Lesson A1–5

# Describing Basic Physical Science Laws Applied in Agricultural Mechanics

**Unit A.** Mechanical Systems and Technology

**Problem Area 1.** Introduction to Agricultural Mechanics and Technology Systems

**Lesson 5.** Describing Basic Physical Science Laws Applied in Agricultural Mechanics

## New Mexico Content Standard:

***Pathway Strand:*** Power, Structural and Technical Systems

***Standard:*** **I:** Apply physical science principles to engineering applications with mechanical equipment, structures, biological systems, land treatment, power utilization, and technology.

***Benchmark:*** **I-A:** Relate power generation to energy sources.

***Performance Standard:*** **6.** Discuss efficiency of systems (e.g., fuel cells, chemical, wind, hydro, nuclear, electric, mechanical, solar, biological).

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

1. Explain how Boyle's Law relates to agricultural mechanics.
2. Explain how the Law of Conservation of Energy relates to agricultural mechanics.
3. Explain how Ohm's Law relates to agricultural mechanics.
4. Explain how Pascal's Law relates to agricultural mechanics.

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

***Recommended Resources.*** One of the following resources should be selected to accompany the lesson:

Buriak, Philip, and Edward W. Osborne. *Physical Science Applications in Agriculture.* Danville, Illinois: Interstate Publishers, Inc., 1996. (Textbook, Chapters 16, 17, and 18)

Cooper, Elmer L. *Agricultural Mechanics Fundamentals & Applications.* Albany, New York: Delmar Publishers, 1997. (Textbook and Lab Manual, Units 31 and 37)

***Other Resources.*** The following resources will be useful to students and teachers:

Burke, Stanley R., and T.J. Wakeman. *Modern Agricultural Mechanics.* Danville, Illinois: Interstate Publishers, Inc., 1992. (Textbook)

Johnson, Donald M., et. al. *Mechanical Technology in Agriculture.* Danville, Illinois: Interstate Publishers, Inc., 1998. (Textbook, Chapters 2 and 13)

## List of Equipment, Tools, Supplies, and Facilities

Writing surface
Overhead projector
Transparencies from attached masters

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

Amperes
Robert Boyle
Boyle's Law
Compression ratio
Electrons
Horsepower
Law of Conservation of Energy
Molecules
Ohm's Law
Blaise Pascal
Pascal's Law
Resistance
Torque
Voltage

**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:

*Begin by having students read sections from the recommended references. After doing so, call on various students to summarize the material they read. Ask your students "What are some laws of science that you are familiar with?" (ex. Law of Gravity) Discuss how an idea or theory becomes a law. Tie in the student learning objectives with the discussion.*

# Summary of Content and Teaching Strategies

## Objective 1: Explain how Boyle's Law relates to agricultural mechanics.

***Anticipated Problem:*** What is Boyle's Law and how does it relate to agricultural mechanics?

I. ***Robert Boyle***, an English scientist, discovered in 1662 that the pressure a gas exerts can be increased by reducing its volume while holding temperature constant. This is possible because all matter, including gases, is made up of tiny particles called ***molecules***. Boyle was able to develop a theory, which was later proven to be a law. That law is called Boyle's Law.

   A. ***Boyle's Law*** states that the product of pressure times volume in a gas at constant temperature is a constant. This means that when the volume of gas is decreased, the gas molecules bombard the container walls more frequently. The result is an increase in pressure against the walls of the container. The volume of a gas is inversely proportional to the pressure applied to the gas. That means that pressure increases at the same rate that volume decreases. Boyle's Law is expressed in the formula $P_1 \times V_1 = P_2 \times V_2$ where $P_1$ = original pressure of a gas; $V_1$ = original volume of a gas; $P_2$ = pressure of a gas under new conditions; $V_2$ = volume of a gas under new conditions. Boyle's Law explains pressure-volume relationships for both decreasing and increasing volumes. One way this law is related to agricultural mechanics is in internal combustion engines.

   B. In internal combustion engines, the ***compression ratio*** is the volume of air in a cylinder before compression compared to the volume of air in the cylinder after compression. This law provides an explanation on why diesel engines are more powerful than gasoline engines. Diesel engines normally have a compression ratio of 16 to 1 or higher, while a gasoline engine's ratio is normally 8 to 1. The higher ratio equates to more power.

*There are many techniques that can be used to assist students in mastering this material. Students need text material to aid in understanding Boyle's Law and how it relates to agricultural mechanics. Chapter 17 of Physical Science Applications in Agriculture is recommended. Use TM: A1–5A to aid in student discussion on this topic.*

**Objective 2:** Explain how the Law of Conservation of Energy relates to agricultural mechanics.

***Anticipated Problem:*** What is the Law of Conservation of Energy and how does it relate to agricultural mechanics?

II. Physical science laws govern much of what agricultural mechanics is able to do with machines. One such law is the Law of Conservation of Energy. The ***Law of Conservation of Energy*** states that energy cannot be created nor destroyed. This tells us that energy output of a system cannot exceed the energy input to the system. This law of science is most evident in dealing with power transmission systems. Most applications of power begin with the rotating of shafts. The amount of work being done by rotating shafts can be measured. The unit used to do such measurement is called horsepower. ***Horsepower*** is defined as the force needed to lift 550 pounds, one foot high, in one second. The horsepower of most applications is finite. Therefore, tradeoffs must be made between ***torque*** (a turning or twisting force) and speed. The Law of Conservation of Energy governs these tradeoffs.

*There are many techniques that can be used to assist students in mastering this material. Students need text material to aid in understanding the Law of Conservation of Energy and how it relates to agricultural mechanics. Chapter 18 of Physical Science Applications in Agriculture is recommended.*

**Objective 3:** Explain how Ohm's Law relates to agricultural mechanics.

***Anticipated Problem:*** What is Ohm's Law and how does it relate to agricultural mechanics?

III. The flow of ***electrons*** (charged particles) through a conductor, provides the energy needed to power many machines in agriculture and elsewhere. An energy source provides the push needed to move these electrons through the conductor. This movement of electrons is called ***voltage.*** Voltage may be compared to the available water that can flow through a garden hose. ***Amperes*** is a measure of the rate at which electrons move through the conductor. In the garden hose example, amperage may be compared to the rate at which water actually flows through the hose. The amount of energy needed to push the electrons through the conductor is dependent on the conductor's ***resistance*** or opposition to flow. This resistance is measured in ohms. ***Ohm's Law***, first proposed by G.S. Ohm, a German scientist, states that the amount of current in an electrical circuit is directly proportional to the voltage applied across the circuit and inversely proportional to the resistance of the circuit. This means that as voltage increases, the flow of current (amps) increases. But, as resistance (ohms) increases, the current flow (amps) decreases. Ohm's Law is expressed in the following formula: $E = I \times R$ where E = Voltage; I = Current (measured in amperes); R = Resistance (measured in ohms).

*There are many techniques that can be used to assist students in mastering this material. Students need text material to aid in understanding Ohm's Law and how it relates to agricultural mechanics. Chapter 16 of Physical Science Applications in Agriculture is recommended. Use TM: A1–5B to aid in student discussion.*

**Objective 4:** Explain how Pascal's Law relates to agricultural mechanics.

***Anticipated Problem:*** What is Pascal's Law and how does it relate to agricultural mechanics?

IV. In 1653, ***Blaise Pascal***, a French scientist formulated the fundamental law that explains the operation of hydraulic equipment. ***Pascal's Law*** states that pressure applied to a confined fluid is transmitted undiminished in all directions, acts with equal force on equal areas, and acts at right angles to the walls of the container. An example of this law can be seen by using a container of liquid. A 10-lb force applied to the stopper (having an area of 1 $in^2$) will result in a pressure of 10 lbs per $in^2$ being exerted by the fluid.

*There are many techniques that can be used to assist students in mastering this material. Students need text material to aid in understanding Pascal's Law and how it relates to agricultural mechanics. Chapter 13 of Mechanical Technology in Agriculture is recommended. Use TM: A1–5C to aid in student discussion.*

**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. Questions at the end of the chapters in the textbook may also be used in the review/summary.

**Application.** Application can involve the following student activities.

Fluid Power Transmission experiment in Chapter 18 of *Physical Science Applications in Agriculture.*

**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 activity. A sample written test is attached.

## Answers to Sample Test:

### *Part One: Matching*

1=g, 2=h, 3=i, 4=f, 5=b, 6=c, 7=d, 8=a, 9=j, 10=e

### *Part Two: Completion*

1. increases
2. horsepower
3. volume

### *Part Three: Short Answer*

1. 2.7 amps
2. 10 ohms

**Sample Test** Name_____

# Test

## Lesson A1–5: Describing Basic Physical Science Laws Applied in Agricultural Mechanics

***Part One: Matching***

*Instructions*. Match the term with the correct response. Write the letter of the term by the definition.

| | |
|---|---|
| a. Blaise Pascal | f. Law of Conservation of Energy |
| b. resistance | g. compression ratio |
| c. amperes | h. Boyle's Law |
| d. voltage | i. molecules |
| e. electrons | j. Robert Boyle |

_____ 1. The volume of air in a cylinder before compression compared to the volume of air in the cylinder after compression.

_____ 2. States that the product of pressure times volume in a gas at constant temperature is a constant.

_____ 3. Tiny particles that make up all matter.

_____ 4. States that energy cannot be created nor destroyed.

_____ 5. Opposition to flow.

_____ 6. Measure of the rate at which electrons move through the conductor.

_____ 7. Push needed to move electrons through the conductor.

_____ 8. French scientist who formulated the fundamental law that explains the operation of hydraulic equipment.

_____ 9. English scientist who discovered that the pressure a gas exerts can be increased by reducing its volume while holding temperature constant.

_____ 10. Charged particles.

### *Part Two: Completion*

*Instructions.* Provide the word or words to complete the following statements.

1. Using Ohm's Law, we can determine that as voltage _____, the flow of current (amps) increases.
2. _____ is defined as the force needed to lift 550 pounds one foot in one second.
3. Boyle's Law tells us that pressure increases at the same rate that _____decreases.

### *Part Three: Short Answer*

*Instructions.* Provide information to answer the following questions.

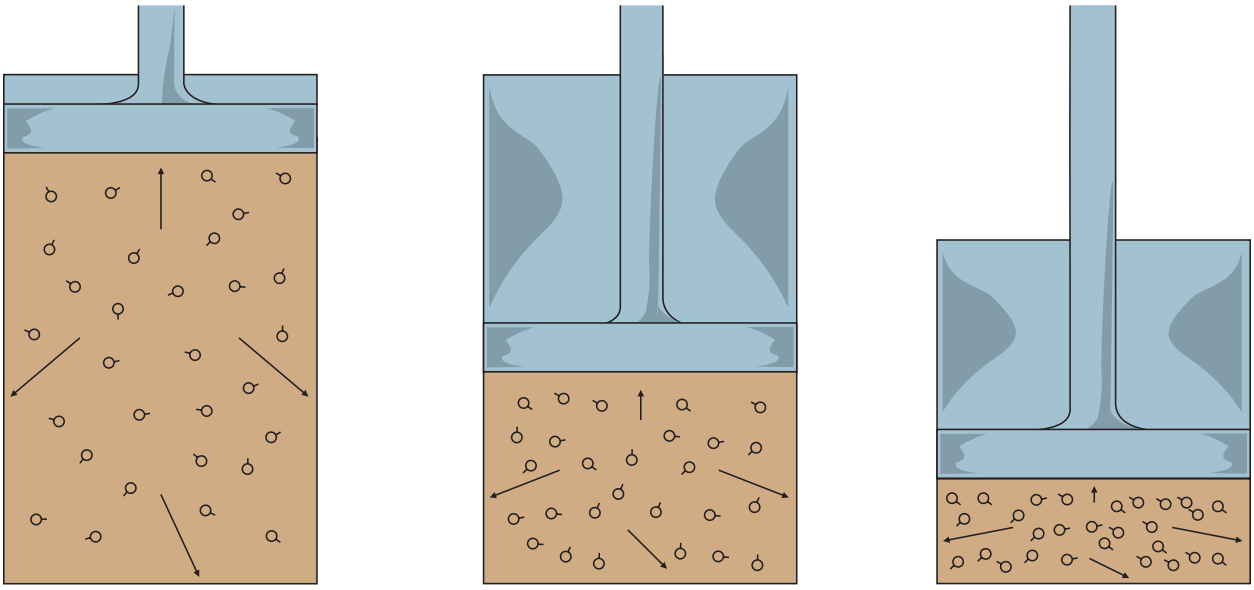
Using Ohm's law, calculate the follow problems.

1. How much current will flow through a 240 volt circuit containing a total resistance of 45 ohms?

2. What is the resistance in a 12 volt circuit if 1.2 amps of current is flowing in the circuit?

TM: A1–5A

# BOYLE'S LAW COMPRESSION RATIO IN A CYLINDER



**Original Volume and Pressure** | **½ Volume, Pressure Doubled** | **¼ Volume, Pressure Quadrupled**

*(Courtesy, Interstate Publishers, Inc.)*

# OHM'S LAW

$$E = 1 \times R$$

where,

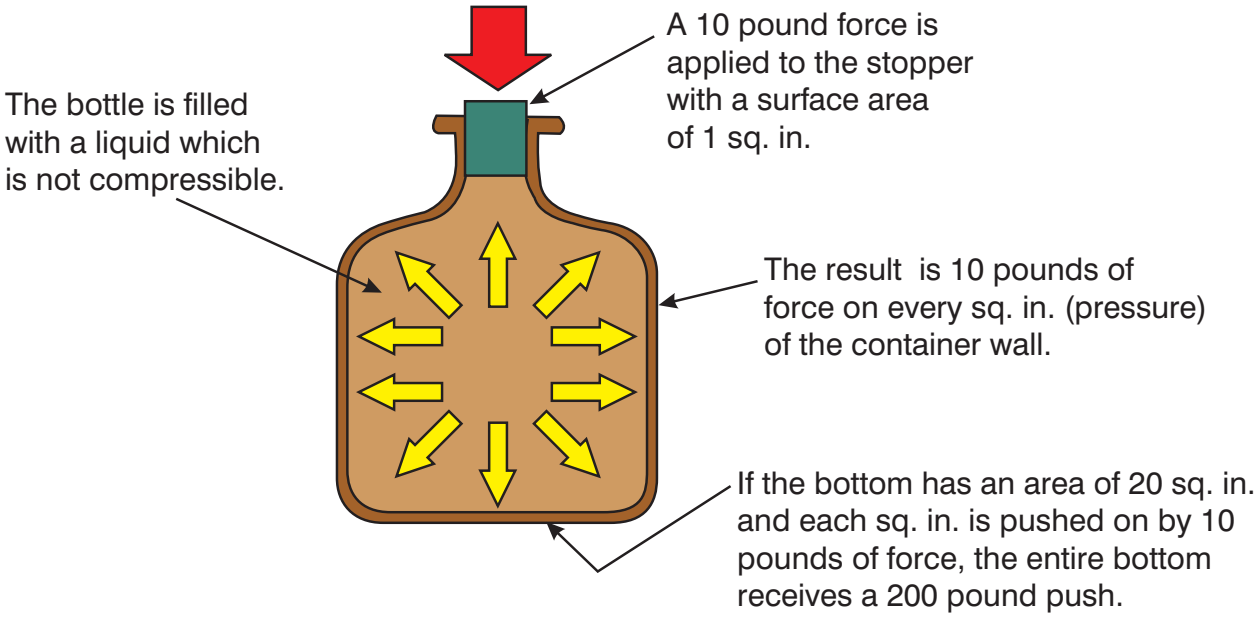
E = Voltage

I = Current (measured in amperes)

R = Resistance (measured in ohms)

**TM: A1–5C**

# A SIMPLE APPLICATION OF PASCAL'S LAW




*(Courtesy, Interstate Publishers, Inc.)*