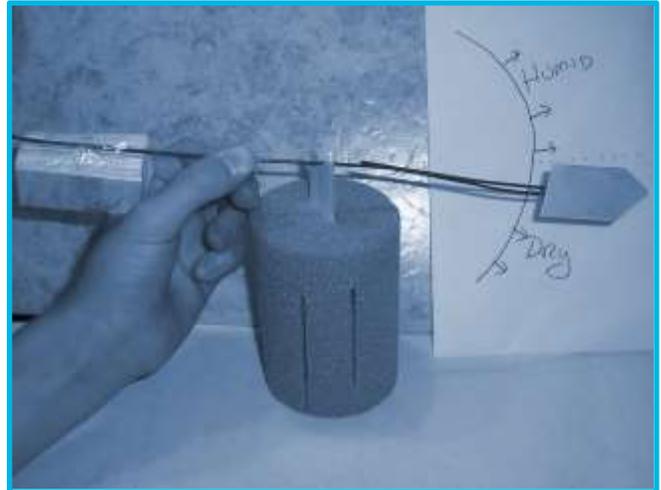


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Lesson Focus

Lesson focuses on how sensors are used in many applications to gather information about our environment. This lesson focuses on the hygrometer, a sensor used to measure humidity. Through this lesson, students work in teams to design and build a hygrometer out of everyday items to measure humidity levels. The student hygrometers are not meant to be exact, but are expected to indicate a change. Students select from everyday items to build their hygrometer, test their machine using a spray bottle to increase humidity, evaluate the effectiveness of their system and those of other teams, and present their findings to the class.



Lesson Synopsis

The "Making Sense of Sensors" lesson explores sensors, and focused specifically on how humidity is measured. Students work in teams of "engineers" to design and build their own "hygrometer" out of everyday items. Students plan a design, and then build and test a system to measure changes in humidity. Students evaluate the systems of all student teams, review their results, and present findings to the class.

Age Levels

8-18.

Objectives

- ◆ Learn about engineering design.
- ◆ Learn about instrumentation.
- ◆ Learn about planning and construction.
- ◆ Learn about teamwork and working in groups.

Anticipated Learner Outcomes

As a result of this activity, students should develop an understanding of:

- ◆ engineering design
- ◆ problem solving
- ◆ teamwork

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Lesson Activities

Students learn how instruments that measure humidity come in different designs and serve many purposes. Students work in teams to design and build their own hygrometer out of everyday items that can indicate changes in relative humidity. The student hygrometers are not meant to be exact, but are expected to indicate a change. Student teams review their own designs, the designs of other teams, and present their findings to the class.

Resources/Materials

- ◆ Teacher Resource Documents (attached)
- ◆ Student Worksheets (attached)
- ◆ Student Resource Sheets (attached)

Alignment to Curriculum Frameworks

See attached curriculum alignment sheet.

Internet Connections

- ◆ TryEngineering (www.tryengineering.org)
- ◆ National Weather Service Meteorological Conversions and Calculations (<https://www.wpc.ncep.noaa.gov/html/heatindex.shtml>)

Supplemental Reading

- ◆ A Treatise On Meteorology: The Barometer, Thermometer, Hygrometer, Rain-Gauge And Ozonometer (ISBN: 1409788326)
- ◆ Temperature And Humidity Measurement (ISBN: 9814021091)
- ◆ Humidity Control Design Guide for Commercial And Institutional Buildings (ISBN: 1883413982)

Optional Writing Activity

- ◆ Write an essay or a paragraph about why a civil engineer developing a new museum to house watercolor paintings might be concerned about humidity.

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**For Teachers:
 Teacher Resource**

◆ **Lesson Goal**

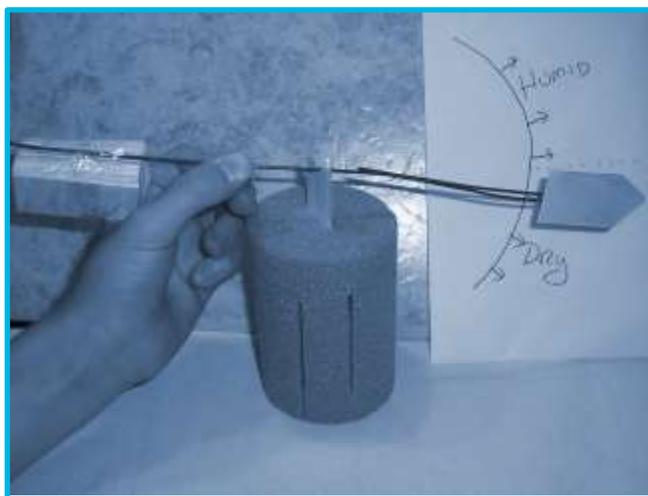
Lesson focuses on how sensors are used in many applications to gather information about our environment. This lesson focuses on the hygrometer, a sensor used to measure humidity. Through this lesson, students work in teams to design and build a hygrometer out of everyday items to measure humidity levels. The student hygrometers are not meant to be exact, but are expected to indicate a change. Students select from everyday items to build their hygrometer, test their machine using a spray bottle to increase humidity, evaluate the effectiveness of their system and those of other teams, and present their findings to the class.

◆ **Lesson Objectives**

- ◆ Learn about engineering design.
- ◆ Learn about instrumentation.
- ◆ Learn about planning and construction.
- ◆ Learn about teamwork and working in groups.

◆ **Materials**

- ◆ Student Resource Sheet
- ◆ Student Worksheets
- ◆ Classroom materials:
 - Water spray bottle, with mist option if possible
- ◆ One set of materials for each group of students:
 - Water absorbing materials such as cotton balls, tissue paper, cardboard, litmus paper, writing paper
 - Wood blocks, plastic or paper cups, straws, cardboard, cotton balls, aluminum foil, rubber bands, tape, toothpicks, paper towels, wire



◆ **Procedure**

1. Show student "engineering" teams their various Student Reference Sheets. These may be read in class, or provided as reading material for the prior night's homework.
2. Divide students into groups of 2-3 students, providing a set of materials per group.
3. Explain that students must work as a team to design a hygrometer out of everyday items that can indicate a change in humidity. Explain that they may base their design on a pivoting gauge (such as the Coventry Hygrometer), or may come up with their own design.
4. Students meet and develop a plan for their hygrometer, including a list of all materials they require for construction.

Making Sense of Sensors

5. Student teams draw their plan and present their plan to the class. Students may adjust their plan based on feedback received at this stage.
6. Student teams build their hygrometer. They may determine that additional materials are needed to complete this step. If so, they need to indicate the new materials or quantity of materials on their design worksheet.
7. Note that students will have to develop their own scale for their hygrometers. They may choose a numerical scale, or mark one section "humid" while another section is "dry."
8. During the testing phase, the hygrometers will be left overnight in the classroom to generate a base "reading" of humidity. These measurements will be recorded. Then, the hygrometers will be exposed to humidity by a soft spray of water. The hygrometer readings after exposure to humidity are then measured and recorded.

Reading on Hygrometer before exposure to mist	Reading on Hygrometer after exposure to 4 sprays of mist	Reading on Hygrometer after exposure to 8 sprays of mist	Reading on Hygrometer after exposure to 16 sprays of mist

9. Teams then complete an evaluation/reflection worksheet, and present their findings to the class.

◆ **Time Needed**

Two to three 45 minute sessions

◆ **Tips**

Younger student teams may require assistance in setting up a balanced pivot for their hygrometer.

◆ **Extension Ideas**

Have the class test what happens if one of the student designed hygrometers is left in a sealed container with a cup of very salty water. (If left overnight, the hygrometer should show a relative humidity level of 75%.)



Student Resource: What is Humidity?

Humidity is the amount of water vapor in the air. In daily language the term "humidity" is normally taken to mean relative humidity. Relative humidity is defined as the ratio of the partial pressure of water vapor in a parcel of air to the saturated vapor pressure of water vapor at a prescribed temperature. Humidity may also be expressed as absolute humidity and specific humidity.

Relative humidity is an important metric used in forecasting weather. Humidity indicates the likelihood of precipitation, dew, or fog. High humidity makes people feel hotter outside in the summer because it reduces the effectiveness of sweating to cool the body by preventing the evaporation of perspiration from the skin. This effect is calculated in a heat index table.



◆ Measuring Relative Humidity

The measurement of relative humidity requires two facts: the temperature, and the dew point. The dew point is the temperature the air must be cooled to in order for condensation to occur. The higher the humidity, the closer the dew point is to the air temperature. When the humidity is 100 percent, the dew point and the temperature are the same. The dew point can never be higher than the temperature of the air at any given time.

Humidity can be measured in several different ways, but most commonly humidity is reported as the "relative humidity." Relative humidity is the ratio of the amount of moisture in the air compared to the amount the air is capable of holding at a given temperature, expressed as a percentage. An online humidity calculator may be found online at the National Weather Service Meteorological Conversions and Calculations website at www.wpc.ncep.noaa.gov/html/heatindex.shtml.

◆ Engineering Implications

Engineers in many disciplines must consider humidity levels in their work. A civil engineer, for example, might be designing a building to house rare books which might be damaged by excessive moisture. Or, an air conditioning and refrigeration engineer might be developing a system to protect rare tapestries in a museum. Chemical and petroleum engineers may face situations where gases and condensing vapors co-exist. Reliable tools are important to engineers as they solve the challenges they face in many fields.

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Student Resource: **What are Sensors?**

◆ **Why We Use Sensors**

Sensors are devices that measure something about the environment and either causes a reaction to take place or reports data which can be read by a person.

For example, a thermometer measures the temperatures outside, or might measure a person's temperature. Some businesses and homes have "low temperature sensors" which trigger a phone call to a property owner to let them know that the temperature in a building has dropped to a dangerous level which might cause pipes to freeze.

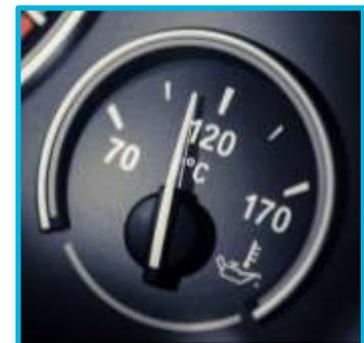
Another type of a sensor is a light sensor, which causes a light to turn on, for example when it becomes dark outside. These are popular in outdoor lighting, and are often solar powered and turn on an exterior light at dusk and off at dawn.

Another sensor is a motion sensor. These are used in burglar alarm systems and also often trigger lights to turn on. For example, the light to the right might be mounted outside a building so when someone walked to an entryway, a light would turn on to guide the way. Some cameras now have motion sensors built in too. They are used to photograph wildlife while not disturbing the animals.

Sensors are also used in familiar devices such as touch sensitive elevator buttons or special computer screens. And hundreds of sensors can be found in the average car -- keeping track of everything from how much gas is left in a tank to how pressured the tires are.

◆ **How Do Sensors Work?**

Every type of sensor operates a little differently. For example, a mercury thermometer shows temperature changes because the liquid mercury expands or contracts up or down a calibrated glass tube with a scale printed on it. Motion sensors might have a beam of light crossing a doorway, or might incorporate radar. For example many grocery store doors open automatically when a customer walks toward the door and causes the radar to bounce back, triggering a response by a motor which opens the door. Some motion sensors detect infrared energy, in the form of heat from a person or animal which might trigger a light to turn on. And, to maintain accuracy, all sensors need to be calibrated from time to time.



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Student Resource: **What is a Hygrometer?**

◆ **How Hygrometers Work**

Hygrometers are instruments used for measuring humidity. It measures water vapor content in the air and communicates changes in humidity visibly and immediately through a graph or a dial. There are several types including:

- Hair hygrometer - uses a human hair as the sensing instrument. The hair lengthens when the air is moist and contracts when the air is dry, but remains unaffected by air temperature. This system works, but the hair does not respond instantly to changes and requires time for measurement.
- Mechanical hygrometer - uses absorbent paper as the sensing instrument. The paper becomes heavier as it absorbs water from the air.
- Electric hygrometer - uses a plate coated with carbon. Electrical resistance of the carbon coating changes as the moisture content of the air changes.
- Infrared hygrometer uses a beam of light containing two separate wave lengths to gauge atmospheric humidity. One of the wavelengths is absorbed by water vapor, the other is unaffected, providing an extremely accurate index of water vapor for paths of a few inches or thousands of feet.

◆ **Coventry Hygrometer**

A nice, old example is the Coventry Hygrometer. It is based on how paper expands and contracts with changes in moisture. It is housed at the Science Museum in London, was invented by John Coventry, and made by George Adams the Younger in about 1790. It provides a very simple measure of the moisture in the air and was widely used by chemists and naturalists. A pile of paper discs soaked in brine was suspended on one arm of a balance. The other arm moved over a scale. The paper absorbed water in the atmosphere and so became heavier in humid conditions, tipping the scale as an indication of humidity.

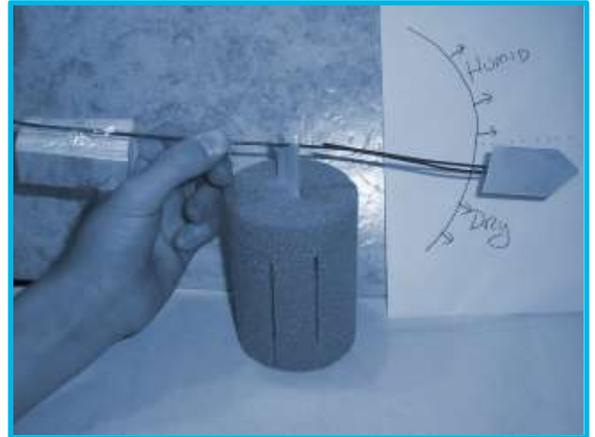


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Student Worksheet:
Design Your Own Hygrometer

You are part of a team of engineers who have been given the challenge of developing an instrument to detect changes in humidity -- a hygrometer. You'll have lots of materials to choose from, and will likely have to incorporate a pivot and gauge within your hygrometer. If your system works, you'll be able to report a change in the humidity in your classroom. How you accomplish the task is up to your team!.



◆ **Planning Stage**

Meet as a team and discuss the problem you need to solve. You'll need to determine which materials you'll request from the many everyday items your teacher has available. As a team, come up with your best design and draw it in the box below. Be sure to indicate the materials you anticipate using, including the quantity you'll request from your teacher. Present your design to the class. You may choose to revise your teams' plan after you receive feedback from class.

Design:

Materials Needed:

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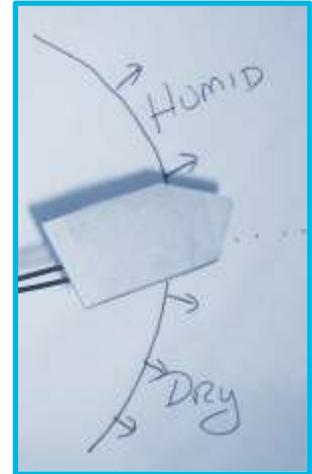
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Student Worksheet (continued):

In the box below, draw the scale that you will use to "measure" changes in humidity. You may use numbers or words in your scale. You may wish to copy the one you draw to use within your hygrometer, or make another one that fits the size of your instrument during construction.

Scale:

Example:



Student Worksheet (continued):

◆ Construction Phase

Build your hygrometer. During construction you may decide you need additional items or that your design needs to change. This is ok -- just make a new sketch and revise your materials list. You may want to trade items with other teams, or request additional materials from your teacher.

◆ Testing Phase

Leave your hygrometer overnight to generate a base "reading" of humidity. The next day, record the "normal" humidity measurement in the box below.

Next, the hygrometers will be exposed to humidity by a series of sprays of mist/water. Mark your hygrometers "readings" after each spray.

Reading on Hygrometer before exposure to mist	Reading on Hygrometer after exposure to 4 sprays of mist	Reading on Hygrometer after exposure to 8 sprays of mist	Reading on Hygrometer after exposure to 16 sprays of mist

◆ Evaluation Phase

Teams then complete an evaluation/reflection worksheet, and present their findings to the class.



Student Evaluation Form

1. Did you succeed in creating a hygrometer that indicated a change in humidity?
2. What aspect of your design do you think worked best? Why?
3. What hygrometer "engineered" by another student team did you find most inspiring? How did it work better than yours, or what did feature did you appreciate that the other team came up with?
4. Did you decide to revise your original design while in the construction phase? Why? How?
5. Hygrometers have been measuring humidity for hundreds of years. Do you think that technology has improved the hygrometer? How?
6. How durable do you think your hygrometer is? Would it be able to continue to work for a week, two weeks, a year, a decade? What would you have to do to your hygrometer to make it reliable for a longer period of time?
7. Do you think you would have been able to complete this project easier if you were working alone? Explain...
8. If you could have used a material or materials that were not provided to you, what would you have requested? Why do you think this material might have helped with the challenge?
9. Can you identify five sensors in your school building?
10. What was your favorite part of the challenge? Design Phase? Building Phase? Testing Phase? Why?

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For Teachers:

Alignment to Curriculum Frameworks

Note: Lesson plans in this series are aligned to one or more of the following sets of standards:

- U.S. Science Education Standards (http://www.nap.edu/catalog.php?record_id=4962)
- U.S. Next Generation Science Standards (<http://www.nextgenscience.org/>)
- International Technology Education Association's Standards for Technological Literacy (<http://www.iteea.org/TAA/PDFs/xstnd.pdf>)
- U.S. National Council of Teachers of Mathematics' Principles and Standards for School Mathematics (<http://www.nctm.org/standards/content.aspx?id=16909>)
- U.S. Common Core State Standards for Mathematics (<http://www.corestandards.org/Math>)
- Computer Science Teachers Association K-12 Computer Science Standards (<http://csta.acm.org/Curriculum/sub/K12Standards.html>)

◆ **National Science Education Standards Grades K-4 (ages 4 - 9)**

CONTENT STANDARD A: Science as Inquiry

As a result of activities, all students should develop

- ◆ Abilities necessary to do scientific inquiry

CONTENT STANDARD B: Physical Science

As a result of the activities, all students should develop an understanding of

- ◆ Properties of objects and materials
- ◆ Position and motion of objects

CONTENT STANDARD D: Earth and Space Science

As a result of their activities, all students should develop an understanding of

- ◆ Changes in earth and sky

CONTENT STANDARD E: Science and Technology

As a result of activities, all students should develop

- ◆ Abilities of technological design

CONTENT STANDARD F: Science in Personal and Social Perspectives

As a result of activities, all students should develop understanding of

- ◆ Changes in environments
- ◆ Science and technology in local challenges

◆ **National Science Education Standards Grades 5-8 (ages 10 - 14)**

CONTENT STANDARD A: Science as Inquiry

As a result of activities, all students should develop

- ◆ Abilities necessary to do scientific inquiry

CONTENT STANDARD B: Physical Science

As a result of their activities, all students should develop an understanding of

- ◆ Properties and changes of properties in matter

CONTENT STANDARD E: Science and Technology

As a result of activities in grades 5-8, all students should develop

- ◆ Abilities of technological design
- ◆ Understandings about science and technology

CONTENT STANDARD F: Science in Personal and Social Perspectives

As a result of activities, all students should develop understanding of

- ◆ Populations, resources, and environments
- ◆ Risks and benefits
- ◆ Science and technology in society

For Teachers:
Alignment to Curriculum Frameworks

◆ **National Science Education Standards Grades 9-12 (ages 14-18)**

CONTENT STANDARD A: Science as Inquiry

As a result of activities, all students should develop

- ◆ Abilities necessary to do scientific inquiry

CONTENT STANDARD B: Physical Science

As a result of their activities, all students should develop understanding of

- ◆ Structure and properties of matter

CONTENT STANDARD E: Science and Technology

As a result of activities, all students should develop

- ◆ Abilities of technological design
- ◆ Understandings about science and technology

CONTENT STANDARD F: Science in Personal and Social Perspectives

As a result of activities, all students should develop understanding of

- ◆ Science and technology in local, national, and global challenges

CONTENT STANDARD G: History and Nature of Science

As a result of activities, all students should develop understanding of

- ◆ Nature of scientific knowledge
- ◆ Historical perspectives

◆ **Next Generation Science Standards Grades 3-5 (Ages 8-11)**

Motion and Stability: Forces and Interactions

Students who demonstrate understanding can:

- ◆ 3-PS2-1. Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object.

Engineering Design

Students who demonstrate understanding can:

- ◆ 3-5-ETS1-1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
- ◆ 3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
- ◆ 3-5-ETS1-3. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

◆ **Next Generation Science Standards Grades 6-8 (Ages 11-14)**

Engineering Design

Students who demonstrate understanding can:

- ◆ MS-ETS1-1 Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
- ◆ MS-ETS1-2 Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

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For Teachers:**Alignment to Curriculum Frameworks****◆Standards for Technological Literacy - All Ages****The Nature of Technology**

- ◆ Standard 3: Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.

Technology and Society

- ◆ Standard 6: Students will develop an understanding of the role of society in the development and use of technology.
- ◆ Standard 7: Students will develop an understanding of the influence of technology on history.

Design

- ◆ Standard 9: Students will develop an understanding of engineering design.
- ◆ Standard 10: Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

Abilities for a Technological World

- ◆ Standard 11: Students will develop abilities to apply the design process.
- ◆ Standard 13: Students will develop abilities to assess the impact of products and systems.

The Designed World

- ◆ Standard 17: Students will develop an understanding of and be able to select and use information and communication technologies.