

H Y D R A U L I C S

&

P N E M A T I C S

Overall Expectation(s): 3. Demonstrate an understanding of different types of systems and the factors that contribute to their safe and efficient operation. (8s20); 2. Investigate a working system and the ways in which components of the system contribute to its desired function (8s19).

Structures and Mechanisms – Systems in Action – Hydraulics –

Activity 1: Students will conduct an experiment using syringes of equal size and a four way valve to demonstrate how external forces applied to an enclosed system are transferred equally in all directions (Pascal's Law).

Activity 2:

Using a 20 mL syringe, tubing and a 5 mL syringe, students will measure the distance a syringe's piston moves as a result of a force and mathematically relate this to area and pressure produced in a hydraulic system.

1. Have students fill four, 5 mL syringes with water to their 3mL lines. Connect these four syringes to a 4-way valve as shown in Figure 1 (BLM 5.1). Label the syringes A, B, C & D.
2. Slide the piston on syringe A in 2 mL to the 1 mL line. Have the students record the direction of movement of the pistons in of B, C & D and not the volume of water which moves into B, C, & D using BLM 5.1b.
3. Pull A back to the 3 mL line and again record the direction the pistons move and any change in the volume of water in B, C & D using BLM 5.1b.
4. Have the students repeat the same procedure using the other three syringes. Compare the results.
5. Discuss the results of this activity with the students to explain how external forces applied to an enclosed system are transferred equally in all directions (Pascal's Law). Have students complete the questions on BLM 5.1b including a written explanation of Pascal's Law

Activity 2

1. Have the students fit a short piece of rubber tubing to a 5 mL syringe and completely fill both with water, being sure that no air is trapped. Connect this to a 20 mL syringe with the plunger or piston fully pushed in as shown in Figure 2 (BLM 5.1).
2. Transfer 5 mL of water from the small syringe to the larger 20 mL syringe being sure to measure the distance (in centimetres) that each plunger or piston moves. In table BLM 5.2, record: the distance each piston moves.
3. Have the students transfer the water back to the 5 mL syringe and note which plunger was easier to move. Record the distance each piston moves.
4. Introduce Pascal's Law: "The pressure put on an enclosed system is transmitted in all directions without loss and it acts with equal pressure or intensity upon equal surfaces." Discuss this principle with respect to what they have just done.
5. Calculate the surface area by dividing the distance moved by the 5 mL plunger by the distance moved by the 20 mL plunger (e.g., $5 \text{ cm} \div 2 \text{ cm} = 2 \frac{1}{2}$ which means the surface area of the 20 mL syringe is $2 \frac{1}{2}$ larger than the surface area of the 5 mL syringe). The relationship for pressure, force and surface area of the end of the plunger is: **Pressure = Force / Area**

Since Pascal's Law states that the pressure in both cylinders is the same, if you ignore the effects of friction, then the force produced by the 5 mL syringe on the 20 mL syringe is $2\frac{1}{2}$ times greater than the force produced by the 20 mL syringe on the 5mL syringe.

Structures and Mechanisms – Systems in Action –Pneumatics –

Activity 3: Students will investigate the advantages and disadvantages of using hydraulic versus pneumatic systems.

Activity 3

1. Take two 20 mL syringes and join them together using a short (5 cm) piece of tubing, as shown in Figure 3 (BLM 5.1). Make sure the plunger or piston of syringe #1 is pulled out before you connect the tubing.
2. Ask the students to predict what will happen when you attempt to push the plunger of #1 in. Try it. Did it behave as predicted? Describe what happened.
3. Now push the piston of syringe #2 back in. Does the piston on syringe #1 return to its original position?
4. Pull the plunger of #2 back out and record what happens to piston or plunger #1.
5. Push the plunger of #1 and #2 in at the same time. Describe what happens.
6. Disconnect syringe #1, and depress the piston in each syringe fully, then reconnect them.
7. Try pulling the plunger of #1 out. Then let go. Describe what happens. Can you explain what happens?
8. Repeat the above steps, but use water instead of air.
9. Pose the question: Would using a longer piece of tubing (50 cm) make a difference?

SubTask 5 - Pneumatic Forces (BLM 5.1)

Figure 1

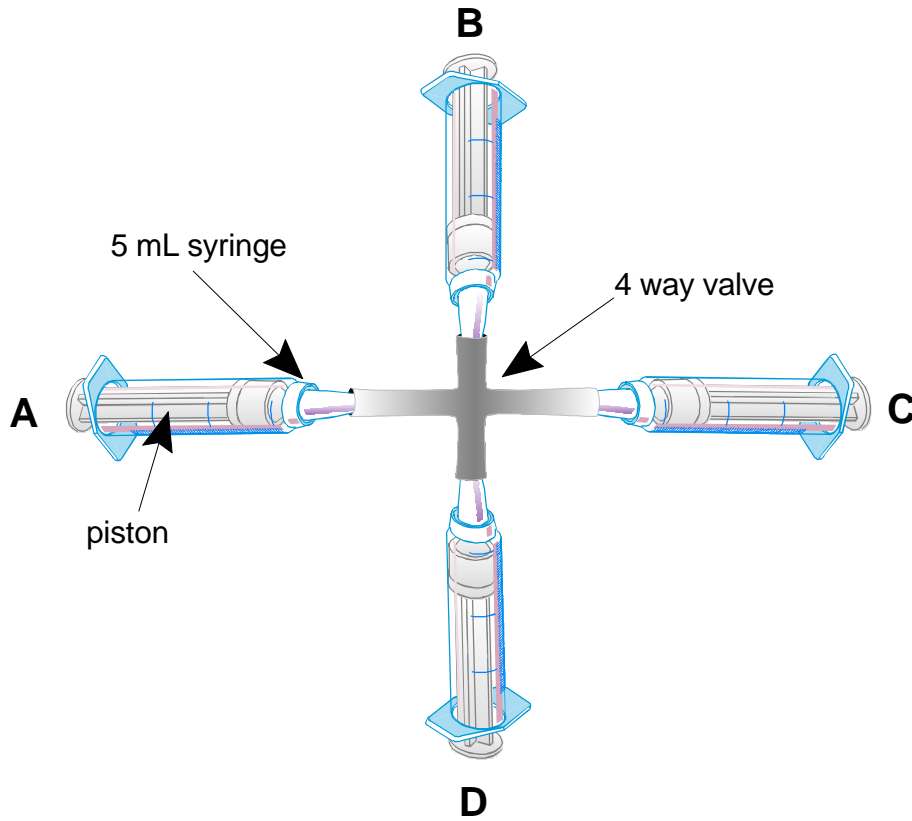
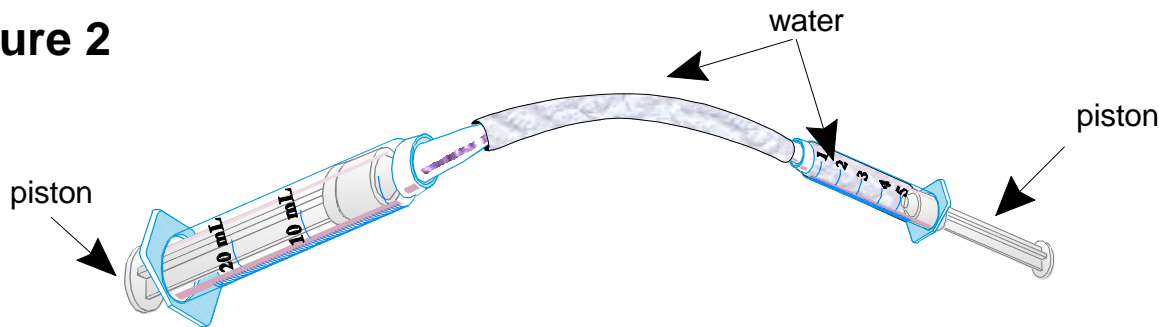
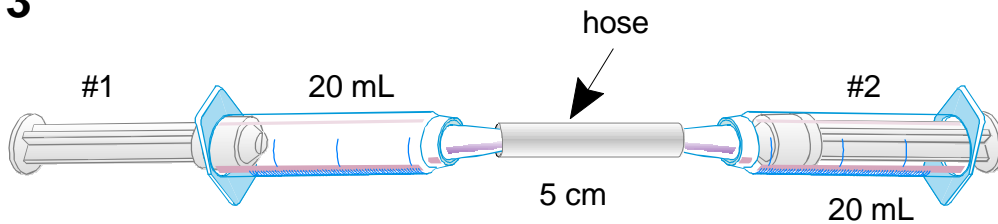


Figure 2



Activity 3



BLM 5.1b**TRANSFERRING OF FORCES**

I. Complete the following table when syringe A moves to the 1mL line.

SYRINGE	DIRECTION OF MOVEMENT	AMOUNT OF VOLUME MOVEMENT
A		
B		
C		

II. Complete the following table when syringe A moves back to the 3mL line.

SYRINGE	DIRECTION OF MOVEMENT	AMOUNT OF VOLUME MOVEMENT
A		
B		
C		

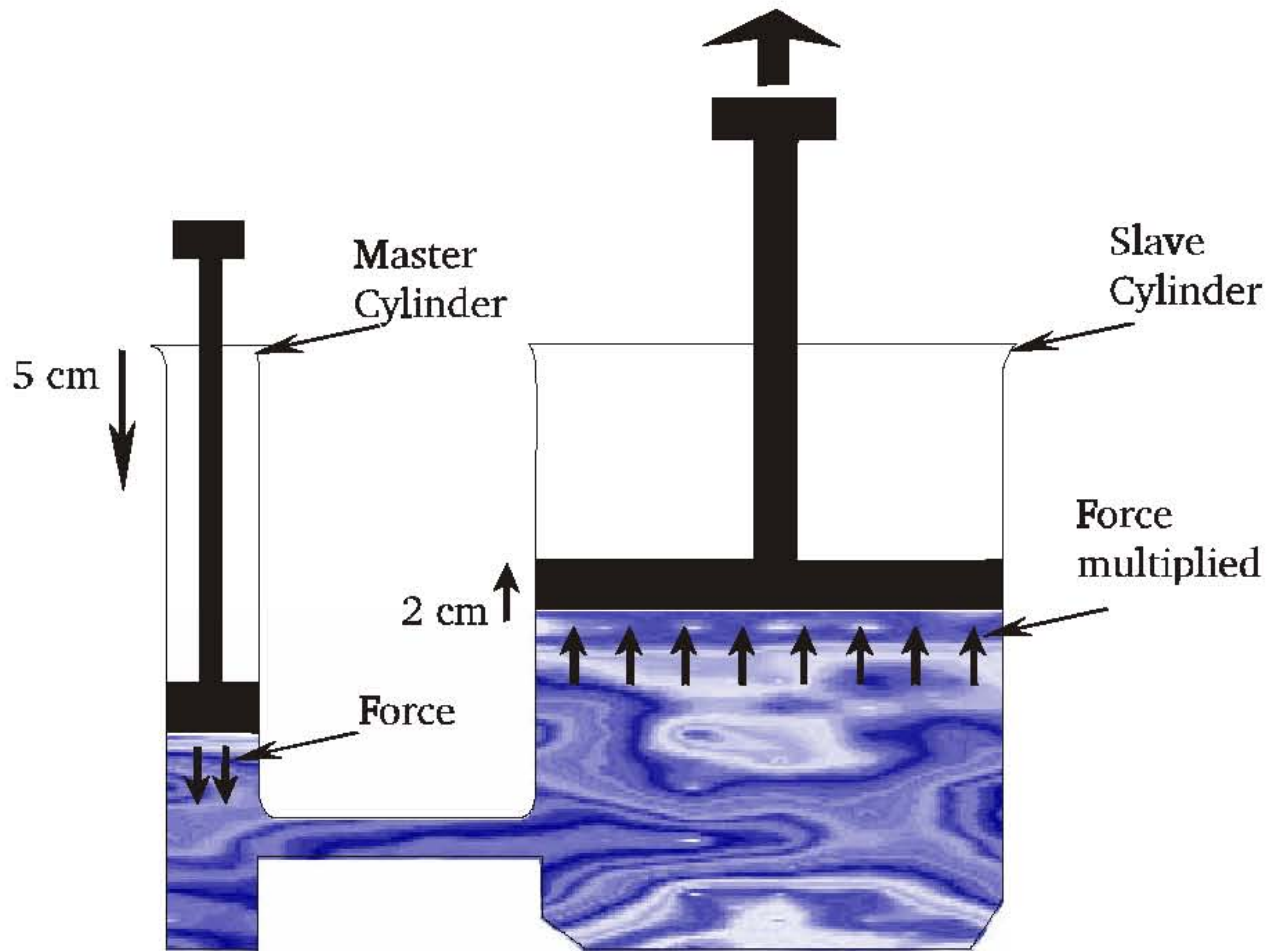
1. What happened when you repeated the same procedure (I. & II.) as above substituting the other syringes in place of Syringe A?
2. What did you learn about the movement of the syringes?
3. In your own words, explain **PASCAL'S LAW**.

BLM 5.2
Table 1

TRANSFERRING FLUIDS AND DISTANCE PISTON MOVED

Syringe Size	Distance Moved by Piston (cm)	example
5 mL		e.g. 5 cm
20 mL		e.g. 2 cm

BLM 5.3



“ Principle of the Hydraulic Press ”