 psi
  - $3.14 \text{ in}^2 \times 60 \text{ psi} = 188 \text{ lbs}$
  - 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

Introduction

- If you need the piston to stay extended or retracted, add a mechanical latch

Components

- Be careful to ensure the piston rod cannot get bent

Mechanisms

- Hard to get locknuts/lock washers in large sizes, so nuts on pistons likely to come loose

Resources



# Flow Controls

Introduction

- Regulate flow of air into and out of a cylinder

Components

- Used to control speed of a pneumatic cylinder

Mechanisms

- If used, attach directly to cylinder (only one end needed)

Resources

- Seems to regulate air flowing in both directions, but one direction is restricted a little more



# Fittings

Introduction

Components

Mechanisms

Resources

- 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

Introduction

Components

Mechanisms

Resources

- 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

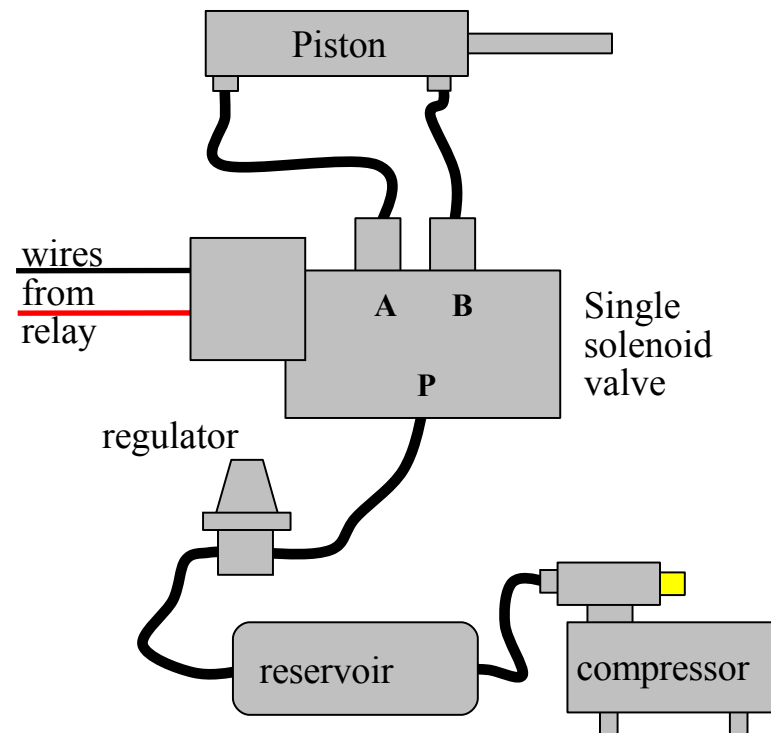
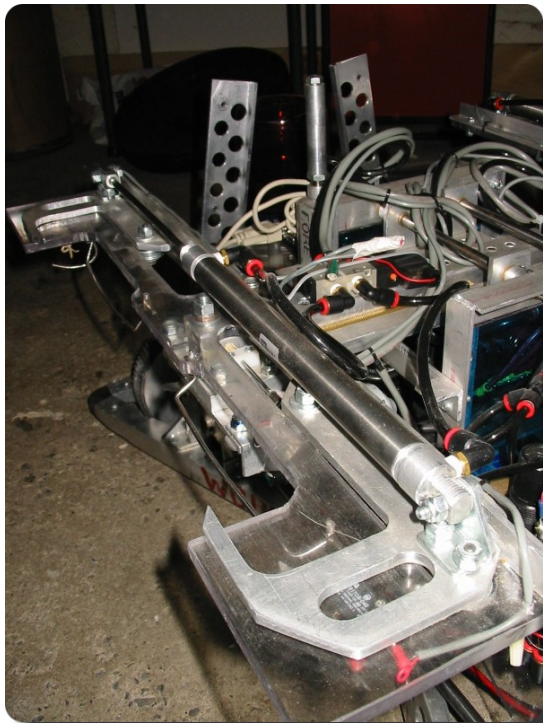
Introduction

Components

Mechanisms

Resources

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



## Short Rotation

Introduction

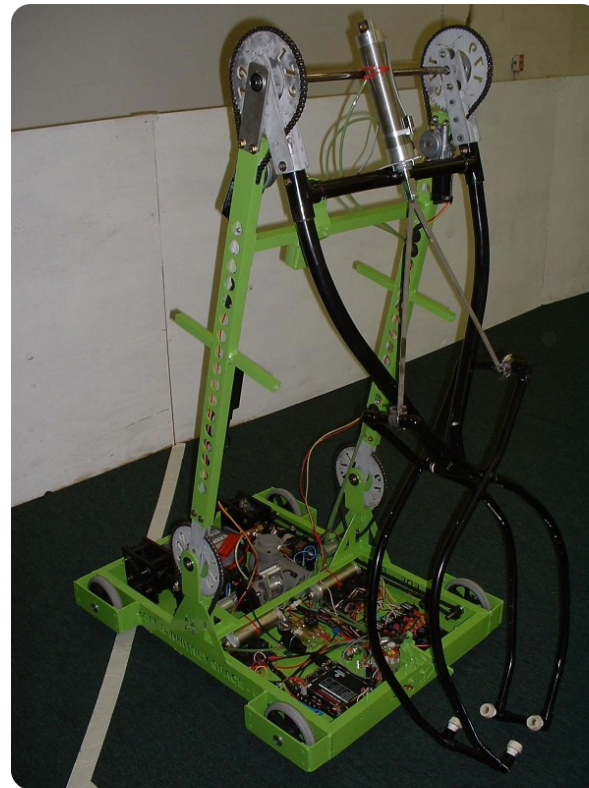
- Arm joints

Components

- Grabbers

Mechanisms

Resources



# Short Rotation

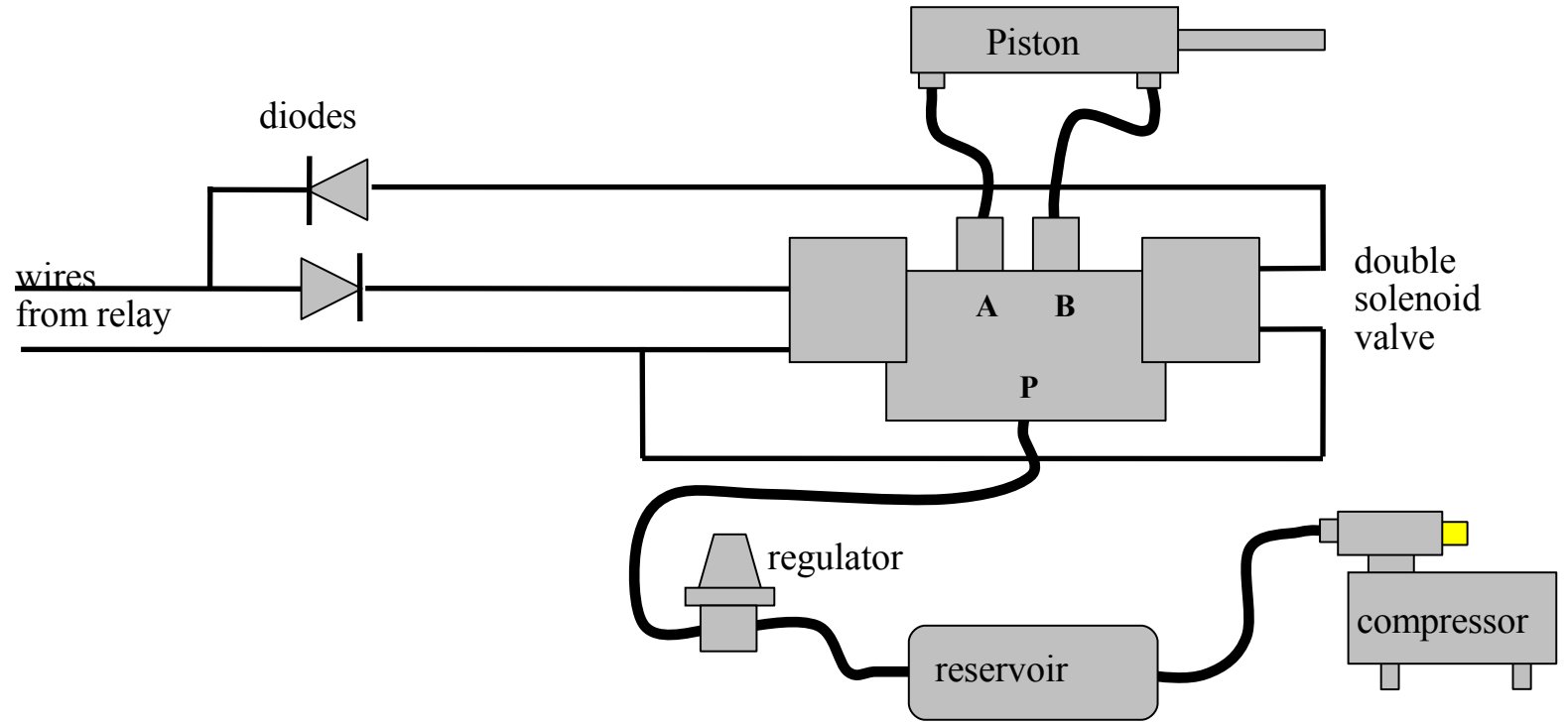
Introduction

Components

**Mechanisms**

Resources

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



# Constant Force

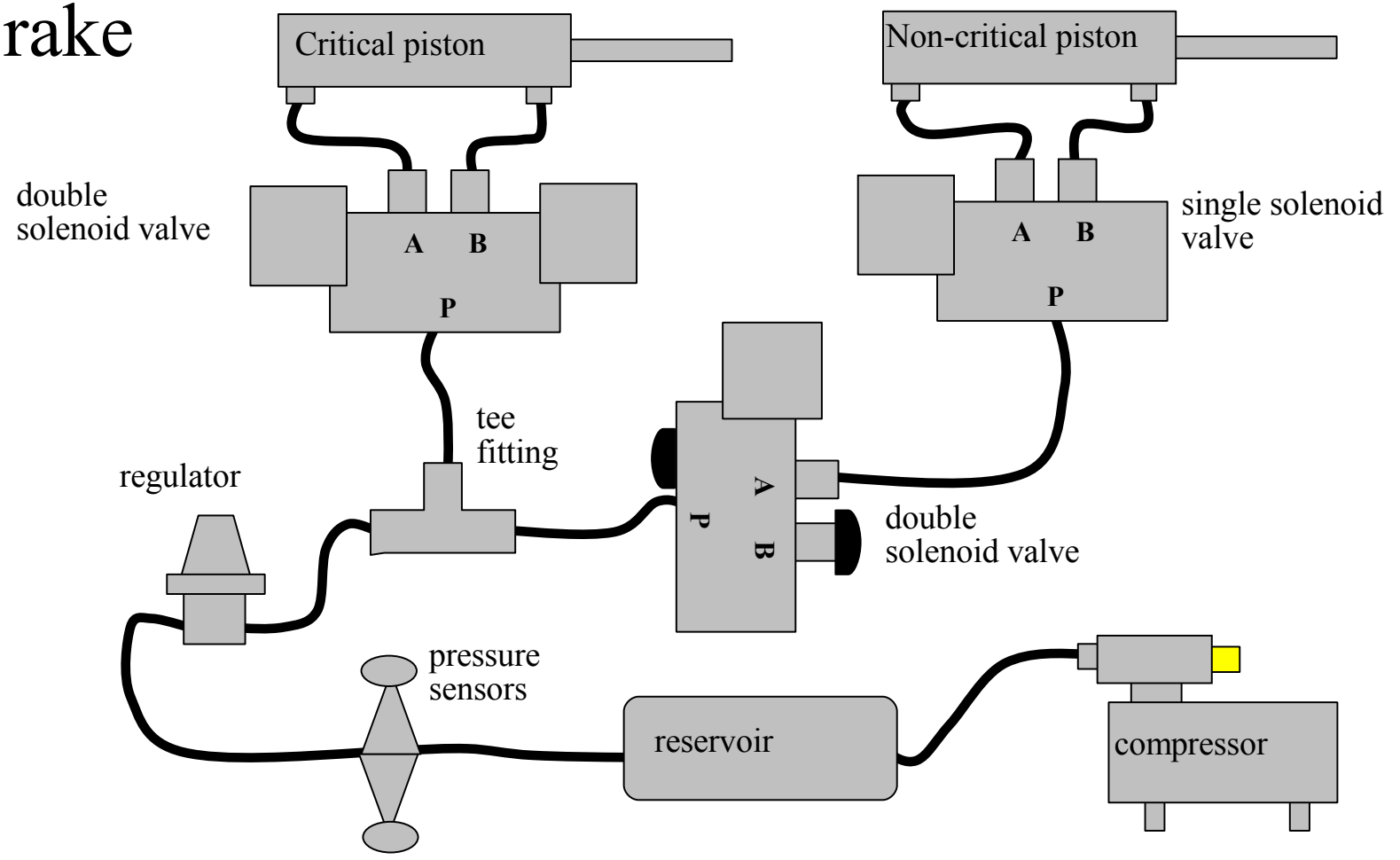
Introduction

Components

Mechanisms

Resources

- Gear shift
- Brake



# Resources

# Resources

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Introduction

- [www.firstroboticscanada.org](http://www.firstroboticscanada.org)

- Grippers, Joints galleries in 'Resources' section

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Components

- [www.chiefdelphi.com/forums/papers.php](http://www.chiefdelphi.com/forums/papers.php)

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Mechanisms

- White papers on many topics

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**Resources**

- [www.chiefdelphi.com](http://www.chiefdelphi.com)

- Very active and helpful FIRST forums

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# Questions?

- Ian Mackenzie ([ian.e.mackenzie@gmail.com](mailto:ian.e.mackenzie@gmail.com))

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Introduction

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Components

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Mechanisms

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**Resources**

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