The Compass Alliance Pathways: Pneumatics

A robot used in FIRST Robotics competitions can utilize pneumatics systems to move mechanisms. Pneumatic systems use pressurized air to accomplish tasks. Pneumatics are light, powerful, and can be easily and quickly modified. Pneumatics are a great option once you know how to use them, but as with any new system, there are tricks to learn and mistakes to make, so it is recommended for teams to first try them in the offseason before deciding to use them during the season.

Level 0: Stepping Stones

Creating a pneumatics system involves working with tubing and fittings. Here are some basic tips for working with tubes and fittings in FRC

- In order to have a reliable pneumatics system, it is important to be able to apply PTFE tape to threaded fittings properly. PTFE tape is used for sealing threads to ensure a strong, tight seal.
    - A video on how to properly apply PTFE tape can be found here.
    - Loctite 542 can be easier to use for sealing threads in small fittings.
- It is also important to make a straight cut when trimming tubing in order ensure a secure connection. A tubing cutter such as the one linked here, should be used to cut tubes.
- It is important to always label tubing. Whenever you add tubes to your pneumatic system, label each end. This allows for quick identification of where tubing is routed to and can speed up the process of diagnosing and fixing problems.
- Strain relief is very important when routing tubing. Make sure that tubes are the correct length, and are not routed at sharp angles to ensure that airflow is not restricted. Use zip ties to secure tubes to the frame of the robot.

The flow of air is controlled by solenoids, which are valves controlled by electric signals that direct air into the pneumatic system. Double and single acting solenoid valves can be used on a robot, and their differences are explained here.

Level 1: Venturing Onwards

- FIRST provides a guide explaining all of the pneumatic components that are required to make a functional pneumatic system on your robot. Plumbing instructions and example pneumatic system setups are included. The guide is linked here.
- A Pneumatics Control Module (PCM) will be needed to control your pneumatic system electrically. The PCM provides an output for the compressor, input for the pressure switch, and outputs for solenoids. FIRST provides an overview of the PCM and wiring instructions here.

- An additional guide to assembling all of the pneumatic components and electrical wiring is linked here.
- It is a good idea to read the current FRC game manual to make sure that your system conforms to the pneumatics rules and regulations.
- Once you have a pneumatic system designed, simulation software such as autoSIM-200 and FluidSIM® 5, can be used to simulate the behavior of your pneumatic system.

Level 2: Forging New Paths

Once you are comfortable setting up a basic pneumatic system, you can start taking into consideration the advantages of different cylinders for different tasks and the advantages of onboard and offboard compressors.

- Cylinders come in different stroke lengths and bore sizes. The bigger the cylinder, the more air it uses. Because of this, it is best to use the smallest cylinder size that can get the job done because there is a limit to how much air is available to use during a match. However, while a smaller cylinder uses less air, it puts out less force, so using a bigger cylinder may be necessary for certain tasks. Information on choosing a cylinder and calculating the specifics of its force, speed, and air usage can be found here.
- When creating a pneumatic system on your robot, you have the option to mount the compressor on the robot.
    - Mounting the compressor on the robot allows for the air supply to continually be refilled. If you want to conserve space on the robot or your system requires a lot of air, then having an onboard compressor will take up less space than having many air tanks (but even with an onboard compressor you will still need air storage). Having an onboard compressor means that having minor leaks in the system aren't as big of a problem (you should still fix leaks when you find them) because the air supply is being replenished during the match. If a leak starts in a situation where you cannot fix it immediately (like in the middle of a match) then the air will be replenished quicker than it is lost.
    - Constantly running the air compressor will overheat it, which can damage the compressor and the components around it .
    - A compressor weighs more than air tanks, so having an offboard compressor can reduce the weight of your robot. In most cases, having an onboard compressor is not necessary. Estimate how much air your robot will use during a match so you can plan out your air storage configuration.

Appendix A - Revision History

Revision #	Revision Date	Revision Notes
1.0	Sept. 2018	Initial Release