**Manual Pneumatic Cylinder position control**

**Objectives:**

In this lab activity, your group will:

* Gain hands-on experience controlling the position of a pneumatic cylinder using a manual valve.
* Become familiar with basic pneumatic components and their operation.
* Interpret and work with a basic pneumatic circuit schematic.

**Introduction**

In this experiment, you will manually control the position of a double-acting pneumaticcylinder using a manual directional control valve. The cylinder is connected to a linear load, which moves along a track. As the load moves to the left, it encounters an opposing force generated by a single-acting pneumatic cylinder. The magnitude of this opposing force can be adjusted using a pressure regulator. Conversely, when moving the load to the right, the force from the single-acting cylinder assists the double-acting cylinder in moving the load.

This lab provides an opportunity to develop hands-on skills in pneumatic actuation, gain experience working with key pneumatic components, and improve your ability to read and interpret pneumatic circuit schematics. By controlling and observing the behavior of this system, you’ll also gain insight into basic principles of force balancing and manual position control in pneumatic applications.

**Background**

**Pneumatic Cylinders**

Pneumatic systems use compressed air to transmit and control energy for performing mechanical work. One of the most common actuators in pneumatic systems is the pneumatic cylinder, which converts the energy of compressed air into linear motion.

There are two main types of pneumatic cylinders:

* **Single-Acting Cylinder:**  
  A single-acting cylinder uses compressed air to move the piston in one direction (typically extension), while a return spring or external force moves it back in the opposite direction when the air is released. These are commonly used in applications where work is required in only one direction.
* **Double-Acting Cylinder:**  
  A double-acting cylinder uses compressed air to move the piston in both directions — one port for extension and another for retraction. These cylinders are preferred when controlled movement is needed in both directions or when no return spring is practical due to the load or stroke length.

In this experiment, a **double-acting cylinder** will be controlled by a **manual directional control valve** to move a load, while a **single-acting cylinder** will generate an adjustable opposing force. The force from the single-acting cylinder is controlled using a pressure regulator. The interaction between these two actuators will allow you to explore the concepts of position control, force balancing, and manual actuation in a simple pneumatic system.

**5-Port, 3-Position, Closed-Center Manually-Operated Valve**

The double-acting pneumatic cylinder in this lab is operated using a 5-port, 3-position, closed-center manually-operated valve. This type of directional control valve plays a critical role in directing airflow to and from the cylinder. Below is an overview of its operation:

* **5 Ports:**  
  The valve includes five ports: two ports connect to the pneumatic cylinder (one to the rod side and one to the piston side), two exhaust ports, and one inlet port for compressed air.
* **3 Positions:**  
  The valve can be shifted between three positions:
  1. **Extend Position:** Connects the compressed air supply to the piston side of the cylinder while exhausting the rod side.
  2. **Retract Position:** Connects the compressed air supply to the rod side while exhausting the piston side.
  3. **Closed-Center Position:** Blocks all ports, isolating both sides of the cylinder and halting any movement.
* **Closed-Center Configuration:**  
  In the center position, the valve prevents airflow to and from the cylinder, effectively holding the piston in its current position. This is useful for maintaining a steady state or pausing motion without venting pressure.

Understanding the operation of these pneumatic components and how they interact within a basic circuit will prepare you to effectively control and troubleshoot pneumatic systems in both industrial and laboratory settings.

**Pneumatic System Description**

Figure 1 illustrates the pneumatic system used in this experiment. The system includes an air compressor to generate compressed air and a filter-regulator unit to clean the air and regulate the working pressure supplied to the system.

A manual 5-port, 3-position, closed-center directional control valve is used to operate a double-acting pneumatic cylinder. This cylinder moves a linear cart system along a track. As the cart moves to the left, it encounters an opposing force produced by a single-acting pneumatic cylinder. The opposing force from this cylinder can be adjusted using a manual pressure regulator. When moving the load to the right, the single-acting cylinder assists the double-acting cylinder in moving the load.

Compressed air enters the system through the valve’s supply port (P). The two actuator ports (A and B) are connected to the piston and rod sides of the double-acting cylinder, while two exhaust ports (R and S) release air from the system as needed. The valve can be manually shifted between three positions:

1. Extend Position: Directs compressed air to the piston side of the cylinder while exhausting the rod side.
2. Retract Position: Directs compressed air to the rod side while exhausting the piston side.
3. Closed-Center Position: Blocks all ports, isolating both sides of the cylinder to hold its current position.

This configuration allows manual control of the load’s position and provides an opportunity to observe how varying the opposing force affects system behavior.



Figure 1: Pneumatic system schematic with manual valve, double-acting and single-acting cylinders, and adjustable opposing force.

**Procedure**

1. **A close up of a machine

   AI-generated content may be incorrect.Power Up the System**
   * Connect the power cord for the pneumatic training platform and turn on the **main power switch** located at the rear of the unit.
2. **A close-up of a machine

   AI-generated content may be incorrect.Start the Air Supply:**  
   Turn on the **compressor toggle switch** on the front panel to begin filling the air storage tank.
3. **Set System Pressure:**  
   Adjust the **filter-regulator unit** to set the system pressure to **75 psi** (or the specified lab value) for the dual acting cylinder by pulling up on the knob, rotating it to the desired setting, and locking it back down.
4. **Inspect Circuit Connections:**  
   Verify that all pneumatic connections match the provided schematic (**Figure** 1). Confirm that:
   * The **air supply port (P)** is connected to the air source.
   * **Ports A and B** are connected to the piston and rod sides of the double-acting cylinder.
   * **Exhaust ports R and S** are properly vented.
   * **Single acting cylinder** is connected properly to the pressure regulator
5. **Activate Shut-off Valve**
   * Adjust the shut-off valve to allow pressure into the pressure regulator that will be controlling the force applied by the single acting cylinder.
6. **Set Opposing Force:**  
   Adjust the **pressure regulator** on the single-acting cylinder to the desired opposing pressure value.
7. **Operate the Manual Valve:**
   * Shift the valve to the **extend position** to move the cart to the left against the opposing force. Observe the motion.
   * Return the valve to the **closed-center position** to hold the load in place.
   * Shift the valve to the **retract position** to move the load to the right with assistance from the single-acting cylinder.
   * Pause at **closed-center** as needed to observe and note the system’s response.
8. **Repeat and Adjust:**  
   Repeat steps 6 and 7 while varying the opposing pressure. Record observations for different settings.
9. **Shutdown Procedure:**  
   After completing the test:
   * Return the manual valve to the **closed-center** position.
   * Turn off the **compressor toggle switch**.
   * Depressurize the system by slowly venting air through a designated exhaust valve or connector.
   * Turn off the **main power switch**.

**Results & Discussion**

**Results:**  
Record the following for each trial:

* Opposing pressure setting (psi)
* Direction of load motion (left or right)
* Notable observations (e.g., speed, smoothness of motion, difficulty in holding position at closed-center)

Create a table summarizing your results for various opposing pressures.

**Discussion:**

* **Effect of Opposing Force:**  
  Discuss how increasing the opposing pressure affected the ability of the double-acting cylinder to move the load to the left. At what pressure did movement slow down, become uneven, or stop entirely? Explain why this occurs based on force balance principles.
* **System Behavior at Closed-Center Position:**  
  Describe how effectively the closed-center valve position held the load in place. Were there any noticeable leaks, drifts, or pressure losses? What factors might contribute to any observed movement while in this position?
* **Assistance During Retraction:**  
  Comment on how the single-acting cylinder’s force assisted the double-acting cylinder when moving the load to the right. Did higher opposing pressures help speed up or slow down this motion? Why?
* **Practical Implications:**  
  Reflect on how manual control with a closed-center valve differs from automatic control systems. Where might such a setup be useful in real-world applications? What limitations did you observe in manual actuation?
* **Sources of Error:**  
  Identify possible sources of experimental error, such as pressure fluctuations, valve sticking, inaccurate pressure readings, or misaligned components.