

Matthew Bobrowsky  
Mikko Korhonen  
Jukka Kohtamäki

# USING PHYSICAL SCIENCE **GADGETS & GIZMOS**

# GRADES 6-8

# PHENOMENON-BASED LEARNING

**NSTA**press  
National Science Teachers Association

USING PHYSICAL SCIENCE

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# ABOUT THE AUTHORS

## MATTHEW BOBROWSKY, PHD

Dr. Matt Bobrowsky has been involved in scientific research and science education for several decades. For four years, he served as Director of the Physics Demonstration Facility at the University of Maryland—a collection of over 1,600 science demonstrations. Also at the University of Maryland, Matt was selected as a Faculty Mentor for the Fulbright Distinguished International Teachers Program, where he met Mikko Korhonen.

Matt has taught physics, astronomy, and astrobiology both in the classroom and online. He has written K–12 science curricula and serves on the Science Advisory Committee for the Howard County Public School System in Maryland. Matt has conducted countless professional development workshops for science teachers and special presentations for students, speaking on a variety of topics beyond physics, such as the scale of the universe, life in the universe, misconceptions about science among students and the public, the process of science, and science versus pseudoscience. He is often asked to be an after-dinner speaker or keynote speaker at special events. Matt is a “Nifty Fifty” speaker for the USA Science & Engineering Festival and a Shapley Lecturer for the American Astronomical Society. Matt has received a number of awards for teaching excellence from the University of Maryland, including the Stanley J. Drazek Teaching Excellence Award (given to the top 2 instructors out of ~800) and the Board of Regents’ Faculty Award for Excellence in Teaching (given to the top 3 instructors out of ~7,000). Matt’s teaching is always innovative because he uses pedagogical techniques that are based on current science education research and known to be effective.

In his research, Matt has been involved in both theoretical and observational astronomy. He developed computer models of planetary nebulae—clouds of gas expanding outward from aging stars—and has observed them with telescopes on the ground as well as with the Hubble Space Telescope. One of the planetary nebulae that Matt investigated is the Stingray Nebula, which he discovered using Hubble.

## **MIKKO KORHONEN**

Mikko Korhonen obtained a master's degree from Tampere Technical University in Finland, where he studied physics, mathematics, and pedagogics. Since then, he has been teaching physics, mathematics, and computer science at various schools in Finland. He has also developed a number of educational programs that brought some of his students to top scientific facilities in the world, including the Nordic Optical Telescope (NOT) observatory in La Palma, Spain, the CERN laboratory at the Franco-Swiss border, and the LATMOS laboratory in France. Most recently, some of his students have attended the Transatlantic Science School, which Mikko founded.

Mikko has written numerous other educational publications, including a book of physics experiments, manuals of physics problems with answers, an article on mathematics and logic for computer science, and two books with Jukka Kohtamäki on using toys to teach physics, one at the middle school and one at the high school level. (This book is an adaptation of the Finnish version of the middle school book.)

Mikko has obtained numerous grants and awards for his school and students, including awards from the NOT science school and the Viksu science competition prize, as well as individual grants from the Finnish National Board of Education and the Technology Industries of Finland Centennial Foundation, and grants for his "physics toys" project. His students are also award winners in the Finnish National Science Competition. Mikko received one of the Distinguished Fulbright Awards in Teaching, which brought him to the University of Maryland for a semester, where he worked with Matt Bobrowsky. Most recently, Mikko received the award of Distinguished Science Teacher in 2013 by the Technology Industries of Finland Centennial Foundation.

## **JUKKA KOHTAMÄKI**

Jukka Kohtamäki obtained his master of science degree from Tampere University of Technology in Finland and since then has been teaching grades 5–9 at the Rantakylä Comprehensive School, one of the largest comprehensive schools in Finland. Jukka has participated in long-term professional development teaching projects and projects involving the use of technology in learning, as well as workshops that he and Mikko Korhonen conducted for Finnish science teachers. His writing includes teaching materials for physics and computer science, and he has written two books with Mikko on using toys to teach physics, one at the middle school and one at the high school level. (This book is an adaptation of the Finnish version of the middle school book.)

Jukka is a member of the group under the National Board of Education that is writing the next physics curriculum in Finland. He is also participating in writing curricula in chemistry and natural science (which is a combination of biology, geology, physics, chemistry, and health education). His goals are to get students engaged in lessons, to have them work hands on and minds-on, to encourage creativity in finding solutions, and to get students to discuss natural phenomena using the "language of physics." In 2013, Jukka received the Distinguished Science Teacher Award from the Technology Industries of Finland Centennial Foundation.

*“The most beautiful thing  
we can experience is the  
mysterious. It is the source  
of all true art and science.”*

— Albert Einstein

# AN INTRODUCTION TO PHENOMENON-BASED LEARNING

## TO THE STUDENT

In 1931 Albert Einstein wrote, “The most beautiful thing we can experience is the mysterious. It is the source of all true art and science.” Keep this in mind as we introduce you to phenomenon-based learning, a learning approach in which you start by observing a natural phenomenon—in some cases just a simple toy—and then build scientific models and theories based on your observations.

The goal is for you to first watch something happen and then become curious enough to find out why. You will experiment with some simple gizmos and think about them from different perspectives. Developing a complete understanding of a concept might take a number of steps, with each step providing a deeper understanding of the topic. In some cases, you will need to do further research on your own to understand certain terms and concepts. Like real scientists, you can also get help from (and provide help to) collaborators. This book’s approach to learning is based on curiosity and creativity—a fun way to learn!

## TO THE TEACHER

The pedagogical approach in this book is called phenomenon-based learning (PBL), meaning learning is built on observations of real-world phenomena—in this case of some fun toys or gadgets. The method also uses peer instruction, which research has shown results in more learning than traditional lectures (Crouch and Mazur 2001). In the PBL approach, students work and explore in groups: Exercises are done in groups, and students’ conclusions are also drawn in groups. The teacher guides and encourages the groups and, at the end, verifies the conclusions. With the PBL strategy, the concepts and the phenomena are approached from different angles, each adding a piece to the puzzle with the goal of developing a picture correctly portraying the real situation.

The activities in this book can be used for various purposes. The introductions and the questions can be used as the basis for discussions with the groups before the students use the gizmos, that is, as a motivational tool. For example, you can ask where we see or observe the phenomenon in everyday life, what the students know about the matter prior to conducting the activities, and so on.

PBL is not so much a teaching method as it is a route to grasping the big picture. It contains some elements that you may have seen in inquiry-based, problem-based, or project-based learning, combined with hands-on activities. In traditional physics teaching, it’s common to divide phenomena into small, separate parts and discuss them as though there is no connection among them (McNeil 2013). In our PBL approach, we don’t artificially create boundaries within phenomena. Rather, we try to look at physical phenomena very broadly.

## AN INTRODUCTION TO PHENOMENON-BASED LEARNING

PBL encourages students to not just think about what they have learned but to also reflect on how they acquired that knowledge. What mental processes did they go through while exploring a phenomenon and figuring out what was happening? PBL very much lends itself to a K-W-L approach (what we Know, what we Want to know, and what we have Learned). K-W-L can be enhanced by adding an H for “How we learned it” because once we understand that, we can apply those same learning techniques to other situations.

When you first look at this book, it might seem as if there is not very much textual material. That was intentional. The idea is to have more thinking by the students and less lecturing by the teacher. It is also important to note that the process of thinking and learning is not a race. To learn and really get the idea, students need to take time to think ... and then think some more—so be sure to allow sufficient time for the cognitive processes to occur. For example, the very first experiment (using a tuning fork) can be viewed in two seconds, but in order for students to think about the phenomenon and really get the idea, they need to discuss the science with other group members, practice using the “language of science,” and internalize the science involved—which might take 20 minutes. During this time, the students may also think of real-life situations in which the phenomenon plays a significant role, and these examples can be brought up later during discussions as an entire class.

*“Most of the time my students didn’t need me; they were just excited about a connection or discovery they made and wanted to show me.”*

—Jamie Cohen (2014)

## LEARNING GOALS AND ASSESSMENT

The most important learning goal is for students to learn to think about problems and try a variety of approaches to solve them. Nowadays, most students just wait for the teacher to state the answer. The aim here is for students to enjoy figuring out what’s going on and to be creative and innovative. Combining this with other objectives, a list of learning goals might look something like this:

By the end of these lessons, students will

- think about problems from various angles and try different strategies;
- demonstrate process skills, working logically and consistently;
- collaborate with others to solve problems;
- use the language of physical science (and science in general);
- reflect on the thinking processes that helped them to acquire new knowledge and skills in physical science; and
- view physical science as interesting and fun.

You will also notice that there are no formal quizzes or rubrics included. There are other ways to evaluate students during activities such as these. First, note that the emphasis is not on getting the “right” answer. Teachers should not simply provide the answer or an easy way out—that would not allow students to learn how science really works. When looking at student answers, consider

## AN INTRODUCTION TO PHENOMENON-BASED LEARNING

the following: Are the students basing their conclusions on evidence? Are they sharing their ideas with others in their group? Even if a student has the wrong idea, if she or he has evidential reasons for that idea, then that student has the right approach. After all members of a group are in agreement and tell you, the teacher, what they think is happening, you can express doubt or question the group's explanation, making the students describe their evidence and perhaps having them discuss it further among themselves. Student participation as scientific investigators and their ability to give reasons for their explanations will be the key indicators that the students understand the process of science.

The PBL approach lends itself well to having students keep journals of their activities. Students should write about how they are conducting their experiment (which might differ from one group to another), ideas they have related to the phenomenon under investigation (including both correct and incorrect ideas), what experiments or observations showed the incorrect ideas to be wrong, answers to the questions supplied for each exploration, and what they learned as a result of the activity. The teacher can encourage students to form a mental model—perhaps expressed as a drawing—of how the phenomenon works and why. Then they can update this model in the course of their investigations. Students might also want to make a video of the experiment. This can be used for later reference as well as to show family and friends. Wouldn't it be great if we can get students talking about science outside the classroom?

A few of the questions asked of the students will be difficult to answer. Here again, students get a feel for what it's like to be a real scientist exploring uncharted territory. A student might suggest an incorrect explanation. Other students in the group might offer a correction, or if no one does, perhaps

further experimentation, along with guidance from the teacher, will lead the students on the right course. Like scientists, the students can do a literature search (usually a web search now) to see what others know about the phenomenon. Thus there are many ways for a misconception to get dispelled in a way that will result in more long-term understanding than if the students were simply told the answer. Guidance from the teacher could include providing some ideas about what to observe when doing the experiment or giving some examples from other situations in which the same phenomenon takes place. Although many incorrect ideas will not last long in group discussions, the teacher should actively monitor the discussions, ensuring that students do not get too far off track and are on their way to achieving increased understanding. We've provided an analysis of the science behind each exploration to focus your instruction.

By exploring first and getting to a theoretical understanding later, students are working like real scientists. When scientists investigate a new phenomenon, they aren't presented with an explanation first—they have to figure it out. And that's what the students do in PBL. Real scientists extensively collaborate with one another; and that's exactly what the students do here as well—work in groups. Not all terms and concepts are extensively explained; that's not the purpose of this book. Again, like real scientists the students can look up information as needed in, for example, a traditional physics textbook. What we present here is the PBL approach, in which students explore first and are inspired to pursue creative approaches to answers—and have fun in the process!

### PBL IN FINLAND

The Finnish educational system came into the spotlight after the Programme of International

## **AN INTRODUCTION TO PHENOMENON-BASED LEARNING**

Student Assessment (PISA) showed that Finnish students were among the top in science literacy proficiency levels. In 2009, Finland ranked second in science and third in reading out of 74 countries. (The United States ranked 23rd and 17th, respectively.) In 2012, Finland ranked 5th in science. (The U.S. was 28th.) Finland remains #1 in science among member nations of the Organization for Economic Co-operation and Development (OECD). Finland is now seen as a major international leader in education, and its performance has been especially notable for its significant consistency across schools. No other country has so little variation in outcomes among schools, and the gap within schools between the top- and bottom-achieving students is quite small as well. Finnish schools seem to serve all students well, regardless of family background or socioeconomic status. Recently, U.S. educators and political leaders have been traveling to Finland to learn the secret of their success.

The PBL approach is one that includes progressive inquiry, problem-based learning, project-based learning, and in Finland at least, other methods at the teachers' discretion. The idea is to teach bigger concepts and useful thinking skills rather than asking students to memorize everything in a textbook.

### **AUTHORS' USE OF GADGETS AND GIZMOS**

One of the authors (M.B.) has been using gizmos as the basis of teaching for many years. He also uses them for illustrative purposes in public presentations and school programs. The other two authors (M.K. and J.K.) have been using PBL—and the materials in this book—to teach in Finland. Their approach is to present physics phenomena to students so that they can build ideas and an understanding of the topic by themselves, in small

groups. Students progress from thinking to understanding to explaining. For each phenomenon there are several different viewpoints from which the student can develop a big-picture understanding as a result of step-by-step exploration. The teacher serves only as a guide who leads the student in the right direction. PBL is an approach that is not only effective for learning but is also much more fun and interesting for both the teacher and the students.

### **SAFETY NOTES**

Doing science through hands-on, process, and inquiry-based activities or experiments helps to foster the learning and understanding of science. However, in order to make for a safer experience, certain safety procedures must be followed. Throughout this book, there are a series of safety notes that help make PBL a safer learning experience for students and teachers. In most cases, eye protection is required. Safety glasses or safety goggles noted must meet the ANSI Z87.1 safety standard. For additional safety information, check out NSTA's "Safety in the Science Classroom" at [www.nsta.org/pdfs/SafetyInTheScienceClassroom.pdf](http://www.nsta.org/pdfs/SafetyInTheScienceClassroom.pdf). Additional information on safety can be found at the NSTA Safety Portal at [www.nsta.org/portals/safety.aspx](http://www.nsta.org/portals/safety.aspx).

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# 4

# AIR PRESSURE

**A**ir pressure has a significant role in everyday life. Pressure-related concepts such as vacuum, excess pressure, and high and low pressure are encountered almost daily. We talk about negative pressure, vacuum pumps, atmospheric pressure, and pressure chambers. Bicycle tires can be inflated to a pressure that is several times higher than the atmospheric pressure. Passengers in airplanes feel pressure changes during the flight. Air pressure also significantly affects the weather.

Air pressure depends on the temperature and the number of gas molecules in a certain volume. As the temperature gets warmer, the gas molecules move faster and collide with surfaces more often. This makes the pressure higher. Reducing the volume of a container makes the pressure increase, and decreasing the temperature or increasing the volume makes the pressure decrease.

In the *International System of Units* (SI units), the unit of pressure is *newtons* per square meter ( $N/m^2$ ). This unit is also known as the *pascal* (Pa): when the force of one newton is applied to one square meter of area, the pressure is equal to one pascal.

The weight of the atmosphere above an object pushes on the object with a certain amount of air pressure. However, air pressure does not only push downward, but in all directions. So there is air pressure not only on the floor of your classroom, but also on the walls and ceiling. Near the surface of the Earth, the air pressure averages 101.3 kPa (1 kPa = 1,000 Pa), and it decreases at higher altitudes. The other often-used unit of pressure is the *bar*. It corresponds approximately to the normal atmospheric pressure. One bar is defined as 100 kPa.

In this chapter, you will learn about concepts and phenomena concerning air pressure.

## KEYWORDS

Knowing these terms will help you to enjoy the explorations.

**atmosphere**

**air pressure**

**vacuum**

**force**



# Exploration



**FIGURE 4.1: Atmospheric Pressure Mat**

## IT'S A HOLD-UP!

With the Atmospheric Pressure Mat (Figure 4.1), you will study the force caused by a pressure difference as well as the reason for the pressure difference.

### Procedure

1. Choose an object to lift. You can lift objects that weigh up to 20 kg (44 lb) with the mat, so you can choose, for instance, a chair or a small table as long as it has a smooth surface.
2. Put the mat on the object, making sure that the surface is both smooth and clean, and lift from the hook attached to the mat. Be careful about the balance of the object as you lift it—the object can accidentally detach and fall.
3. Repeat the procedure by lifting various (for example, lighter or heavier) objects with different surfaces.
4. Put something like a towel or a tablecloth between the mat and the object you are lifting or try to lift the cloth itself.

### Questions

- What happened to the mat when it attached to the surface and you lifted it with the hook?
- What makes it possible to lift objects with the Atmospheric Pressure Mat?
- Based on your observations, on what kind of surfaces will lifting with the mat not work? Why is that?
- How could you improve the Atmospheric Pressure Mat to lift even heavier loads?

Pressure and force have a relation:

$$P = \frac{F}{A}$$

where  $P$  is the pressure,  $F$  is the force, and  $A$  is the area over which the force is applied. Estimate or calculate how great a load could be lifted if there was a perfect vacuum under the mat.



### SAFETY NOTES

- Wear safety glasses or goggles.
- Use caution when lifting the objects. Keep your feet out of the way in case the chair or table falls to the floor.



FIGURE 4.2: Suction cups

## PRESSURE POWER

You can study partial vacuums and pressure differences with suction cups (Figure 4.2).



### SAFETY NOTES

- Wear safety glasses or goggles.
- Make sure your arms are in an area free of any objects to prevent injury when pulling the suction cups apart.

### Procedure

1. Compress the cups against each other and then pull them apart.
2. Repeat the experiment with some paper or cloth between the cups.
3. Invent something new for which these cups can be useful.

### Questions

- You may hear a sound when compressing the cups together. Why?
- What causes the force that keeps the cups together?
- How can you more easily separate the cups?
- What are suction cups normally used for?

## PRESSURE GLOBE

The Pressure Globe (Figure 4.3) is used when studying the concepts of forces produced by pressure differences or a partial vacuum. The Pressure Globe has a balloon inside it and a plug on the bottom.

### Procedure

1. Place the plug in the bottom of the globe and try to inflate the balloon.
2. Remove the plug. Blow up the balloon, plug the globe when the balloon is filled, and then take your mouth off the balloon.
3. Remove the plug again.
4. Blow up the balloon again, and plug the globe when the balloon is filled. Then, put 100 ml of water into the balloon. Over a sink, or standing outside, remove the plug.

### Questions

- Were you able to inflate the balloon when the plug was in the bottom? Explain why or why not.
- What happens when you inflate the balloon while the plug is removed? Why?
- Explain what happens when you remove the plug while the balloon is inflated.
- What happened when the water was in the balloon and you removed the plug? Why?

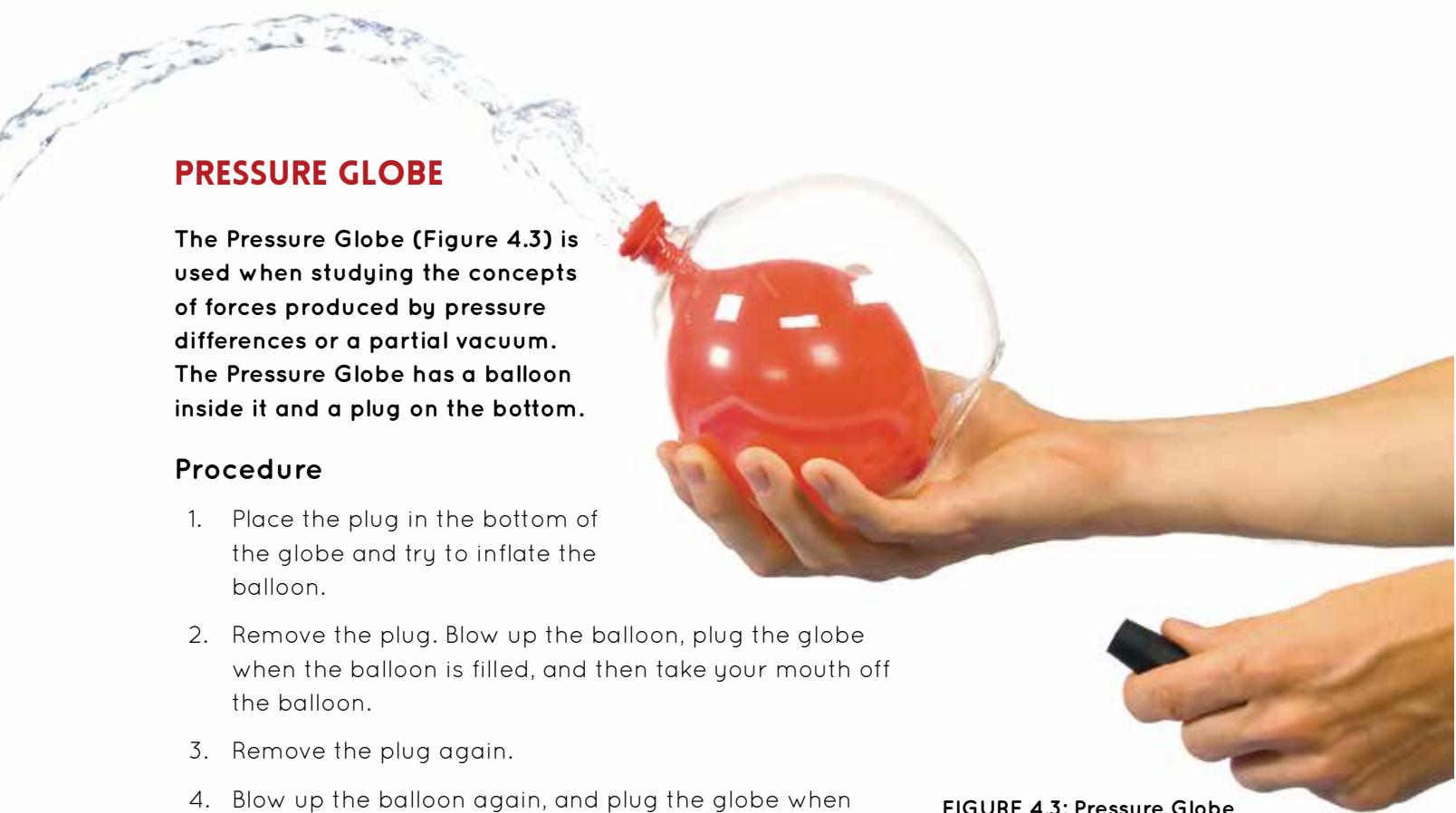


FIGURE 4.3: Pressure Globe

### SAFETY NOTES

- Wear safety glasses or goggles.
- Immediately wipe up any splashed water to prevent a slip or fall hazard.

## WATER ROCKET

The water rocket is a very impressive experiment, which can be used to learn about increased pressure or pressure differences. When done carefully, the experiment is safe, but we suggest that you use the Bottle Rocket Launcher (Figure 4.4) with the help of an assistant. You should use a pump that has a pressure gauge.

### Procedure

1. Read all of the instructions that came with the water rocket.
2. Set up the launch pad with the stake securely in the ground, and make sure that there are no people, cars, buildings, power lines, trees, and so on close to your launch station.
3. Fill the bottle half full with water.
4. Attach the bottle to the launch pad's plug, and put the cotter pin in place.
5. Extend the other end of the launch cord as far as possible.
6. Attach the pump hose to the valve stem on the end of the pressurizing hose.
7. Check for stability by pulling on the string to make sure the stand is well anchored and won't tip over when launching.
8. Start pumping. Monitor the rocket at all times in case something starts to go wrong.
9. When there are approximately five bars of pressure in the bottle, do the countdown and launch the rocket by sharply pulling the cotter pin away.

### Questions

- Predict how high the rocket will go.
- Why does the rocket leave the ground?
- Why did you need to have water in the bottle?
- What do you see in the bottle after the rocket has landed? Why?



FIGURE 4.4: Bottle Rocket Launcher



### SAFETY NOTES

- Wear safety glasses or goggles.
- Never stand over or near the water rocket while it is being pressurized or launched.
- Stay clear of the stake—it presents a potential impalement hazard.
- Only perform this experiment outside in an open field, never inside.

# Analysis

## IT'S A HOLD-UP!

The Atmospheric Pressure Mat (Figure 4.5) allows you to explore the relationship between pressure and volume in gas. The gas pressure in a container is caused by molecules colliding with the walls of the container. As you pull up on the mat for the exploration, the volume under the mat starts to expand. However, the (small) amount of air under the mat remains the same and simply spreads out more in that larger volume, thus reducing the density of the air. Then, the collisions of molecules with the table become less frequent, meaning that there is less air pressure pushing down on the top of the table.

In contrast, there is much more air pressure pushing up on the bottom of the table. The difference between these two pressures—on the top of the table and the bottom of the table—provides enough force to hold the table up. In other words, the upward air pressure on the bottom of the table is greater than the downward pressure on the top of the table by



FIGURE 4.5: Atmospheric Pressure Mat

an amount equal to the weight of the table: The table remains suspended.

The surface of the object being lifted must be smooth so that air molecules do not leak in under the mat. A rough surface such as a tablecloth lets air leak in, thus equalizing the pressure above and below the table. Then gravity makes the table fall.

When calculating the maximum load that can be lifted, you might assume that there is a perfect vacuum under the mat. In real life, you cannot have a perfect vacuum, and the mat will not hold as much weight as you calculate. Cleaning the surface and the mat as well as using a larger mat will increase the ability to lift heavier loads.

## PRESSURE POWER

Pressing the suction cups (Figure 4.6) together squeezes the air out from between them. The escaping air makes the edges of the cups vibrate, producing a sound that you can hear.



FIGURE 4.6: Suction cups

When you start to pull the cups apart, the volume between them increases, but the amount of air molecules remains the same. The pressure therefore becomes lower as a result of less frequent collisions of the air molecules against the inner surfaces of the cups. The air pressure outside the cups is still the same, so it is pushing the cups together. Suction cups should really be called pressure cups (and the official toy name is Atmospheric Pressure Cups) because it is pressure that holds them together. Suction (or pressure) cups are widely used. For example, you can attach a navigation device to the windshield of a car, and they can also be helpful when handling glass.



FIGURE 4.7: Pressure Globe

## PRESSURE GLOBE

The explorations with the Pressure Globe (Figure 4.7) work because of the differences in pressure between the air in a balloon and the air in a hollow glass ball. With the plug in the globe, blowing air into the balloon is difficult because the air pressure in the globe (and a small amount of elasticity from the balloon) keep the balloon compressed. While blowing, you compress the air between the balloon and globe, and the increased pressure pushes in on the balloon even more. You can blow a small amount of air into the balloon, but you quickly reach a point at which you cannot blow any more in.

Once you remove the plug and blow into the balloon, you can make the pressure inside the balloon higher than the outside air pressure and expand the balloon. When you stop blowing air into the balloon, it deflates because of its elasticity increasing the pressure enough to force the air out.

If you plug the globe after blowing up the balloon, the balloon stays inflated. The balloon tries to contract, but there is no path for the air to get behind the balloon. A slightly lower pressure is created between the balloon and the globe.

Finally, in the step with water, the water stays in the balloon when the globe is plugged because the reduced air pressure in the globe is not enough to push the water out. When the plug is removed, air flows into the globe and the pressure increases to the point where the pressure is the same on both sides of the balloon. At that point, the elasticity of the balloon pushes the water out.

## WATER ROCKET

The Bottle Rocket Launcher (Figure 4.8) provides one of the most dramatic explorations. Pumping air into the water rocket increases the pressure inside the bottle, which is higher than the surrounding, normal air pressure. When the rocket is launched, the higher inside pressure forces the water out as the pressure inside returns to the normal air pressure. The water is moving downward so (because momentum is conserved) the rocket starts to move upward. Another way of looking at it is that the pressure inside the bottle pushes up on the top of the bottle. The high speed of the rocket is due to the small mass of the rocket compared to the mass of water ejected, and secondly because the water is moving so fast.

After the landing, you can see a small cloud inside the bottle. When the moist air in the bottle suddenly expanded, the air molecules lost energy as they pushed out the water and air. This means that the air in the bottle cooled off. (This is an adiabatic process—in which rapid expansion of the air caused it to cool off. This is the opposite case of the adiabatic process in the Fire Syringe in Chapter 3 in which the air became warmer because it was compressed.) If the air in the bottle cools off enough, it will reach the dew point, and fog will form in the bottle. As this happens, the relative humidity in the bottle increases, while the amount of vapor remains the same. When the relative humidity reaches 100% a cloud forms inside the bottle.



FIGURE 4.8: Bottle Rocket Launcher

## Web Resources

Learn about how pressure changes in air and water and predict how the pressure will change in various circumstances.

<http://phet.colorado.edu/en/contributions/view/3569>

Learn how the properties of gas (volume, heat, etc.) vary in relation to each other.

<http://phet.colorado.edu/en/simulation/gas-properties>

Exercises dealing with fluid pressure and depth.

[www.grc.nasa.gov/www/K-12/WindTunnel/Activities/fluid\\_pressure.html](http://grc.nasa.gov/www/K-12/WindTunnel/Activities/fluid_pressure.html)

Activity on relationships among altitude, air density, temperature, and pressure.

[www.grc.nasa.gov/www/K-12/problems/Jim\\_Rinella/AltitudevsDensity\\_act.htm](http://grc.nasa.gov/www/K-12/problems/Jim_Rinella/AltitudevsDensity_act.htm)

Activity on relationship between air pressure and temperature.

[www.grc.nasa.gov/www/K-12/Missions/Rhonna/pre\\_act.htm](http://grc.nasa.gov/www/K-12/Missions/Rhonna/pre_act.htm)

Control a piston in a chamber to explore relations among pressure, temperature, density, and volume.

<http://jersey.uoregon.edu/vlab/Piston/>

Simulation to investigate how pressure changes in air and water.

<http://phet.colorado.edu/en/simulation/under-pressure>

Questions to go with the PhET “Under Pressure” simulation.

<http://phet.colorado.edu/en/contributions/view/3611>

Fluid pressure activity.

<http://phet.colorado.edu/en/contributions/view/3569>

# Relevant Standards

Note: The Next Generation Science Standards can be viewed online at [www.nextgenscience.org/next-generation-science-standards](http://www.nextgenscience.org/next-generation-science-standards).

## PERFORMANCE EXPECTATIONS

### MS-PS2-2

Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object. [Clarification Statement: Emphasis is on balanced (Newton's First Law) and unbalanced forces in a system, qualitative comparisons of forces, mass and changes in motion (Newton's Second Law), frame of reference, and specification of units.] [Assessment Boundary: Assessment is limited to forces and changes in motion in one-dimension in an inertial reference frame, and to change in one variable at a time. Assessment does not include the use of trigonometry.]

## SCIENCE AND ENGINEERING PRACTICES

### Developing and Using Models

Modeling in 6–8 builds on K–5 and progresses to developing, using and revising models to describe, test, and predict more abstract phenomena and design systems.

- Develop a model to predict and/or describe phenomena. (MS-PS1-1),(MS-PS1-4)
- Develop a model to describe unobservable mechanisms. (MS-PS1-5)

### Analyzing and Interpreting Data

Analyzing data in 6–8 builds on K–5 and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis.

- Analyze and interpret data to determine similarities and differences in findings. (MS-PS1-2)

## Obtaining, Evaluating, and Communicating Information

Obtaining, evaluating, and communicating information in 6–8 builds on K–5 and progresses to evaluating the merit and validity of ideas and methods.

- Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or not supported by evidence. (MS-PS1-3)

## CONNECTIONS TO NATURE OF SCIENCE

### Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena

- Theories and laws provide explanations in science.
- Laws are statements or descriptions of the relationships among observable phenomena.

## DISCIPLINARY CORE IDEAS

### PS1.A: Structure and Properties of Matter

- Gases and liquids are made of molecules or inert atoms that are moving about relative to each other. (MS-PS1-4)

### PS2.A: Forces and Motion

- For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first, but in the opposite direction (Newton's third law). (MS-PS2-1)
- The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion. (MS-PS2-2)

## CROSSCUTTING CONCEPTS

### Patterns

- Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.

### Cause and Effect

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.
- Systems can be designed to cause a desired effect.

### Systems and System Models

- When investigating or describing a system, the boundaries and initial conditions of the system need to be defined.

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# USING PHYSICAL SCIENCE GADGETS & GIZMOS

GRADES 6–8

PHENOMENON-BASED LEARNING

*"The most beautiful thing we can experience is the mysterious.  
It is the source of all true art and science."* — Albert Einstein

The authors say there are three good reasons to buy this book:

1.

To improve your students' thinking skills and problem-solving abilities

2.

To acquire easy-to-perform experiments that engage students in the topic

3.

To make your physics lessons waaaaay more cool

What student—or teacher—can resist the chance to experiment with Rocket Launchers, Sound Pipes, Drinking Birds, Dropper Poppers, and more? The 35 experiments in *Using Physical Science Gadgets and Gizmos, Grades 6–8*, cover topics including pressure and force, thermodynamics, energy, light and color, resonance, and buoyancy.

The phenomenon-based learning (PBL) approach used by the authors is as educational as the experiments are attention-grabbing. Instead of putting the theory before the application, PBL encourages students to first experience

how the gadgets work and then grow curious enough to find out why. Students engage in the activities not as a task to be completed but as exploration and discovery.

The idea is to help your students go beyond simply memorizing physical science facts. *Using Physical Science Gadgets and Gizmos* can help them learn broader concepts, useful thinking skills, and science and engineering practices (as defined by the *Next Generation Science Standards*). And—thanks to those Sound Pipes and Dropper Poppers—both your students and you will have some serious fun.

Grades 6–8

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