Student Learning Objectives. Instruction in this lesson should result in students achieving the following objectives:

1. Define pneumatics, and explain the major parts of a supply system.
2. Describe the purpose of a flow meter.
3. Explain the safety practices for pneumatics.
4. Inspect, analyze, and repair pneumatic system components.
5. Explore careers associated with pneumatic systems.

Resources. The following resources may be useful in teaching this lesson:

- E-unit(s) corresponding to this lesson plan. CAERT, Inc. [http://www.mycaert.com](http://www.mycaert.com).
**Equipment, Tools, Supplies, and Facilities**

- Overhead or PowerPoint projector
- Visual(s) from accompanying master(s)
- Copies of sample test, lab sheet(s), and/or other items designed for duplication
- Materials listed on duplicated items
- Computers with printers and Internet access
- Classroom resource and reference materials

**Key Terms.** The following terms are presented in this lesson (shown in bold italics):

- air filter
- air storage tank
- compressor
- flow meter
- manifold
- motor
- needle valves
- pneumatics
- pressure limit switch
- pressure regulator
- pressure system gauge
- safety filter
- safety valve

**Interest Approach.** Use an interest approach that will prepare the students for the lesson. Teachers often develop approaches for their unique class and student situations. A possible approach is included here.

*Display several pneumatic tools for the students (e.g., air wrench, nail gun, and air compressor). Ask the students to identify the tools (which they most likely will be able to do easily). Ask a show of hands as to how many students have used air tools in the past. Of the students who raise their hands, ask them to describe what is happening inside the tool to make it work (e.g., how the nail gun actually fires the nail).*
Objective 1: Define pneumatics, and explain the major parts of a supply system.

Anticipated Problem: What is pneumatics, and what are the major parts of a supply system?

I. **Pneumatics** is any system or tool that uses compressed gas (typically air) to create motion or mechanical advantage. Most pneumatic systems, regardless of the machine complexity, have several parts in common.

   A. All pneumatic systems must utilize some form of a compressor. A **compressor** is a tool that takes in outside air and forces it into a storage tank where it cannot escape. As more air is forced into the tank, the pressure inside the tank continues to rise.

   B. The compressor is driven by a **motor**, which is a gas- or electric-powered device that creates rotary motion. The rotary motion controls a piston in the compressor that takes in air and forces it into the storage tank.

   C. The **air storage tank** is a device that receives the air from the compressor to hold under pressure until needed by the pneumatic circuit.

   D. Because dirt and debris particles can damage compressors and pneumatic tools, compressors are outfitted with an **air filter**, which is a porous screen-like material to catch foreign material.

   E. A **safety filter** is a secondary screen-like material to remove even smaller foreign particles from the air before it enters the compressor and storage tank.

   F. As the pressure inside the storage tank increases, the pressure limit switch is utilized. The **pressure limit switch** is a device that senses the tank pressure and will automatically turn the compressor off when a set pressure is reached. In addition, the pressure switch will engage the compressor when the tank pressure falls below a preset level. Pressure in most air tanks is measured in pounds per square inch (psi).

   G. If the pressure limit switch fails to shut the compressor off and pressure continues to build, a safety valve will open. A **safety valve** is a device designed to open and allow extra pressure to escape into the atmosphere to prevent the tank from rupturing.

   H. When the air in the storage tank is needed, it travels down a **manifold**, which is a connector between the air supply system and the pneumatic circuit (tool).

   I. A **pressure regulator** is a device that controls the amount of air pressure allowed to enter the pneumatic circuit to operate the machine or tool. The regulator is
adjustable, allowing the operator to increase or decrease the pressure for certain applications.

J. A **pressure system gauge** is a tool attached to the pressure regulator to show the air pressure entering the pneumatic circuit.

K. **Needle valves** are tools used to stop the supply of pressurized air to the circuit. When the valves are turned in, they seal the opening for the compressed air to move through.

**Teaching Strategy:** Begin this objective with a discussion on the basic principles of pneumatics. Once students understand the basic functioning of a pneumatic system, use VM–A. If possible, show the students an air compressor, and have them safely operate an air tool. Assign LS–A.

**Objective 2:** Describe the purpose of a flow meter.

**Anticipated Problem:** What is the purpose of a flow meter?

II. A **flow meter** is a tool that measures the amount of air flowing through a pneumatic circuit, typically in standard cubic feet per hour (SCFH). A flow meter has various applications and is used whenever an operator must know how much air is flowing through a pneumatic system.

A. In factories, a flow meter is used to measure how much air or another gas is flowing into a container. A flow meter ensures the products are correctly mixed with gases.

B. A flow meter is important in the bottling of soda. The carbonation is due to the mixing of carbon dioxide gas with the liquid. A flow meter can show how much carbon dioxide is being added. If there is too little, the soda is flat. If there is too much, the soda bottle could rupture.

C. A flow meter is used in the production of potato chips. Gases are pumped into the chip bag to protect the chips during shipping and to increase freshness. A flow meter insures that the correct amount of gas is pumped into the bag without damaging the bag or the chips.

**Teaching Strategy:** Ask students to list areas of manufacturing that would use a flow meter. Use the Internet to research uses of flow meters in food packaging. Additionally, students could research compressed air and flow meters in agricultural settings, such as vacuum planters.
Objective 3: Explain the safety practices for pneumatics.

Anticipated Problem: What safety practices are associated with pneumatics?

III. As with any system that operates under pressure, pneumatics can pose several safety hazards because of the nature of the operation. It is important to always follow a few basic safety rules when working with pneumatic devices or tools.

A. Proper safety glasses or goggles should be worn when working with pressurized air. Objects can be propelled by the air and cause significant eye injuries if they strike the operator. In addition, a pressurized jet of air can damage unprotected eyes.

B. When using an air compressor to drive pneumatic tools or devices, the needle valves must be closed before connecting, disconnecting, or making any changes to the pneumatic circuit. The circuit should be completely depressurized before making any changes.

C. Pneumatic cylinders can move quickly and can pose an injury hazard if body parts, loose clothing, or other objects come into contact with moving cylinders. People must always be aware of their surroundings, especially where pneumatic cylinders are being used.

D. All pneumatic components and fittings should be handled carefully. Damage to these components may not be immediately noticeable. However, if a component breaks, it can cause injury when the pneumatic circuit is pressurized.

E. A person should always read, understand, and follow all safety guidelines associated with compressors, air tools, and other pneumatic devices. Safety should be the top priority when working with any air-driven device.

Teaching Strategy: Discuss the possible injuries that could happen when using air-powered tools or devices. If possible, you may wish to demonstrate the power of a simple air compressor by using the blower gun to blow the debris off a lawnmower. Students can observe how the debris could pose serious eye risks without safety glasses.

Objective 4: Inspect, analyze, and repair pneumatic system components.

Anticipated Problem: How can people inspect, analyze, and repair pneumatic system components?

IV. Most pneumatic systems are composed of a few basic components that should be inspected regularly and repaired if necessary. Hoses, connectors, couplings, and compressors are common fail points in pneumatic systems and should be given the closest and most regular inspections.

A. A pneumatic system is only as strong as the hoses delivering pressurized air to the system components or air tools. Pneumatic hoses should be inspected for any
signs of wear, cracking, bulging, or tearing. If any of these conditions are found, the impacted hoses should be replaced immediately.

1. Hoses should always be the proper material, size, and pressure rating for the application in the equipment or tool. Choosing hoses that do not meet the demands of the machine are a sure way for leaks or ruptures to result.
2. Cracks and bulges in hoses are signs that the hoses are exposed to heat or ozone from machinery, or they are underrated for the pressure needed and used in the machinery or tool.

B. Connectors or couplings are typically crimped onto the ends of air hoses, which allow the hoses to be attached to a pneumatic compressor system. It is important to make sure the hose end connector and compressor connector are meant to be used together; otherwise a blow off could occur when pressure is applied.

1. Connectors and couplings should be inspected for signs of leaking or cracking. Cracked connectors may operate well under low pressure, but they may fail unexpectedly under higher pressure applications.
2. Excessive or under-crimping of pneumatic connectors could lead to hoses leaking or rupturing. Pneumatic hoses often are sold pre-assembled from the factory. It is important not to try to alter the connections on a factory-made hose.

C. Finally, it is necessary to inspect the routing of hoses to insure that no crimps or bends in the hoses could cause disruption of air flow. Hoses should not be twisted or routed where they could rub on moving parts and cause wear. If poor routing of hoses is found, the machine should be shut down and the hoses repaired and rerouted before continuing use.

**Teaching Strategy:** Begin by bringing in a worn or ruptured pneumatic hose for students to examine. Discuss various ways that hoses could become worn or damaged during normal use. Use VM–B. Examine various pneumatic components (online if not possible in person) to show students how proper connector selection is critical for safe machinery use. The following Web site [http://www.grainger.com/](http://www.grainger.com/) has many components to search and view. Assign LS–B.

**Objective 5:** Explore careers associated with pneumatic systems.

**Anticipated Problem:** What careers are associated with pneumatic systems?

V. Even though the use of pneumatic-driven equipment has been around for many years, the number of careers and jobs associated with air-pressurized systems continues to grow in agriculture and other industries.

A. Some career areas related to pneumatics

1. Mechanical engineers are responsible for designing and overseeing the manufacturing of new pneumatic systems or upgrading existing systems for better
efficiency. Engineers must be able to troubleshoot problems in a system and suggest corrections to solve these problems.

2. Pneumatic mechanics construct the hoses, compressors, and other system components and install them into equipment. Mechanics are typically responsible for inspection and repair of existing air-pressurized systems.

3. Product managers work with engineers and pneumatic sales departments to ensure that the product being produced is what is desired by customers. Managers must be able to see trends in the industry and suggest advancements necessary to meet the growing demands for pneumatics.

4. Sales managers work with manufacturers and retail outlets to provide the equipment that consumers desire to purchase. Managers must work with customers, retailers, and manufacturers. Therefore, people skills are a must for sales work.

5. Shop technicians are entry-level careers that involve the maintenance and repair of pneumatic equipment. Technicians must be able to read and understand repair manuals and schematics. In addition, they must be able to perform physically demanding work.

B. The education required for a career in pneumatic systems varies with each area. A mechanical engineer will need a bachelor’s degree in engineering or a related field, while a pneumatic mechanic may need an associate’s degree. Some areas, such as a shop technician, may only require a high school diploma, but employers often search for candidates with additional education or for those willing to further their education as they work.

Teaching Strategy: Numerous careers are associated with pneumatic systems and air-driven tools. If possible, have students go online to search for pneumatic-related careers in their area. Search community college and university programs to find the offerings and requirements for various trainings and degrees in pneumatics. Ask the hiring manager of a local business, such as an agricultural repair shop that deals with pneumatics systems or pneumatic tools, to share desirable qualities or skills in employees. Assign LS–C.

Review/Summary. Use the student learning objectives to summarize the lesson. Have students explain the content associated with each objective. Student responses can be used in determining which objectives need to be reviewed or taught from a different angle. If a textbook is being used, questions at the ends of chapters may be included in the Review/Summary.

Application. Use the included visual master(s) and lab sheet(s) to apply the information presented in the lesson.

Evaluation. Evaluation should focus on student achievement of the objectives for the lesson. Various techniques can be used, such as student performance on the application activities. A sample written test is provided.
Answers to Sample Test:

Part One: Matching
1. d
2. g
3. e
4. f
5. b
6. i
7. h
8. a
9. j
10. c

Part Two: True/False
1. T
2. F
3. F
4. T
5. F
6. T
7. T
8. T

Part Three: Short Answer

1. Answers should include two of the following: In factories, a flow meter is used to measure how much air or another gas is flowing into a container. It ensures the products are correctly mixed with gases. A flow meter is important in the bottling of soda. The carbonation is due to the mixing of carbon dioxide gas with the liquid. A flow meter can show how much carbon dioxide is being added. If there is too little, the soda is flat. If there is too much, the soda bottle could rupture. A flow meter is used in the production of potato chips. Gases are pumped into the chip bag to protect the chips during shipping and to increase freshness. A flow meter insures that the correct amount of gas is pumped into the bag without damaging the bag or the chips.

2. Pneumatic hoses should be inspected for any signs of wear, cracking, bulging, or tearing. If any of these conditions are found, the impacted hoses should be replaced immediately. Hoses should always be the proper material, size, and pressure rating for the application of the hoses in the equipment or tool. Choosing hoses that do not meet the demands of the machine is a sure way for a leak or rupture to occur. Cracks and bulges in hoses are signs that the hoses are exposed to heat or ozone from machinery, or they are underrated for the pressure needed and used in the machinery or tool.
Part One: Matching

Instructions: Match the term with the correct definition.

a. air filter  
   b. air storage tank  
   c. compressor  
   d. flow meter  
   e. manifold  

f. needle valves  
   g. pneumatics  
   h. pressure limit switch  
   i. pressure regulator  
   j. safety valve

_____1. A tool that measures the amount of air flowing through a pneumatic circuit, typically in standard cubic feet per hour (SCFH)

_____2. Any system or tool that uses compressed gas (typically air) to create motion or mechanical advantage

_____3. A connector between the air supply system and the pneumatic circuit (tool)

_____4. Tools used to stop the supply of pressurized air to the circuit

_____5. A device that receives the air from the compressor to hold under pressure until needed by the pneumatic circuit

_____6. A device that controls the amount of air pressure allowed to enter the pneumatic circuit to operate the machine or tool

_____7. A device that senses the tank pressure and will automatically turn the compressor off when a set pressure is reached

_____8. A porous screen-like material to catch foreign material

_____9. A device designed to open and allow extra pressure to escape into the atmosphere to prevent the tank from rupturing

_____10. A tool that takes in outside air and forces it into a storage tank where it cannot escape
Part Two: True/False

Instructions: Write T for true or F for false.

_____1. Air filters in pneumatic systems are critical, as small particles can damage compressors and air-driven tools.

_____2. Careers in pneumatics are declining and are not in great demand.

_____3. If the pressure limit switch fails, needle valves will automatically engage to stop the flow of air into the pneumatic tool or circuit.

_____4. Safety glasses should be worn when working with pressurized air, as a jet of this air could cause damage to unprotected eyes.

_____5. Pneumatic system engineers work with manufacturers and retail outlets to provide the equipment that consumers desire to purchase.

_____6. Hoses should always be the proper material, size, and pressure rating for the application of the hose in the equipment or tool.

_____7. If an operator must know how much air is flowing through a pneumatic system, a flow meter would be necessary.

_____8. Pneumatic hoses should be regularly inspected for signs of wear to prevent the rupture of the hoses under pressure.

Part Three: Short Answer

Instructions: Answer the following.

1. Describe two ways a flow meter would be used in a pneumatic system in an industry.

2. Describe the routine maintenance that should be performed on a pneumatic system in terms of hoses.
This is an air compressor with two pistons.
Check out this air pressure regulator with a safety valve (smaller red knob on left).

This is an air pressure limit switch (black box above the pressure gauge).
These air hoses are showing signs of wear.
Choosing the proper connectors is essential.

A variety of pneumatic connectors exist.
Pneumatic System Components

Purpose

The purpose of this activity is to examine various components and operations of pneumatic valves and systems.

Objective

Explore pneumatic systems through a series of online tutorials.

Materials

- lab sheet
- Internet access
- paper
- writing utensil

Procedure

1. Visit the Web sites listed below, and complete the tutorials on pneumatic valves and pneumatic systems.
   - [https://www.wisc-online.com/learn/career-clusters/stem/hyp5008/simple-pneumatic-circuits](https://www.wisc-online.com/learn/career-clusters/stem/hyp5008/simple-pneumatic-circuits)
   - [https://www.wisc-online.com/learn/career-clusters/stem/hyp4807/pneumatic-directional-control-valves](https://www.wisc-online.com/learn/career-clusters/stem/hyp4807/pneumatic-directional-control-valves)

2. Answer the following questions (on your paper) as you work through the tutorials:
   a. What does the term “way” refer to when describing pneumatic valves?
   b. Define needle valves, and draw the graphic symbol for needle valves.
   c. Define check valves, and draw the graphic symbol for check valves.
   d. What is a directional control valve?
   e. What would be a common application for a two-way directional control valve?
   f. What would be a common application for a three-way directional control valve?
   g. How many ports does a four-way valve have?
   h. What would be a common application for a four-way directional control valve?
Simple Pneumatic Arm

Purpose

The purpose of this activity is to experiment with pneumatics to build a simple pneumatic-controlled arm.

Objective

Conduct activities related to the basic concept of a pneumatic-controlled device.

Materials

- Lab sheet
- 9 craft sticks
- 5 jumbo craft sticks
- 6 quarter-straw pieces (made from large milkshake straws)
- 2 eight-straw pieces
- 1 pipe cleaner
- 2 syringes
- 12" of tubing (must fit on end of syringe)
- Tape
- Computer or another device with Internet access
- Writing utensil
- Paper

Procedure

2. Build the pneumatic arm, and experiment with picking up items with the arm.
3. Experiment with using different sizes of syringes in your pneumatic arm.
4. With your instructor’s permission, design other modifications that could be made to the arm with the use of additional pneumatics.
5. Answer the following questions (on your own paper):
   a. What would be the advantages of using pneumatics in industry vs. hydraulics?
   b. What would be the disadvantages of using pneumatics in industry vs. hydraulics?
   c. Describe the mechanical advantage that occurs when using different sizes of syringes to move the arm.
Pneumatic Career Research

Purpose

The purpose of this activity is to identify and research careers in pneumatics.

Objective

Identify and describe various career options related to pneumatic systems.

Materials

- lab sheet
- device with Internet access
- writing utensil
- paper

Procedure

1. Use the Internet to research and choose a career in pneumatics that interests you. In addition, interview someone who works in a pneumatic-related career area.

2. Choose one of the following methods to display your research:
   - A personal interview (transcribed)
   - An Internet research informational sheet
   - A one-page report detailing and describing your career research
   - A PowerPoint or Prezi presentation detailing your career research

3. In your research, some of the areas you may want to explore may include:
   - Specific jobs
   - Salary range
   - Education required
   - Specific skills needed
   - Job description (e.g., hours, working conditions, and typical day)

4. Your project will be graded on completeness, attention to detail, extent of research, creativity, and proper use of grammar.