ثانوية التكنولوجيا التطبيقية
Applied Technology High School

Technology Exploration-II

Module 3
Pneumatic Systems

PREPARED BY

Academic Services Unit

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Module 3:
Pneumatic Systems

Module Objectives

After the completion of this module, students should be able to:

- Define a pneumatic system.
- State the main components of a pneumatic system.
- Describe the construction and principle of operation of pneumatic cylinder, pump and three-position valve.
- Conduct practical tasks to demonstrate the applications of pneumatic systems.

Module Contents

3.1 Introduction to Pneumatic Systems

The term pneumatic is based on the Greek word 'pneumatikos', meaning 'coming from the wind.' Pneumatic is defined as the use of pressurized air to do work. Pneumatic machines have been used for many years. In fact, 2,000 years ago a famous Greek inventor, Hero of Alexandria made a large variety of pneumatic machines, including a pneumatic catapult.

Why use pneumatics?

If you have ever been to the dentist and had your teeth drilled or polished, you may have had a close encounter with a pneumatic machine without even knowing it! Pneumatic dental instruments are often the preferred choice of dentists because of the instruments' high momentum and smooth operation.

Some of the benefits of using pneumatic systems are:

- Pneumatic machines can be very small, light, fast, and powerful.
- Air is light and free compared to hydraulic fluid.
- You can very easily store compressed air.
- Pneumatic machines are safe even when their air hoses or individual parts get wet.
- If a pneumatic machine is overloaded, the machine will stop, continue compressing, or release the air through a pressure release valve.

Some of the dangers of pneumatic systems are:

- If there is a hose leak in hydraulic machines, fluid can cause the surrounding area to become slippery and dangerous.
- Note that any fluid, even air, under high pressure can potentially be dangerous!

3.2 Principles of Pneumatics

Consider an empty container, such as Container A (Figure 3.1). Even though it may look empty, it is actually full of air molecules. Air molecules are invisible, but they still possess weight and mass, and exert pressure. Container A's pressure matches the air pressure of the room it is in.

Once the container is sealed (Container B) the molecules trapped inside exert pressure when squeezed or 'compressed' as they collide with each other and the sides of the container. It is the empty space and the elasticity of the impact between the air molecules and the container that allows for the air to be compressed. The force of the air molecules acting on a surface, such as the piston, is called pressure.

The amount of pressure the air molecules exert depends on the number of molecules and amount of collisions that occur between the molecules and the inside surface of the container. Air molecules that are compressed contain potential energy. If the hand and piston are removed (Container C), the compressed air will expand until the pressure inside and outside the container are the same. Using a controlled airflow circuit, the force of expanding air can be converted into kinetic energy that can power and operate a system.

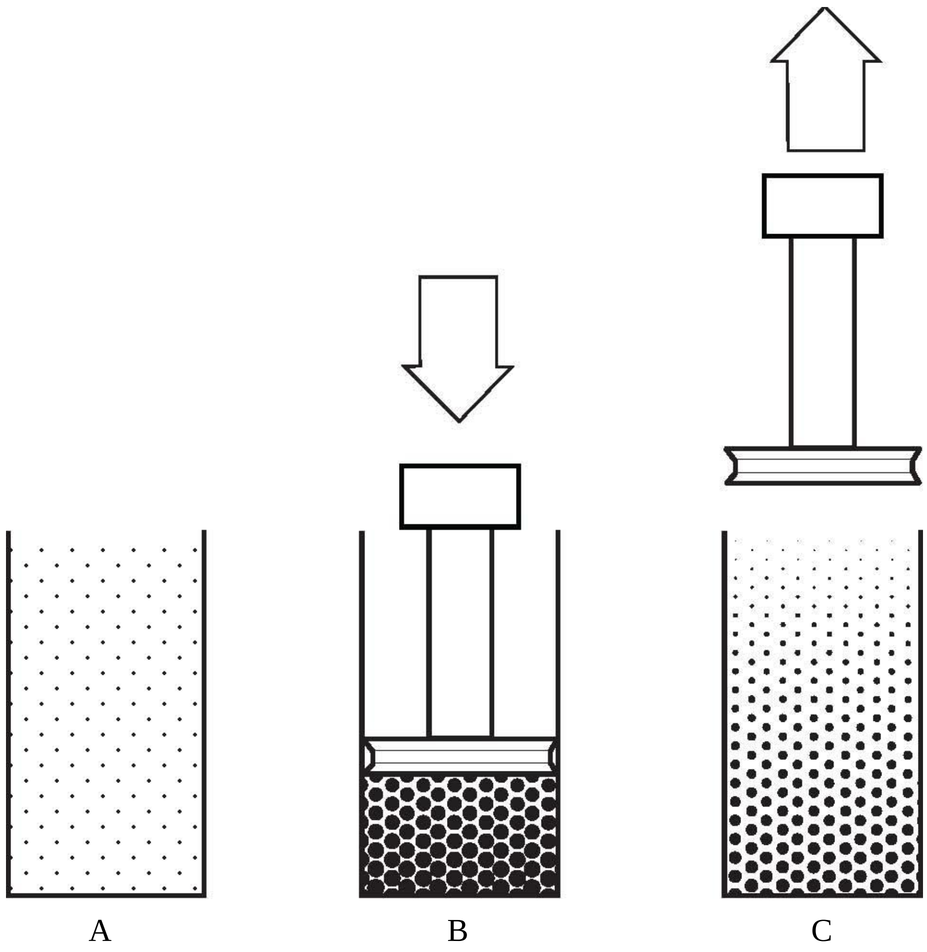


Figure 3.1: Pressure produced by compressed air

3.3 Basic Components of a Pneumatic System

Pumps, cylinders, and valves are the basic components of any pneumatic system. Even though industry uses a much larger variety of components, most operations can be performed with just these three basic components. These three components are discussed in this module.

3.3.1 The Pump

Figure 3.2 shows the main parts of a pneumatic pump.

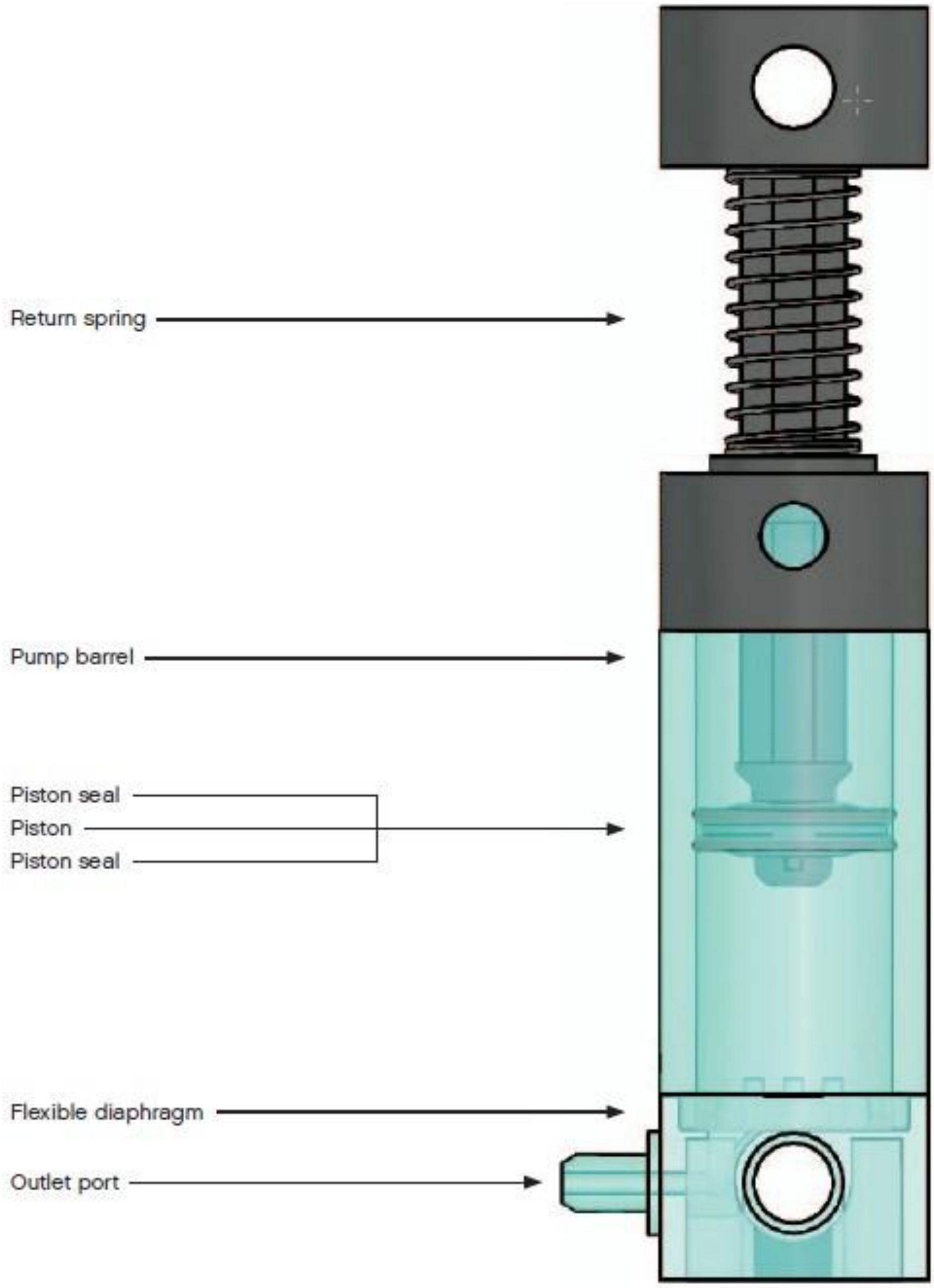


Figure 3.2: Main parts of a pneumatic pump

The pump is used to compress air. To control the airflow inside the pump a specially designed piston and a flexible diaphragm are used.

On the down stroke, the seal of the pump’s piston becomes airtight. The compressed air bends the flexible diaphragm allowing air to flow through to the outlet port.

On the return stroke the piston seal allows air to flow past the piston and back into the barrel of the pump. At the same time, the flexible diaphragm snaps back into place and stops any compressed air from flowing back into the pump barrel (Figure 3.3).

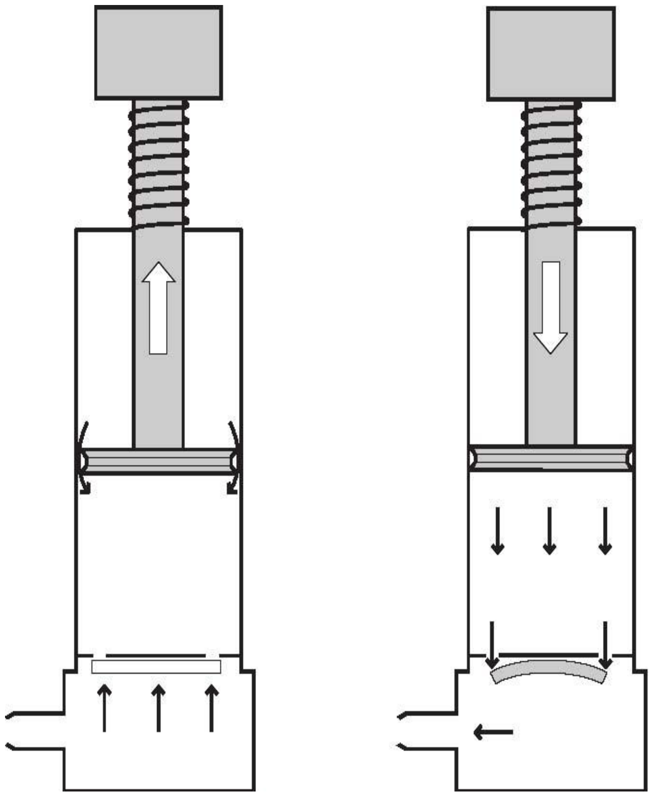


Figure 3.3: Pneumatic pump principle of operation

3.3.2 The Cylinder

Figure 3.4 shows the main parts of a pneumatic cylinder.

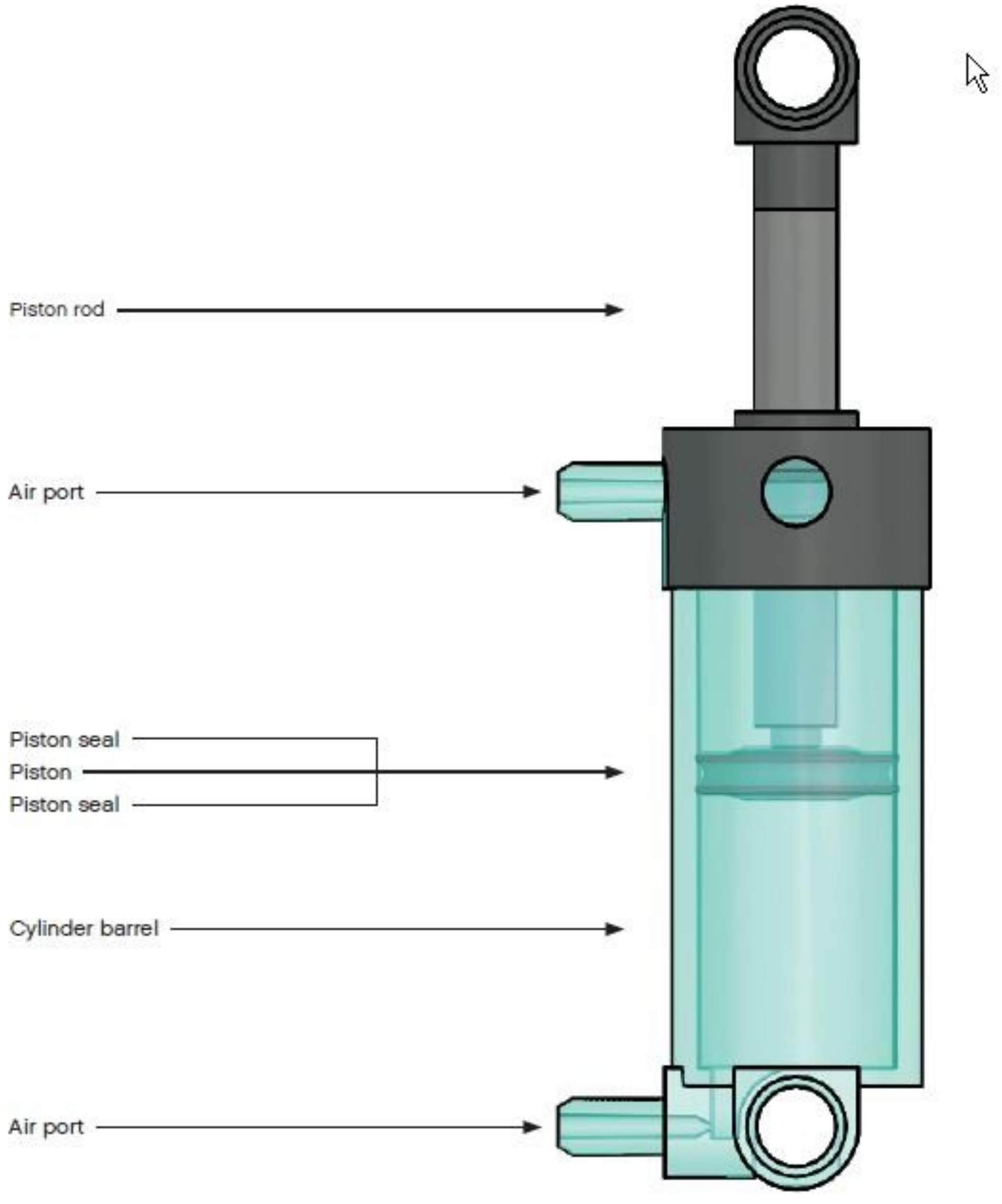


Figure 3.4: Main parts of a pneumatic cylinder

The pneumatic cylinder works by converting the force of expanding air (potential energy) into movement (kinetic energy). When air enters the cylinder, the force of the expanding air will either force the piston up or down, depending on which air port the air has entered from (Figure 3.5).

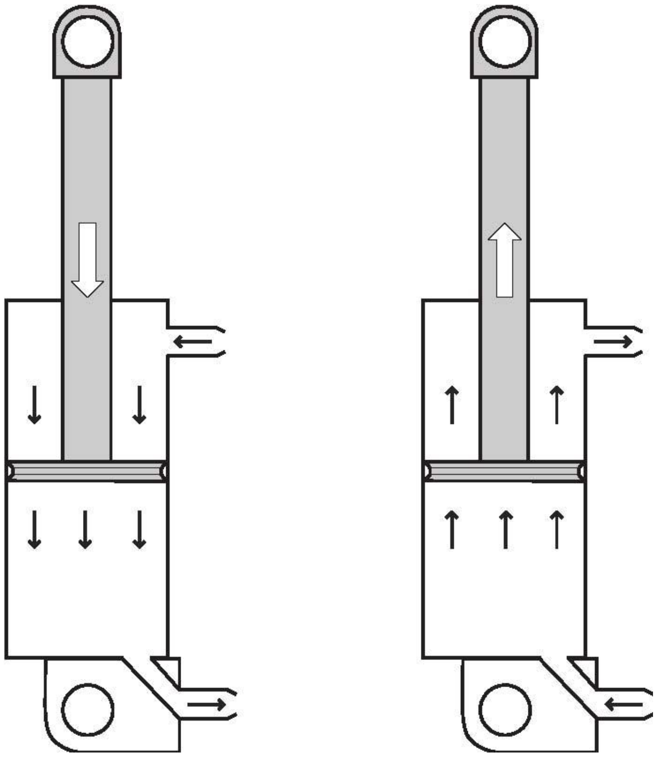


Figure 3.5: Pneumatic cylinder principle of operation

3.3.3 The Three-Position Valve

Figure 3.6 shows the construction of a three-position pneumatic valve. The valve receives compressed air from the pump or tank through the inlet port. The valve directs the airflow through one of the two outlet ports to other pneumatic elements or simply stops the airflow. The rubber valve seal has a specially designed chamber to direct air from the inlet port to one of the two outlet ports. The outlet port that is not being used for compressed air is automatically opened, allowing air from a cylinder to escape.

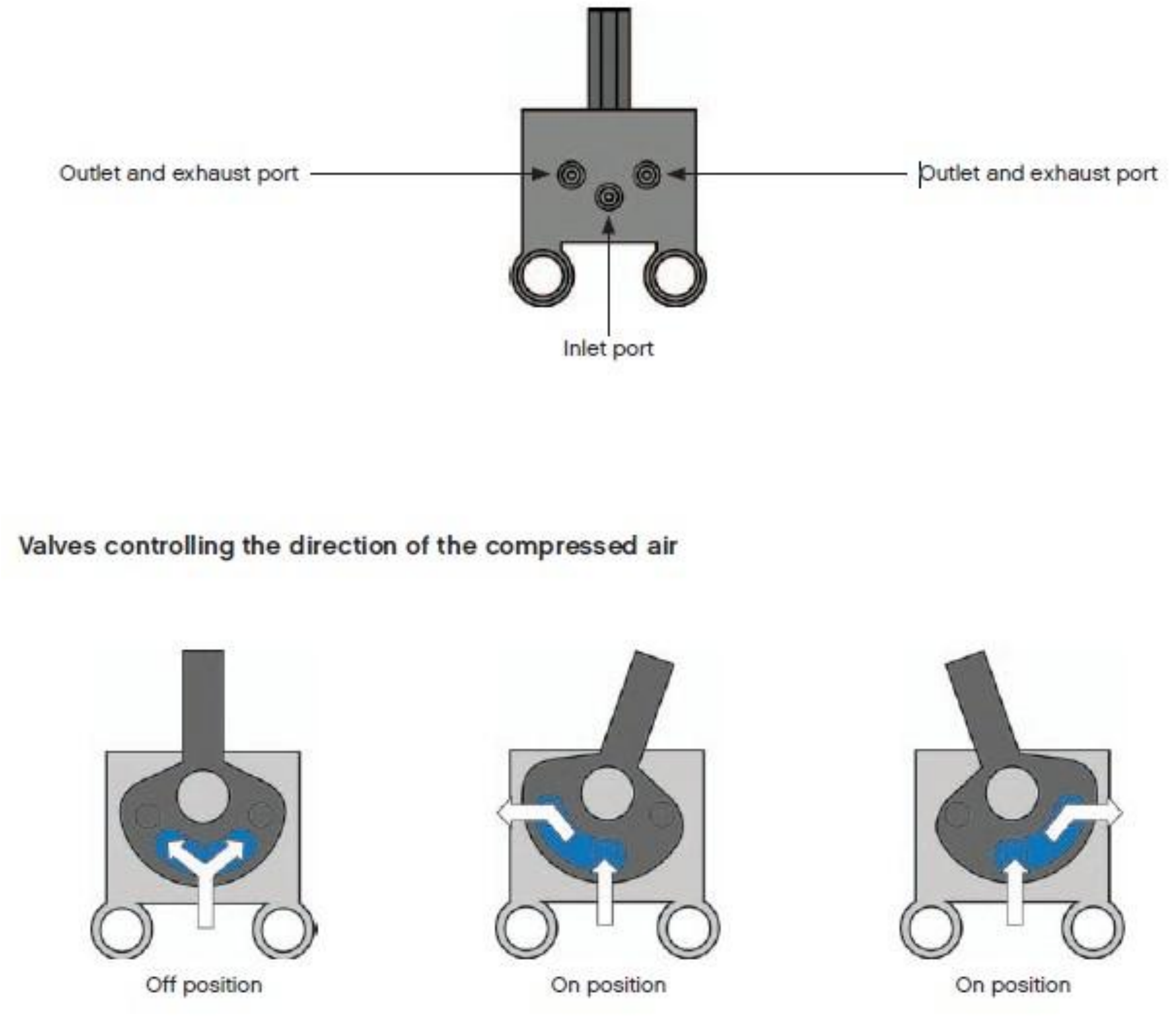


Figure 3.6: Three position pneumatic valve

3.4 Practical Activity 1

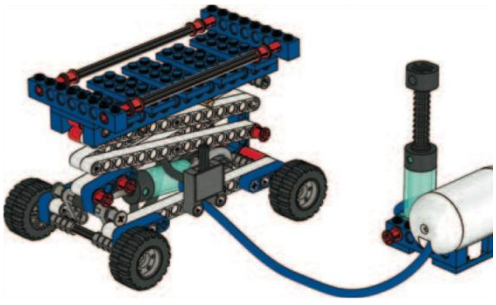
Objective: Using pneumatic cylinder and pump, build the Scissor Lift and investigate how their functions are influenced by weight and height.

Background information:

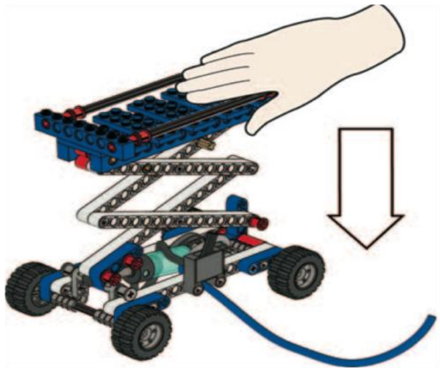
Scissor lifts are designed for easy and safe access to elevated positions and are often used where ladders are not an option. A scissor lift's work platform provides space for tools and movement, and can lift a heavy load.

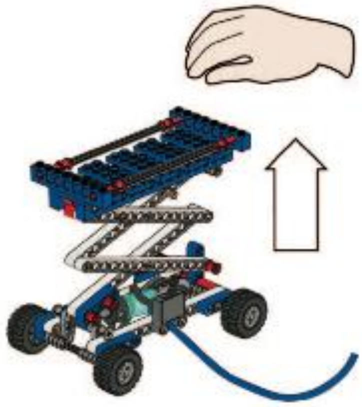
Procedure:

1. Follow *Scissor Lift building instructions* and build the Scissor Lift (All of book 1A and book 1B to page 11, step 15).
2. Pump air into the system and make sure the Scissor Lift raises smoothly



3. Press down on the platform of the raised Scissor Lift
4. When you let go, the platform should bounce back up again. If not, check for air leaks.





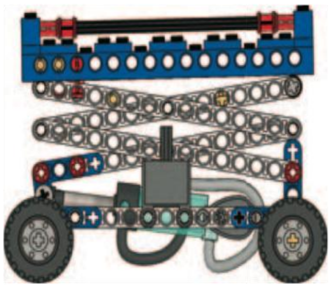
5. Then lower the Scissor Lift and empty the air tank

Hint: The easiest way to empty the air tank is to disconnect the tube going from the air tank to the valve.

6. Test how many pumps are needed to raise Scissor Lift A to its maximum height.
7. Add the manometer (an instrument for measuring pressure) and find out how much pressure is needed to raise Scissor Lift A to its maximum height.

Scissor Lift A

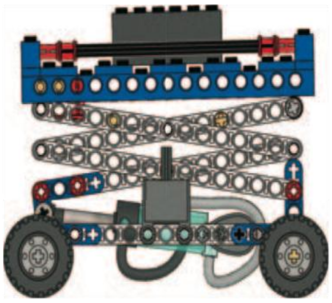
A



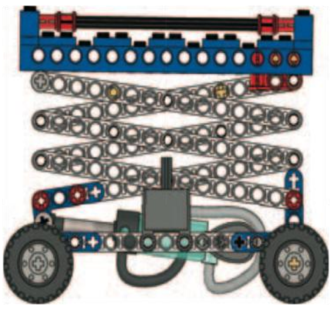
8. Follow the same procedure for Scissor Lifts B, C and D
9. Test several times to make sure your results are consistent.

Scissor Lift B

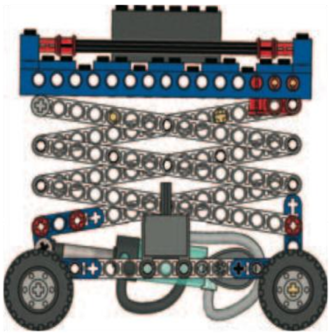
B



C



D



Observation:

Scissor Lift No.	Number of pumps required to reach maximum height	Pressure (bar)
A		
B		
C		
D		

1. Write a brief note about your findings.

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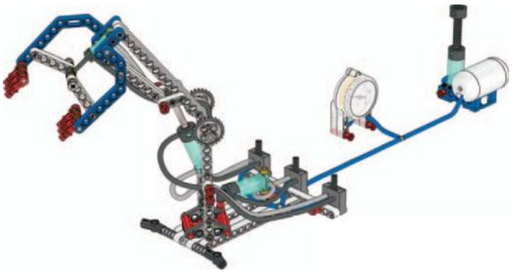
3.4 Practical Activity 2

Objective: To Build the Robot Arm and investigate how to make the most energy efficient sequence of strokes using pneumatic three-position valves.

Background information:

Robotic arms are used for jobs that involve picking up, moving, and placing objects. Usually they do jobs that are difficult or repetitive, and need to be done quickly and efficiently. To achieve maximum efficiency, the picking and placing sequence needs to be decided beforehand.

Procedure:



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1. Build the Robot Arm (All of book 4A and book 4B to page 19, step 19).
2. Pump air into the system and use the manometer to detect whether there is an air leak.
3. Try all valve settings and check all moving parts to ensure that they move freely.
4. Turn the arm to its resting position: turned to the far right, arm up, grippers open. Then, empty the air tank.

What is the most energy efficient sequence?

Find out which sequence is the most energy efficient for picking and placing objects.

5. First, predict which sequence of strokes is the most energy efficient at picking and placing a piece of paper. Your sequence must start in the resting

position, use all six movements at least once, and then return to the resting position.

6. Test your sequence of strokes and note the loss of pressure after each stroke. Start with about 36 PSI (or 2.5 bars of pressure).
7. Test several times to make sure your results are consistent. *Record your findings on graph paper.*
8. Change the sequence of strokes. Test your new sequence to determine if it is more or less efficient.

Stroke	My sequence
A	
B	
C	
D	
E	
F	
G	
H	

9. Write a brief note about your findings.

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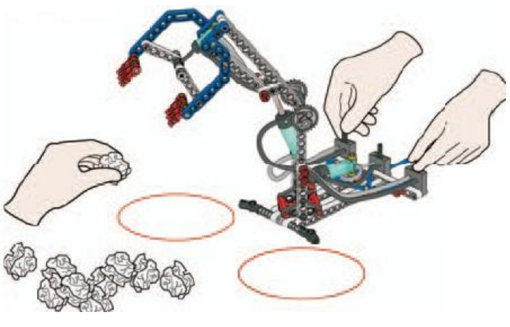
How good are you at operating the robot?

Find out how quickly and accurately you can pick and place pieces of paper from one circle to another circle.

Procedure:



1. First, predict how many pieces of paper you can accurately place inside the circle within 30 seconds.
2. Then, test how many pieces of paper you can accurately place inside the circle within 30 seconds.

3. Repeat the test three times to see if your speed and accuracy improve. Note down your results in the table below.

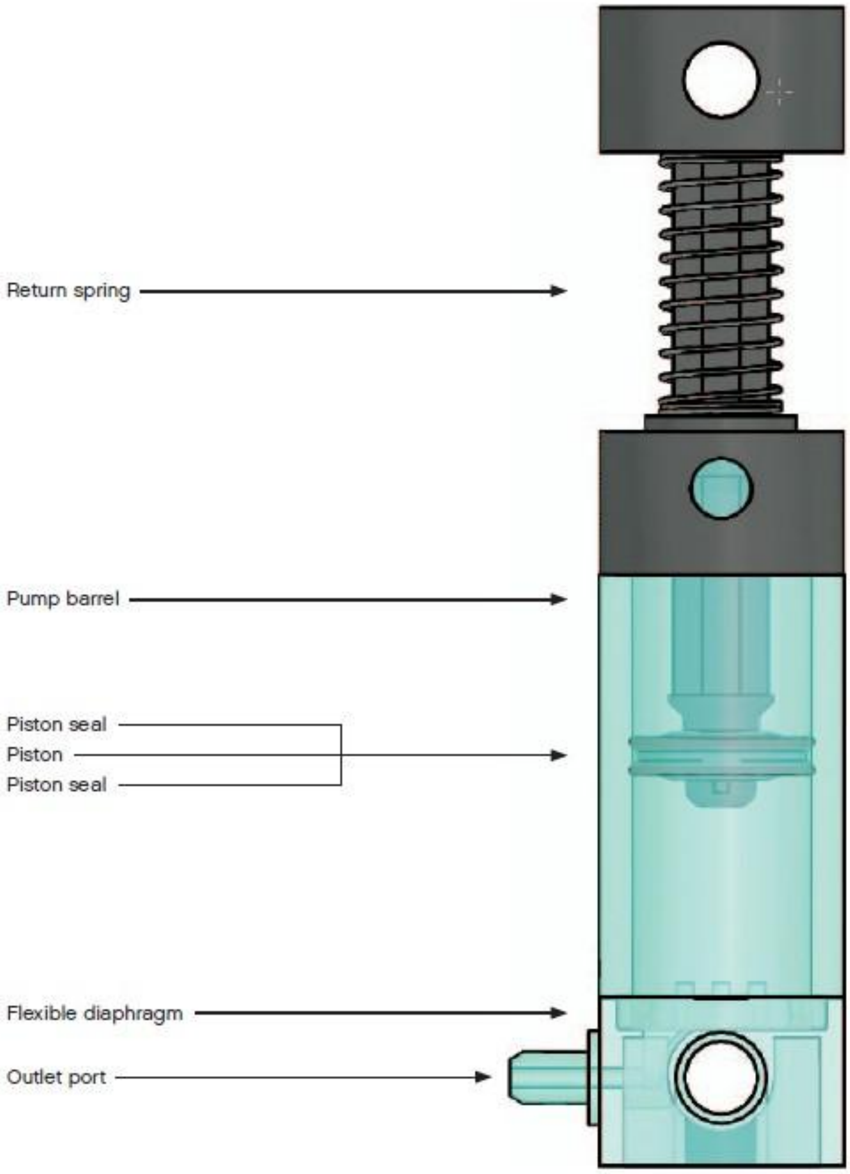
	My prediction	My findings
Test 1		
Test 2		
Test 3		

3.5 Exercises

1. Define a pneumatic system, and briefly describe its principle of operation.

2. State the main components of a pneumatic system.

3. Referring to the picture of a pneumatic pump given below, describe the principle of operation of the pump.


Return spring
Pump barrel
Piston seal
Piston
Piston seal
Flexible diaphragm
Outlet port