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"Teaching Fluid Dynamics Utilizing Fluid Power Applications: A Workshop for Secondary Science Teachers" April 2, 2011

A Summary Report for the
NFPA Education Committee and Foundation Board

By

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On April 2, 2011, 19 middle and high school science teachers participated in "Teaching Fluid Dynamics Utilizing Fluid Power Applications: A Workshop for Secondary Science Teachers" held at the College of Engineering on the campus of Marquette University. Funding for the workshop was provided by the National Fluid Power Association (NFPA) Education and Technology Foundation. This event was hosted by Marquette Engineering Outreach; Jack Samuelson, Engineering Outreach Consultant, was the instructor. Teachers came from public and private schools in Southeastern Wisconsin.

The goals of the workshop were to enhance the teacher's knowledge of fluid properties and fluid dynamics, and the applications of fluid power in modern society, as well as provide them with the skills and materials to conduct experiments involving fluids in their classrooms. During the 6-hour event, the participants engaged in activities that could be replicated in their classrooms, using principles of pneumatics and hydraulics. The hands-on activities included constructing pneumatic rockets, cartesian divers and hydraulic machine models. Online resources of the NFPA and other organizations were demonstrated. At the conclusion of the workshop, discussions were held regarding implementation of the workshop activities in the teacher's classrooms. The teachers were also provided with over $250 of materials, enough to conduct experiments with all of their students.

The workshop was well received by the teachers, as summarized on the following pages. In addition, the workshop had a positive impact on the outreach program. The activities involving cartesian divers and hydraulic machines were integrated into some of the programs offered through Marquette Engineering Outreach for K-12 students.

Marquette Engineering Outreach is grateful for the financial support of the Foundation to provide teachers with the skills and materials necessary to implement fluid dynamics and fluid power activities in their classrooms.

4.2.2011 WORKSHOP EVALUATION SUMMARY

There were 20 teachers preregistered for the workshop; 19 participated and 17 completed the following survey, which was administered at the end of the workshop.

Please respond to the following statements according to this 1 to 5 scale:

5-strongly agree; 4-agree; 3-neutral; 2-disagree; 1-strongly disagree

1. *The material was presented in a clear manner that facilitated understanding.*
   Mean average of responses = 4.9

   Comments: It is always a benefit to have others share ideas/information; Jack encourages this
   All of the hands-on activities were very helpful
   If things were not clear there was opportunity for discussion & asking questions
   Many demonstrations and different ways to use it in class were very nice
   Great methodology, thank you

2. *The pace of the course was appropriate for me.*
   Mean average of responses = 4.4

   Comments: Some parts were a little slow and I would have liked to build a hydraulic device
   A little too much work time at the end
   I have taught AP Physics and had the background to go over things quicker

3. *The instructor demonstrates a thorough grasp of the course material.*
   Mean average of responses = 4.8

   Comments: My understanding of fluid power was minimal before this workshop but now I feel confident enough to instruct my students

4. *The instructor is well organized and uses class time efficiently.*
   Mean average of responses = 4.3

   Comments: Didn't always seem like he knew what he wanted to cover, but an agenda did outline the day which was nice

5. *The materials will be useful in teaching fluid dynamics.*
   Mean average of responses = 4.9

Comments: I would not have access to these materials otherwise
Maybe add a flight component
We wouldn't have been able to do many of these hands-on activities without the materials handed out
Physics semester – next fall

5. *I would recommend this workshop to others.*
Mean average of responses = 4.9

Comments: Great day – thanks you!
It is a great place to meet and talk to other teachers along with learning from the presentation

Other comments:

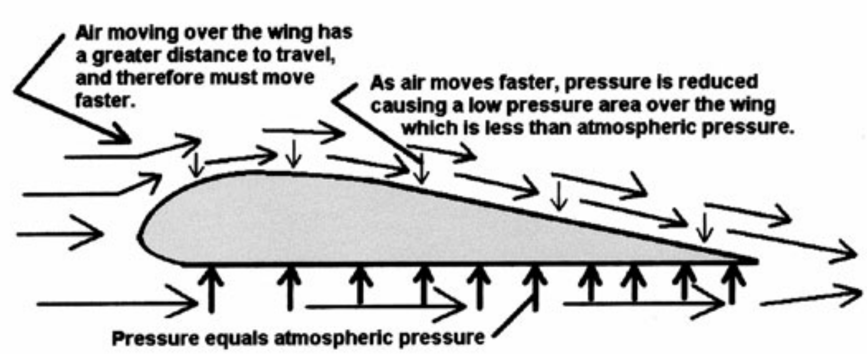
Very interesting workshop
Great, thanks!
Love to see young student involvement
Great workshop; I will use this next week on my unit of simple machines/work
Thank you for all of the materials!
I would recommend opening this workshop to Principles of Engineering teachers
Jack's expertise on STEM is impeccable!
My class is going to truly benefit!
With the 2 bottles have teachers bring a roll of paper towels; thanks for a great Saturday
Jack was informative and entertaining; he asks good questions and he really listens
Thank you; Make and take helps get hands-on ideas into our classrooms and to the students!
Thanks Jack for organizing a very interesting workshop
Thanks for the materials; I enjoyed the Cartesian divers and the neutral buoyancy activities

FLUID DYNAMICS, FLUID POWER RESOURCES for TEACHERS & STUDENTS

www.nfpa.com	National Fluid Power Association
www.pathfindersdesignandtechnology.com	Pathfinders Design & Technology
www.teachersource.com	Educational Innovations
www.arborsci.com	Arbor Scientific
www.sciencekit.com	Science Kit
www.kelvin.com	Kelvin
www.pitsco.com	PITSCO
www.sciplus.com	American Science & Surplus
www.vernier.com	Vernier Software & Technology
www.ck12.org/flexbook/chapter/1891	Flexbooks, Fluids Chapter

FLUID FACTS !

*Fluids can be a gas like air or a liquid like water; liquids and gases behave much the same.
*Gases are easily compressed into a smaller volume; liquids are not easily compressed
*PRESSURE is the amount of area over which a force is spread (Pressure = Force/Area)
*Areas of high pressure tend to push things towards areas of low pressure
*When the pressure on a gas is increased, its volume will decrease
*When the temperature of a gas is increased, its volume will increase
*When the pressure on a gas decreases, its volume will increase
*The earth's atmosphere exerts pressure on objects, due to the weight of the gases in air
*Air pressure at sea level is greater that on a mountain top, because at sea level there is more air above you
*Air is a form of matter and has mass that can be measured
*When the volume of a gas increases, its temperature will decrease
*The density of a fluid = mass/volume (fresh water has a density of 1.0 g/cm^3)
*The deeper in water you go the greater the water pressure, because there is more water on top of you; pressure is due to the weight of the water on top of you
*Objects float in a fluid if their density is less than the fluid's density (this is called positive buoyancy), and sink if the object's density is more (negative buoyancy)
*When an object has NEUTRAL buoyancy, it neither sinks nor rises and its density is the same as the fluid (like a submarine that remains at the same level in the water)
* **Pascal's principle** states that "pressure exerted anywhere in a confined fluid is transmitted equally in all directions throughout the fluid." When you step on the brakes of a car, pressure is applied at the brake pedal, but that pressure is transmitted to all the brakes at each wheel (through the brake fluid that connects to each brake)
***Bernoulli's principle** states that as the speed of a fluid increases, the pressure goes down; this explains the lift force on an airplane wing



The following are summaries of fluid dynamics lab activities provided by Arbor Scientific at their web site: www.arborsci.com. Please refer to this site for the complete lab procedure.

Cloud Machine

Teacher's Notes

Main Topic	Pressure & Fluids
Subtopic	Adiabatic Expansion
Learning Level	Middle
Technology Level	Low
Activity Type	Student

Description: Observe cloud formation when a gas is allowed to expand quickly in volume.

Required Equipment	Pressure Pumper, match, Empty 20oz or half-liter soda bottle
Optional Equipment	

Educational Objectives

- Observe an adiabatic process, specifically cloud formation when a gas quickly expands in volume.

Key Question

- How do clouds form?

Concept Overview

Students introduce water vapor and smoke into a bottle, pressurize it, and quickly release the pressure. The rapid depressurization decreases the temperature of the water vapor, which encourages it to condense around the smoke particles. A cloud forms.

Lab Tips

Soda bottles are designed to withstand very high pressure; however, students should wear safety glasses during this activity.

Caution students to keep hair and clothing away from the flame.

Pressure and Temperature Teacher's Notes

Main Topic	Pressure & Fluids
Subtopic	Gas Laws
Learning Level	Middle
Technology Level	Low
Activity Type	Student

Description: Measure the temperature change caused by an increase in pressure in air-filled container.

Required Equipment	Pressure Pumper, Strip Thermometer, Empty 20oz or half-liter soda bottle
Optional Equipment	

Educational Objectives

- Measure the temperature change caused by an increase in pressure in air-filled container.

Key Question

- How does a change in the pressure of a gas affect its temperature?

Concept Overview

According to Charles' Law, the pressure of a gas and its temperature are directly proportional. If the pressure increases (with volume staying constant), the temperature increases, and vice versa.

The strip thermometer allows students to observe a slight increase in temperature as they pressurize a plastic bottle. The most dramatic observation is the rapid decrease in temperature when the pressure is released.

This concept can be tied to several real-life experiences including refrigeration and why cans of compressed air (used for dusting electronics) carry freeze warnings.

Lab Tips

Soda bottles are designed to withstand very high pressure; however, students should wear safety glasses during this activity.

Caution students to reduce the contact their hands have with the bottle in this experiment, to reduce the temperature changed caused by body heat.

Contributed by Stu Schultz
Physics Pharm Consulting Services

Weighing Air Teacher's Notes

Main Topic	Pressure & Fluids
Subtopic	Gases
Learning Level	Middle
Technology Level	Low
Activity Type	Student

Description: Observe that air has mass.

Required Equipment	Pressure Pumper, Electronic Balance, Empty 2L soda bottle
Optional Equipment	

Educational Objectives

- Observe that air has mass.

Key Question

- Can we measure the mass of air with the equipment in the classroom?

Concept Overview

Air is composed of atoms and molecules. The atoms and molecules have mass and occupy space. Therefore, air is matter. Why can't we see it if it has mass and takes up space? The atoms and molecules are very small, and have a lot of space between them. (The molecules in your desk, on the other hand, are much closer together.) Why can't we feel the mass when we hold air in our hands? The mass of the atoms and molecules in air is very small. You have to collect a lot of atoms and molecules in one place to detect their mass. This activity used the Pressure Pumper to force a lot of air into a small container. The change in the mass of the container represents the mass of air that you pumped in.

Lab Tips

Soda bottles are designed to withstand very high pressure; however, students should wear safety glasses during this activity.

Contributed by Stu Schultz
Physics Pharm Consulting Services

Density of a Liquid — Teacher's Notes

Main Topic	Measurement
Subtopic	Density
Learning Level	Middle
Technology Level	Low
Activity Type	Student

Description: Use a graduated cylinder and balance to find the density of a liquid.

Required Equipment	10-mL graduated cylinder, electronic balance, liquid(s), beaker or other container.
Optional Equipment	Triple-beam balance

Educational Objectives

- Find the density of one or more liquids.

Concept Overview

Density is a physical property of every object with mass and volume. Density is defined as the amount of mass in each unit of volume; i.e. grams per milliliter.

Students will measure the combined mass of the liquid and graduated cylinder and then subtract the mass of the cylinder to find the liquid's mass. This mass, divided by the volume of the liquid, is its density. Three different volumes will be measured and averaged.

Lab Tips

Students should already be familiar with how to read volume on a graduated cylinder by looking at the meniscus. Students should also be familiar with the use of an electronic or triple-beam balance.

Different liquids can be made by dissolving different amounts of salt or sugar in water, if you wish to assign different liquids to each group. The liquids can then be color-coded with food coloring for ease of identification.

Density of a Solid — Teacher's Notes

Main Topic	Measurement
Subtopic	Density
Learning Level	Middle
Technology Level	Low
Activity Type	Student

Description: Use a graduated cylinder and balance to find the density of different solid objects.

Required Equipment	100-mL graduated cylinder, electronic balance, density blocks, water, other small irregular solid objects
Optional Equipment	Triple-beam balance

Educational Objectives

- Find the density of solid cubes and irregular solid objects.

Concept Overview

Density is a physical property of every object with mass and volume. Density is defined as the amount of mass in each unit of volume; i.e. grams per milliliter.

Students will measure the mass of several objects, and then find their volumes and calculate density. Regular objects such as cubes will be measured to find volume. For irregular objects, students will use the displacement method of finding volume. (The object is placed in a known volume of water. The change in total volume is the object's volume.)

Lab Tips

Students should already be familiar with how to read volume on a graduated cylinder by looking at the meniscus. Students should also be familiar with the use of an electronic or triple-beam balance.

The accepted values of some common metals (including those in Arbor Scientific's Density Blocks set) are listed below.

Metal	Density (g/cm^{3})
Aluminum	2.8
Brass	8.3
Copper	9.1
Iron	6.1
Lead	11.6
Zinc	7.0