Important Concepts . . .

Preview Review

Science *Grade 8* *TEACHER KEY*

W1 - Lesson 5: Hydraulics and Pneumatics

V5-07

Important Concepts of Grade 8 Science

W1 - Lesson 1 ..... Mass, Volume, and Density
W1 - Lesson 2 ..... Solubility and Saturation Points
W1 - Lesson 3A..... Viscosity, Flow Rate, and Buoyancy
W1 - Lesson 3B..... Simple Machines
W1 - Lesson 4 .....Gears, Mechanical Advantage, Speed Ratios, and Efficiency
W1 - Lesson 5 .....Hydraulics and Pneumatics
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W3 - Lesson 4 ..... Adaptations to Aquatic Ecosystems
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Materials Required

Textbook:
Science in Action 8

Science Grade 8
Version 5
Preview/Review W1 - Lesson 5 TEACHER KEY

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Preview/Review Concepts for Grade Eight Science

TEACHER KEY

W1 - Lesson 5:
Hydraulics and Pneumatics

OBJECTIVES

By the end of this lesson, you should

- describe and identify hydraulic and pneumatic systems
- calculate force and pressure at various locations in hydraulic and pneumatic systems
- explain Pascal's law
- calculate mechanical advantage in hydraulic systems

GLOSSARY

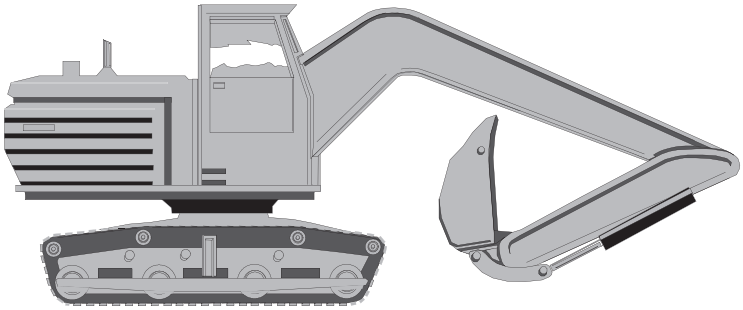
hydraulics - system using confined, pressurized liquids to move loads

pneumatics - system using pressurized gas to move loads

pressure - force applied over a given area

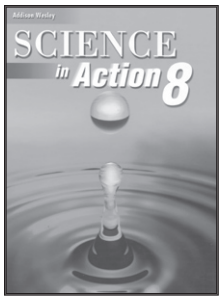
W1 - Lesson 5: Hydraulics and Pneumatics

Welcome to W1 - Lesson 5. This lesson is designed to teach you about hydraulics and pneumatics; it should take about 60 minutes to complete. At the end of this lesson, you will have a short quiz on the material you covered this week.



Hydraulics and Pneumatics

You have probably heard of **hydraulics** and **pneumatics**. What are they? Very simply, they are systems that use confined fluids under pressure to move loads. A hydraulic system uses an incompressible liquid; a pneumatic system uses a compressed gas. Both hydraulics and pneumatics are based on the same principles, and reduce the amount of force needed to move a load.



Activity 1

Read and understand pages 293 to 294 in *Science in Action 8*. Then, answer the following questions.

1. Name some places that hydraulics are used to move loads.

   Answers will vary.

   Some examples are brakes and front end loaders.

2. Name some places that pneumatics are used.

   Answers will vary.

   Some examples are dentist drills and jackhammers.

Pressure

To understand how hydraulics and pneumatics work, you must understand the concept of **pressure**. Pressure is a measure of the amount of force applied to a given area and can be calculated with the formula

$p = F/A$
where p is pressure
F is force usually in newtons
A is area

If area is measured in cm^2, the unit of pressure is N/cm^2. If area is measured in m^2, the unit would be N / m^2 or pascals (Pa).

This equation can be rearranged as $F = pA$ and $A = F/p$

For example, if a force of 60 N is applied to a platform 2 m^2, we could calculate the pressure on that surface as follows.

$$p = \frac{F}{A}$$
$$= \frac{60\ N}{2\ m^2}$$
$$= 30\ N/m^2$$
$$= 30\ Pa$$

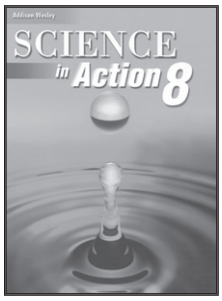
In a **confined fluid**, pressure is transmitted **equally** in all directions. This is called **Pascal's Law**. The pressure applies force to every surface it comes into contact with. Each cm^2 receives the same force. If it applies 1 N of force on a cm^2, it applies 1 N of force to every cm^2 of surface area it contacts.

If a force of 15 N is applied to a 5 cm^2 area in a hydraulic system, what amount of force is transmitted to an area 30 cm^2 in size?

$$= \frac{F}{cm^2}$$
$$= \frac{15\ N}{5\ cm^2}$$
$$= 3\ N/cm^2$$

The total force applied to 30 cm^2 =

$$30\ cm^2 \times \frac{3N}{cm^2} = \quad 90\ N$$



OR you might notice that 30 cm^2 = 6 times as large as the initial area and simply multiply the first force by 6 to get the answer.

Activity 2

Read and understand page 299 in *Science in Action 8*. Then, answer the following questions.

1. If the pressure at one spot in a hydraulic or pneumatic system is 50 Pa, what is the **pressure** at any other spot in the system?

   50 Pa

2. If a hydraulic piston with an area 2 cm^2 is pushed with a force of 50 N, how much **pressure** is created in the liquid?

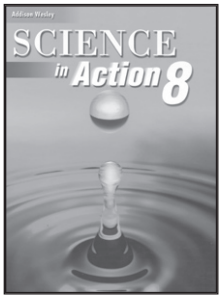
P = F/A = 50 N / 2 cm^2 = 25 N / cm^2

3. If 20 N of force is applied to 2 cm^2 in a hydraulic or pneumatic system, how much **force** is transmitted to 10 cm^2?

20 N / 2 cm^2 x 10 cm^2 = 100 N

Pistons

Hydraulic systems use a combination of two different-sized pistons attached to the ends of a cylinder or flexible pipe. The smaller **input piston** is where external force is applied to the fluid to create pressure. The larger **output piston** is where the fluid pressure applies force, and where the load is positioned.



Activity 3

Read and understand page 295 in *Science in Action 8*. Then, answer the following questions.

1. If there are 100 Pa of pressure in a hydraulic system, what force would be found at the output piston with a surface area of 0.5m^2?

P = F/A F = PA = 100 Pa x 0.5 m^2 = 50 N

2. A jack has a 1 cm^2 input piston where 250 N force is applied. What weight object could be lifted on the 10 cm^2 output piston?

250 N / cm^2 x 10 cm^2 = 2500 N

3. Do you get any mechanical advantage if you put the load on the small piston and apply force to the large piston?

No

Mechanical Advantage in Hydraulic Systems

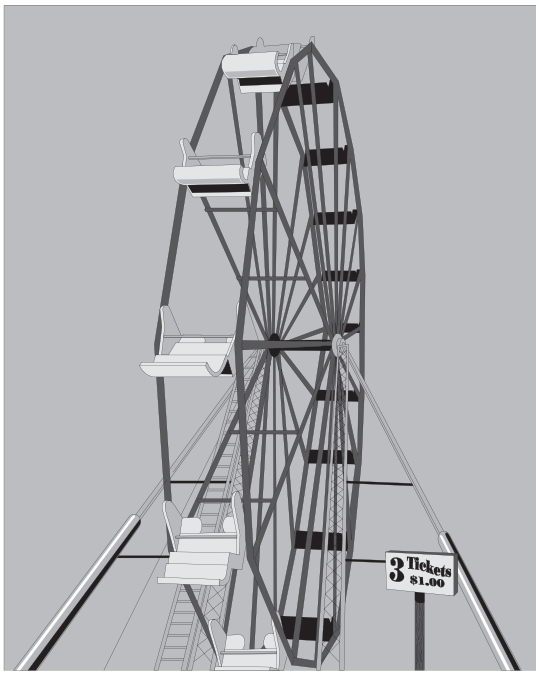
Hydraulics and pneumatics are used to gain mechanical advantage. As with simple machines, the formula for Mechanical Advantge is

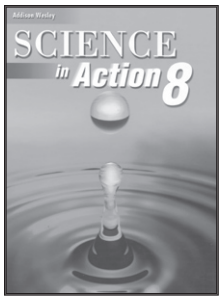
MA = Output force/Input force

For example, in a hydraulic system, if the force input is 20 Newtons and the force output is 600 Newtons, then

$$MA = \frac{600\ N}{20\ N}$$
$$= 30$$

Therefore, you would be getting out 30 times more force than you are putting into the system.





Activity 4

Read and understand pages 298 to 300 in *Science in Action 8*. Then, answer the following questions.

1. A hydraulic hoist at "Pete's Garage" can lift a 2000 kg vehicle. It takes one newton to lift 100 g. How many newtons are required to lift this vehicle?

$$2000\ kg \rightarrow 2\ 000\ 000\ g$$

$$= \frac{2\ 000\ 000\ g}{2000\ kg}$$

$$= 20\ 000\ N$$

2. The fluid compressor on the hoist (input force) provides 1500 Newtons of force on the hydraulic fluid and the 2000 kg car is lifted. Calculate the mechanical advantage. (Uses newtons calculated from question 1.)

$$Input = 1\ 500\ N \qquad Output = 20\ 000\ N$$

$$MA = \frac{Output}{Input}$$

$$= \frac{20\ 000\ N}{1\ 500\ N}$$

$$= 13.3$$

3. As the mechanical advantage of a hydraulic jack increases, what happens to the distance the input piston has to move?

It increases.

4. Why can hydraulic systems provide a large mechanical advantage?

Because fluids transmit pressure equally; the greater the difference in area between the input and output piston, the greater the mechanical advantage.

Take some time to review the material you learned this week. You will be writing a short quiz before you go home.