CLASSROOM ACTIVITIES

UNDER PRESSURE: AIR PRESSURE AND FORCES

Recommended for grades K – 5; can be used with adaptations for PreK or for upper grades

What You Need

For teams of 3, 4 or partners:
Stripes of paper (1 per student) approximately 1.5” wide and 8.5” long

For older students (Grades 3 – 5):
Ping pong balls
Small, clear plastic cups (9 oz works well)

For class demonstration:
Ping pong ball
Small hand-held hair dryer

Optional:
Large, multi-directional floor fan
Inflatable beach ball

Time Frame:
Varies; 30 – 40 minutes

Setting the Stage:
Tell students you are going to perform an experiment, and that you will need some help.

Introduce your supplies – hair dryer and ping pong ball (or optional supplies listed above).

Tell students you are going to turn on the hair dryer and place the ping pong ball in the air stream.

Ask students to share their ideas about what they think may happen when you do this. For younger students, making guesses is fine. For older students, you can present this as a chance for them to make predictions.

NOTE: If time allows, you can have students feel the weight of the ping pong ball and the air from the hair dryer. The more information they have, the better predictions they can make, of course.

Experiment:
Perform the experiment. Hold hair dryer level, with nozzle pointed directly up. Turn on high. Place ping pong ball in air stream. Ball should remain suspended in stream. Feel free to have students add and/or remove ball to/from air stream during experiment.

NOTE: CAUTION – hair dryer may get very hot with setting on high. Make sure students are very careful if working with ping pong ball around hair dryer.

Ask for observations after – or during – the experiment. Observations are things that students notice by using their senses. Answers may vary greatly depending on age/level of student.

continued..
**Under Pressure: Air Pressure and Forces**

**Experiment cont’d:**

Observations may include:
- The ball stayed in the air.
- The ball spun around.
- The ball moved up and down.

Even observations like—“The hair dryer was loud!” are valid. This can easily be connected to the speed of the air due to having the hair dryer set to “high.”

After sharing observations, ask students to share their ideas on why this happened.

Explain to students that the fast moving air made an area of low pressure and that the high pressure around the air stream actually held the ball in the air stream. And, you can expect some confused looks, so get ready to break it down!

You can think of the fast moving air as creating a “hole” in the air in the classroom. The other air wanted to get in and fill up the hole, so it tries to “push” into that hole. The ball sort of gets stuck in the middle, and gets held in place pretty much. This is a very simplified explanation, but it does express the general concept. For younger students, the introduction of “pressure” may not work. The “hole” idea may be more effective.

**Car Connections:**

Air flow can greatly affect the operations of a car. From fuel efficiency to increasing speed in racing, aerodynamics comes into play in many aspects of car design and performance. Aerodynamics is the study of the properties of moving air, and especially of the interaction between the air and solid bodies moving through it. When introducing this term to students, it’s easy to connect this concept to the experiments you’ve just performed with air flow and paper/ping pong balls.

Have students perform some online (or other) research on the evolution of car design—especially race car design. It’s pretty amazing to see the advances made in body shape, fabrication materials and, of course, increases in speed, through the years. When looking at the cars they’re researching, have students think about things like:

- Would this car move fast through the air? Why or why not?
- How could an older car be improved to move more effectively through the air?
- How has the shape of race cars changed over the years and how has this help them go faster?

Going Further:

With hair dryer still on “high” setting, ask students what they think will happen if you slowly rotate the dryer left and right, with the ball in the air stream.

- Will the ball stay in the stream?
- Will the ball fall?

When ball falls (and it will eventually, depending on how quickly you rotate the hair dryer) ask students what other force may have come into play? Could it be gravity?

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**Curriculum Connections**

**ETS1.A: Defining and Delimiting Engineering Problems**  
Asking questions, making observations, and gathering information are helpful in thinking about problems. (K-2-ETS1-1)

**Crosscutting Concepts**  
Cause and Effect  
- Simple tests can be designed to gather evidence to support or refute student ideas about causes. (K-PS2-1), (K-PS2-2)

**Common Core Standards**  
**ELA/Literacy**  
SL.K.3  
Ask and answer questions in order to seek help, get information, or clarify something that is not understood. (K-PS2-2)

**Mathematics**  
K.MD.A.2  
Directly compare two objects with a measurable attribute in common, to see which object has “more of”/”less of” the attribute, and describe the difference. (K-PS3-1), (K-PS3-2)

**MP.2**  
Reason abstractly and quantitatively. (K-2-ETS1-1), (K-2-ETS1-3)

**First Grade: K-2 ETS1**  
**Engineering Design**

**Science and Engineering Practices**  
Developing and Using Models  
- Develop a simple model based on evidence to represent a proposed object or tool. (K-2-ETS1-2)

**continued..**
Car Connections continued:
Now, ask students to make predictions/guesses about what will happen if you lower the speed of the air from the hair dryer. Accept answers and perform experiment. Ask for observations as before.

NOTE: Results can vary greatly depending on the quality of hair dryer used.

History:
Swiss mathematician and physicist Daniel Bernoulli (1700 – 1782) discovered this principle (now called the Bernoulli Principle) while investigating conservation of energy. Bernoulli discovered that an area of fast moving fluid, such as air, creates an area of low pressure, while an area of slow moving fluid creates an area of high pressure – in inverse relationship. Daniel Bernoulli and his scientific discoveries would make an excellent research project for a student! Much can be found about Bernoulli and his work online with a simple search, but here is a good site to get started:


Classroom Experiment:
Time to get the whole class involved!

Distribute paper strips, 1 per student.

Tell students they now get to perform their own experiments. Their challenge is, while holding the paper strip at one end (model for students if necessary), make the paper strip stick straight out (horizontally). However, for this experiment, students cannot use their other hand or touch the strip with any other body part. Students may work together to figure out the challenge, but cannot touch each other’s paper strips to meet the challenge.

Allow time for experimentation.

Re-focus class and ask student teams/groups to share their solutions to your challenge.
- What were some of the methods students tried?
- What were the results?
- Was any group successful?

Once results have been shared, review the hair dryer/ping pong ball experiment with students. Remind students of the “hole” in the air, or the area of low pressure, created by the fast moving air. Challenge them to make this work for the paper.
- Can you use air to make the paper stick straight out, horizontally?
- What is the source of the air you will use?
- Which direction should the air travel?

Allow time for student/group experimentation. Once again, ask students to share their solutions to the challenge.

continued..
Classroom Experiment continued:
If no group came up with it, share one way of using air pressure to meet the challenge by demonstrating for the group. Holding the strip of paper in one hand, blow directly over the paper strip, allowing the strip to extend horizontally. Feel free to practice ahead of time!

By blowing over the strip, as opposed to under or to one side, you are creating a hole in the air, or area of low pressure, and the higher pressure surrounding the strip pushes it up and into the air stream.

Allow students to try this method of meeting the challenge and share results.

Additional Classroom Experiment:
Tell students you have another air challenge for them.

Show students the ping pong ball once again, and show them the small, clear plastic cup.

Challenge students to find a way to make the ball come out of the cup, without touching either the cup or the ball.

NOTE: Students may need to use their hands to simply hold the cup in place eventually when using their wind power!

Allow time for students to experiment in small groups.

Share results and methods for meeting (or not meeting) the challenge.

If no group tried using air, remind students of the air pressure experiments already performed in class.
-Is there any way to use air to get the ball out of the cup?
-Which direction should you blow to make air work for this challenge?

Have students experiment again, using their own air to get the ball out of the cup. There is more than one way to be successful with this challenge.

Allow time for students to experiment in small groups and share results and methods for meeting (or not meeting) the challenge.

If no group came up with it, share one way of using air pressure to meet the challenge by demonstrating for the group. Place cup on a solid surface and blow directly over the cup. Breath should be a short, forceful burst of air. As with the paper strip, feel free to try this on your own before demonstrating it for the class. Explain to students that as with the paper strip and the hair dryer, air pressure is being used to meet this challenge. By blowing directly over the cup, you are creating low pressure. The greater pressure surrounding it actually pushes the ball up, into the air stream and out of the cup.

Curriculum Connections

MP.5
Use appropriate tools strategically. (K-2-ETS1-1), (K-2-ETS1-3)

Second Grade: 2-PS1 Matter and Its Interactions; K-2 Engineering Design

Science and Engineering Practices

Planning and Carrying Out Investigations
- Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence to answer a question. (2-PS1-1)

Analyzing and Interpreting Data
- Analyze data from tests of an object or tool to determine if it works as intended. (2-PS1-2)

Constructing Explanations and Designing Solutions
- Make observations (firsthand or from media) to construct an evidence-based account for natural phenomena. (2-PS1-3)

Asking Questions and Defining Problems
- Ask questions based on observations to find more information about the natural and/or designed world(s). (K-2-ETS1-1)
- Define a simple problem that can be solved through the development of a new or improved object or tool. (K-2-ETS1-1)

Disciplinary Core Ideas

- Different properties are suited to different purposes. (2-PS1-2), (2-PS1-3)

continued..
Under Pressure: Air Pressure and Forces

Allow students to experiment. Keep experiments short, since students tend to huff and puff quite forcefully in attempting to meet this challenge. In other words, don’t let them blow so much they get lightheaded!

Going Further: Classroom Experiment:
Ask students where else they have heard of air pressure? Answers may include weather reports, automotive shops (as in tire pressure), etc. For older students, have them research how air pressure in weather systems affect one another, and in turn, affect our weather.

Have even more fun with pressure! For more air and other fluid pressure experiments and demonstrations, visit: https://www.asme.org/career-education/articles/k-12-grade/5-ways-to-demonstrate-air-pressure-to-children

Resources:
For more connections to aerodynamics, check out these cool sites:

http://www.accelerationnation.com/index.html

http://www.buildyourownracecar.com/race-car-aerodynamics-basics-and-design/


Curriculum Connections

ETS1.A: Defining and Delimiting Engineering Problems
• A situation that people want to change or create can be approached as a problem to be solved through engineering. (K-2-ETS1-1)
• Asking questions, making observations, and gathering information are helpful in thinking about problems. (K-2-ETS1-1)
• Before beginning to design a solution, it is important to clearly understand the problem. (K-2-ETS1-1)

ETS1.B: Developing Possible Solutions
• Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem’s solutions to other people. (K-2-ETS1-2)

Crosscutting Concepts

Patterns
• Patterns in the natural and human designed world can be observed. (2-PS1-1)

Cause and Effect
• Simple tests can be designed to gather evidence to support or refute student ideas about causes. (2-PS1-2)

Common Core Standards

ELA/Literacy
W.2.8
Recall information from experiences or gather information from provided sources to answer a question. (K-2-ETS1-1),(K-2-ETS1-3)
Mathematics
MP.2 Reason abstractly and quantitatively. (2-PS1-2)
MP.5 Use appropriate tools strategically. (2-PS1-2)

Third Grade: 3-PS2 Motion and Stability: forces and Interactions; 3-5-ETS1 Engineering Design

Next Generation Science Standards

Science and Engineering Practices

Asking Questions and Defining Problems
• Ask questions that can be investigated based on patterns such as cause and effect relationships. (3-PS2-3)
• Define a simple problem that can be solved through the development of a new or improved object or tool. (3-PS2-4)

Planning and Carrying Out Investigations
• Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered. (3-PS2-1)
• Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution. (3-PS2-2)

Scientific Investigations Use a Variety of Methods
• Science investigations use a variety of methods, tools, and techniques. (3-PS2-1)

Disciplinary Core Ideas
PS2.A: Forces and Motion
• Each force acts on one particular object and has both strength and a direction. An object at rest typically has multiple forces acting on it, but they add to give zero net force on the object. Forces that do not sum to zero can cause changes in the object’s speed or direction of motion. (Boundary: Qualitative and conceptual, but not quantitative addition of forces are used at this level.) (3-PS2-1)
• The patterns of an object’s motion in various situations can be observed and measured; when that past motion exhibits a regular pattern, future motion can be predicted from it. (Boundary: Technical terms, such as magnitude, velocity, momentum, and vector quantity, are not introduced at this level, but the concept that some quantities need both size and direction to be described is developed.) (3-PS2-2)

PS2.B: Types of Interactions
• Objects in contact exert forces on each other. (3-PS2-1)

ETS1.A: Defining and Delimiting Engineering Problems
• Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. (3-5-ETS1-1)

ETS1.B: Developing Possible Solutions
• At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs. (3-5-ETS1-2)

ETS1.C: Optimizing the Design Solution
• Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints. (3-5-ETS1-3)

Crosscutting Concepts
Patterns
• Patterns of change can be used to make predictions. (3-PS2-2)
Curriculum Connections continued

Cause and Effect
• Cause and effect relationships are routinely identified. (3-PS2-1)
• Cause and effect relationships are routinely identified, tested, and used to explain change. (3-PS2-3)

Common Core Standards
ELA/Literacy
W.3.7
Conduct short research projects that build knowledge about a topic. (3-PS2-1),(3-PS2-2)

Mathematics
MP.2
Reason abstractly and quantitatively. (3-PS2-1)
MP.5
Use appropriate tools strategically. (3-PS2-1), (3-5-ETS1-1), (3-5-ETS1-2), (3-5-ETS1-3)

Fourth Grade: 4-PS3 Energy; 3-5-ETS1 Engineering Design

Science and Engineering Practices

Asking Questions and Defining Problems
• Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause and effect relationships. (4-PS3-3)

Planning and Carrying Out Investigations
• Make observations to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution. (4-PS3-2)

Constructing Explanations and Designing Solutions
• Use evidence (e.g., measurements, observations, patterns) to construct an explanation. (4-PS3-1)
• Apply scientific ideas to solve design problems. (4-PS3-4)

Asking Questions and Defining Problems
• Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost. (3-5-ETS1-1)

Planning and Carrying Out Investigations
• Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered. (3-5-ETS1-3)

Constructing Explanations and Designing Solutions
• Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design problem. (3-5-ETS1-2)

Disciplinary Core Ideas
PS3.A: Definitions of Energy
• Energy can be moved from place to place by moving objects or through sound, light, or electric currents. (4-PS3-2), (4-PS3-3)

PS3.B: Conservation of Energy and Energy Transfer
• Energy is present whenever there are moving objects, sound, light, or heat. When objects collide, energy can be transferred from one object to another thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and produced. (4-PS3-2),(4-PS3-3)
**Curriculum Connections continued**

**PS3.C: Relationship Between Energy and Forces**
- When objects collide, the contact forces transfer energy so as to change the objects’ motions. (4-PS3-3)

**ETS1.A: Defining Engineering Problems**
- Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. (secondary to 4-PS3-4)

**ETS1.A: Defining and Delimiting Engineering Problems**
- Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. (3-5-ETS1-1)

**ETS1.B: Developing Possible Solutions**
- Research on a problem should be carried out before beginning to design a solution. Testing a solution involves investigating how well it performs under a range of likely conditions. (3-5-ETS1-2)
- At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs. (3-5-ETS1-2)

**ETS1.C: Optimizing the Design Solution**
- Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints. (3-5-ETS1-3)

**Crosscutting Concepts**

**Energy and Matter**
- Energy can be transferred in various ways and between objects. (4-PS3-1), (4-PS3-2), (4-PS3-3), (4-PS3-4)

**Science is a Human Endeavor**
- Most scientists and engineers work in teams. (4-PS3-4)
- Science affects everyday life. (4-PS3-4)

**Common Core Standards**

**ELA/Literacy**

RI.4.9
Integrate information from two texts on the same topic in order to write or speak about the subject knowledgeably. (4-PS3-1)

W.4.7
Conduct short research projects that build knowledge through investigation of different aspects of a topic. (4-PS3-2), (4-PS3-3), (4-PS3-4)

**Mathematics**

MP.2
Reason abstractly and quantitatively. (3-5-ETS1-1), (3-5-ETS1-2), (3-5-ETS1-3)

MP.5
Use appropriate tools strategically. (3-5-ETS1-1), (3-5-ETS1-2), (3-5-ETS1-3)

**Fifth Grade: 5-PS1 Matter and its Interactions; 5-PS2 Motion and Stability: Forces and Interactions; 5-PS3 Energy; 3-5-ETS1 Engineering Design**

**Science and Engineering Practices**

**Developing and Using Models**
- Develop a model to describe phenomena. (5-PS1-1)
Curriculum Connections continued

Planning and Carrying Out Investigations
• Conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered. (5-PS1-4)
• Make observations and measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon. (5-PS1-3)

Engaging in Argument from Evidence
• Support an argument with evidence, data, or a model. (5-PS2-1)

Asking Questions and Defining Problems
• Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost. (3-5-ETS1-1)

Planning and Carrying Out Investigations
• Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered. (3-5-ETS1-3)

Constructing Explanations and Designing Solutions
• Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design problem. (3-5-ETS1-2)

Disciplinary Core Ideas

PS2.B: Types of Interactions
• The gravitational force of Earth acting on an object near Earth’s surface pulls that object toward the planet’s center. (5-PS2-1)

ETS1.A: Defining and Delimiting Engineering Problems
• Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. (3-5-ETS1-1)

ETS1.B: Developing Possible Solutions
• Research on a problem should be carried out before beginning to design a solution. Testing a solution involves investigating how well it performs under a range of likely conditions. (3-5-ETS1-2)
• At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs. (3-5-ETS1-2)

ETS1.C: Optimizing the Design Solution
• Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints. (3-5-ETS1-3)

Crosscutting Concepts

Cause and Effect
• Cause and effect relationships are routinely identified, tested, and used to explain change. (5-PS1-4), (5-PS2-1)

Energy and Matter
• Energy can be transferred in various ways and between objects. (5-PS3-1)

Common Core Standards

ELA/Literacy
W.5.7
Conduct short research projects that use several sources to build knowledge through investigation of different aspects of a topic. (5-PS1-2), (5-PS1-3), (5-PS1-4), (3-5-ETS1-1), (3-5-ETS1-3)
Curriculum Connections continued

Mathematics

MP.2
Reason abstractly and quantitatively. (5-PS1-1), (5-PS1-2), (5-PS1-3)

MP.5
Use appropriate tools strategically. (PS1-2), (PS1-3)

Sixth Grade: MS-PS3 Energy; MS-ETS1 Engineering Design

Next Generation Science Standards

Science and Engineering Practices

Analyzing and Interpreting Data
- Analyze and interpret data to determine similarities and differences in findings. (MS-ETS1-3)
- Evaluate competing design solutions based on jointly developed and agreed-upon design criteria. (MS-ETS1-2)

Disciplinary Core Ideas

ETS1.B: Developing Possible Solutions
- Models of all kinds are important for testing solutions. (MS-ETS1-4)

ETS1.C: Optimizing the Design Solution
- Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design. (MS-ETS1-3)

Crosscutting Concepts

Energy and Matter
- Energy may take different forms (e.g. energy in fields, thermal energy, energy of motion). (MS-PS3-5)
- The transfer of energy can be tracked as energy flows through a designed or natural system. (MS-PS3-3)

Common Core Standards

ELA/Literacy

WHST.6-8.7
Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration. (MS-PS3-3), (MS-PS3-4)

Mathematics

MP.2
Reason abstractly and quantitatively. (MS-PS3-4), (MS-PS3-5), (MS-ETS1-1), (MS-ETS1-2), (MS-ETS1-3), (MS-ETS1-4)
Curriculum Connections continued

Seventh Grade: MS-PS1 Matter and Its Interactions;

Next Generation Science Standards

Science and Engineering Practices

Developing and Using Models
• Develop a model to predict and/or describe phenomena. (MS-PS1-1),(MS-PS1-4)

Scientific Knowledge is Based on Empirical Evidence
• Science knowledge is based upon logical and conceptual connections between evidence and explanations. (MS-PS1-2)

Asking Questions and Defining Problems
• Define a design problem that can be solved through the development of an object, tool, process or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions. (MS-ETS1-1)

Analyzing and Interpreting Data
• Analyze and interpret data to determine similarities and differences in findings. (MS-ETS1-3)

Engaging in Argument from Evidence
• Evaluate competing design solutions based on jointly developed and agreed-upon design criteria. (MS-ETS1-2)

Disciplinary Core Ideas

ETS1.B: Developing Possible Solutions
• A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (MS-ETS1-4)
• Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. (MS-ETS1-3)
• Models of all kinds are important for testing solutions. (MS-ETS1-4)

ETS1.B: Developing Possible Solutions
• A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (Secondary to MS-PS1-6)

ETS1.C: Optimizing the Design Solution
• Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of the characteristics may be incorporated into the new design. (Secondary to MS-PS1-6)
• The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. (Secondary to MS-PS1-6)

Crosscutting Concepts

Cause and Effect
• Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-PS1-4)

Common Core Standards

ELA/Literacy

WHST.6-8.7
Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional focused questions that allow for multiple avenues of exploration. (MS-PS1-6)

Mathematics

MP.2
Reason abstractly and quantitatively. (MS-PS1-1),(MS-PS1-2), (MS-PS1-5)
Curriculum Connections continued

Eighth Grade: MS-PS3 Energy; MS-ETS1 Engineering Design

Next Generation Science Standards

Science and Engineering Practices

Developing and Using Models
• Develop a model to describe unobservable mechanisms. (MS-PS3-2)

Asking Questions and Defining Problems
• Define a design problem that can be solved through the development of an object, tool, process or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions. (MS-ETS1-1)

Disciplinary Core ideas
PS3.C: Relationship Between Energy and Forces
• When two objects interact, each one exerts a force on the other that can cause energy to be transferred to or from the object. (MS-PS3-2)

ETS1.A: Defining and Delimiting Engineering Problems
• The more precisely a design task’s criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions. (MS-ETS1-1)

ETS1.B: Developing Possible Solutions
• A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (MS-ETS1-4)
• Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. (MS-ETS1-3)
• Models of all kinds are important for testing solutions. (MS-ETS1-4)

ETS1.C: Optimizing the Design Solution
• Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design. (MS-ETS1-3)

Crosscutting Concepts
Systems and System Models
• Models can be used to represent systems and their interactions – such as inputs, processes, and outputs – and energy and matter flows within systems. (MS-PS3-2)

Common Core Standards
ELA/Literacy
WHST.6-8.7
Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration. (MS-ETS1-2)

Mathematics
MP.2
Reason abstractly and quantitatively. (MS-PS3-1), (MS-ETS1-1), (MS-ETS1-2), (MS-ETS1-3), (MS-ETS1-4)