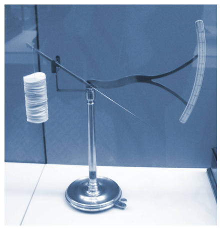
Making Sense of Sensors



Provided by TryEngineering - www.tryengineering.org

Lesson Focus

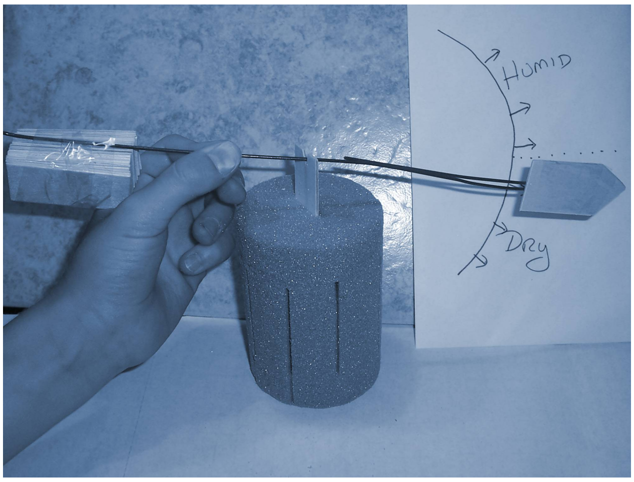
Lesson focuses on how sensors are used in many applications to gather information about our environment. This lesson focuses on the hygrometer, a sensor used to measure humidity. Through this lesson, students work in teams to design and build a hygrometer out of everyday items to measure humidity levels. 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.

Year Levels

5 – 10 Science Inquiry Skills and Science as a Human Endeavour



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

Lesson Activities

Students learn how instruments that measure humidity come in different designs and server 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)
- How to measure humidity using a hygrometer (http://www.bom.gov.au/info/weatherkit/section2/hygro.shtml)
- Curriculum links (www.acara.edu.au)

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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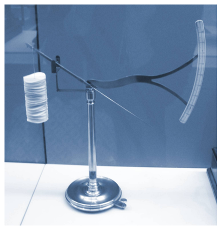

For Teachers:
Teacher Resource

◆ 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.
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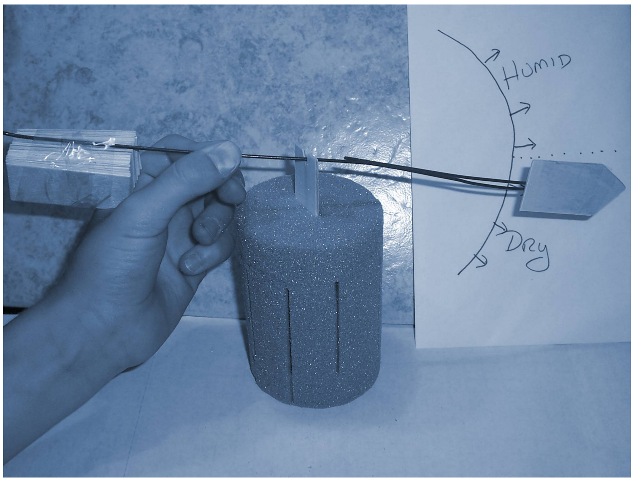
- Learn about teamwork and working in groups.



◆ 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.

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.

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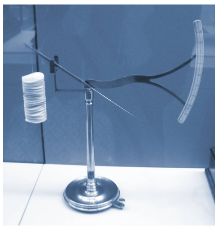

For Teachers:
Teacher Resource (continued)

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%.)

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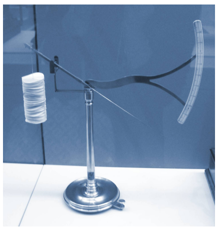


Student Resource:
What is Humidity?

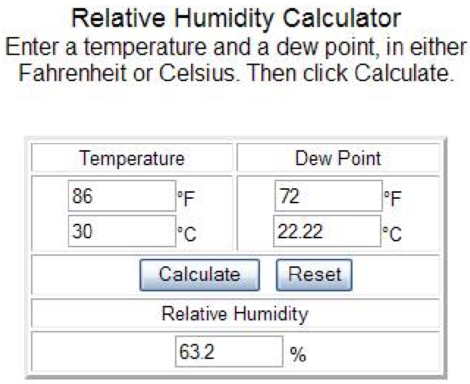
Humidity is the amount of water vapour in the air. In daily language the term "humidity" is normally taken to mean relative humidity. Relative humidity is defined as the ratio of the partial pressure of water vapour in a parcel of air to the saturated vapour pressure of water vapour at a prescribed temperature. 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 U.S. National Oceanic and Atmospheric Administration website: www.hpc.ncep.noaa.gov/html/dewrh.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, and 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 vapours co-exist. Reliable tools are important to engineers as they solve the challenges they face in many fields.

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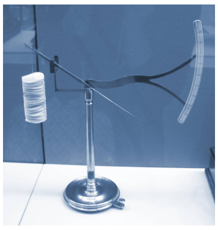
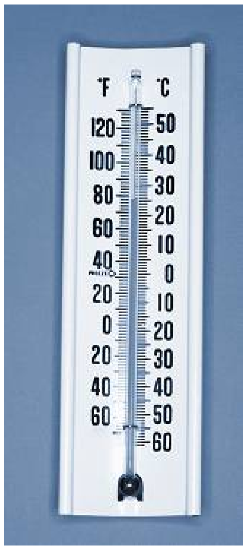


Student Resource:
What are Sensors?

◆ 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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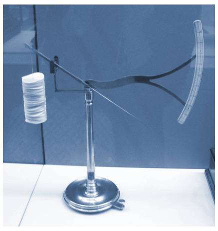


Student Resource:
What is a Hygrometer?

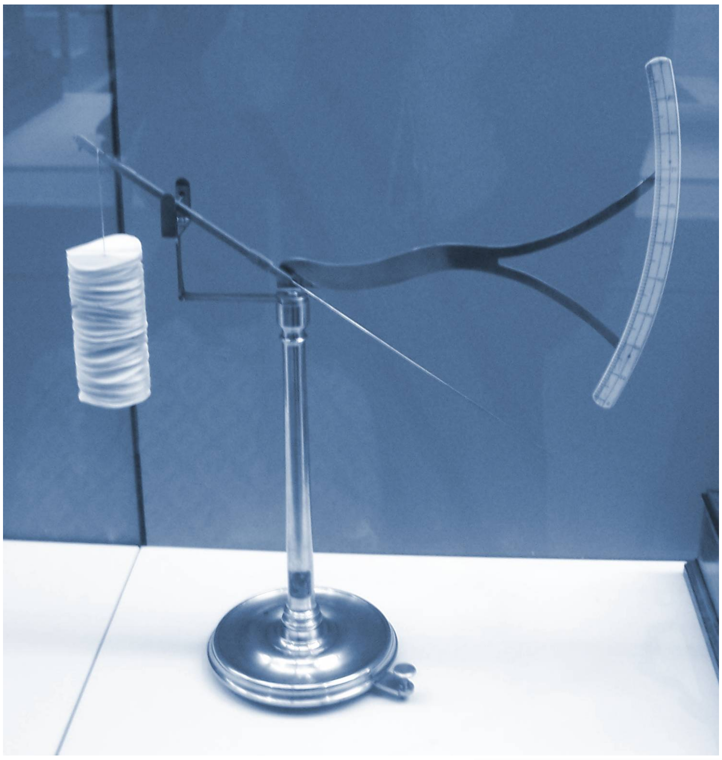
◆ How Hygrometers Work

Hygrometers are instruments used for measuring humidity. It measures water vapour 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 vapour, the other is unaffected, providing an extremely accurate index of water vapour 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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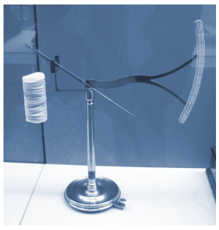
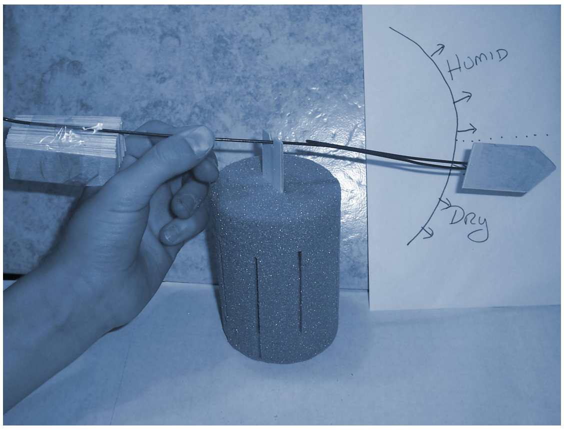


Student Worksheet:
Design Your Own Hygrometer

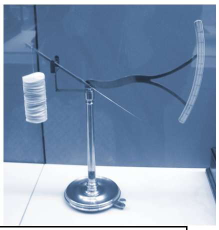


You are part of a team of engineers who have been given the challenge of developing an instrument to detect changes in humidity -- a hygrometer. You'll have lots of materials to choose from, and will likely have to incorporate a pivot and gauge within your hygrometer. If your system works, you'll be 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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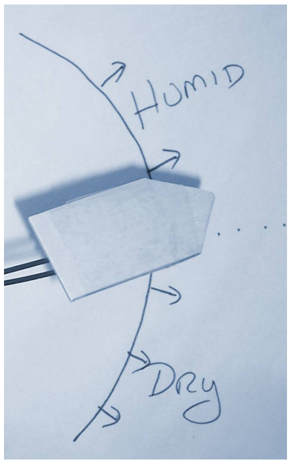
Student Worksheet (continued):

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:



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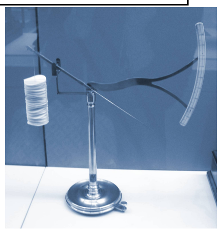

Student Worksheet (continued):

◆ 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.

Modified and aligned to Australian Curriculum by Queensland Minerals and Energy Academy

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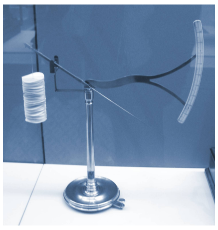


Student Evaluation Form

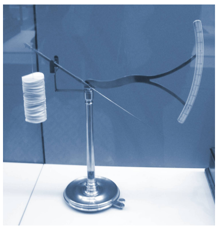
1. Did you succeed in creating a hygrometer that indicated a change in humidity?

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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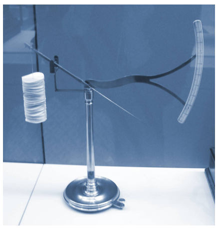

For Teachers:
Alignment to Curriculum Frameworks

Science Inquiry Skills
Year 5

With guidance, select appropriate investigation methods to answer questions or solve problems (**ACSIS086**)

Use equipment and materials safely, identifying potential risks (**ACSIS088**)

Suggest improvements to the methods used to investigate a question or solve a problem (**ACSIS091**)

Year 6

With guidance, select appropriate investigation methods to answer questions or solve problems. (**ACSIS103**)

Use equipment and materials safely, identifying potential risks (**ACSIS105**)

Suggest improvements to the methods used to investigate a question or solve a problem (**ACSIS108**)

Year 7

Collaboratively and individually plan and conduct a range of investigation types including fieldwork and experiments, ensuring safety and ethical guidelines are followed (**ACSIS125**)

In fair tests, measure and control variables, and select equipment to collect data with accuracy appropriate to the task **(ACSIS126)**

Reflect on the method used to investigate a question or solve a problem, including evaluating the quality of data collected, and identify improvements to the method **(ACSIS131)**

Year 8

Collaboratively and individually plan and conduct a range of investigation types including fieldwork and experiments, ensuring safety and ethical guidelines are followed (**ACSIS140**)

In fair tests, measure and control variables, and select equipment to collect data with accuracy appropriate to the task **(ACSIS141)**

Reflect on the method used to investigate a question or solve a problem, including evaluating the quality of data collected, and identify improvements to the method **(ACSIS146)**

Year 9

Plan, select and use appropriate investigation methods, including fieldwork and laboratory experimentation, to collect reliable data; assess risk and address ethical issues associated with these methods **(ACSIS165)**

Select and use appropriate equipment, including digital technologies, to systematically and accurately collect and record data **(ACSIS166)**

Evaluate conclusions, including identifying sources of uncertainty and possible alternative explanations, and describe specific ways to improve the quality of the data **(ACSIS171)**

Year 10

Plan, select and use appropriate investigation methods, including fieldwork and laboratory experimentation, to collect reliable data; assess risk and address ethical issues associated with these methods **(ACSIS199)**

Select and use appropriate equipment, including digital technologies, to systematically and accurately collect and record data **(ACSIS200)**

Evaluate conclusions, including identifying sources of uncertainty and possible alternative explanations, and describe specific ways to improve the quality of the data **(ACSIS205)**

Science as a Human Endeavour

Year 5

Science involves testing predictions by gathering data and using evidence to develop explanations of events and phenomena **(ACSHE081)**

Scientific understandings, discoveries and inventions are used to solve problems and directly affect people's lives **(ACSHE083)**

Year 6

Science involves testing predictions by gathering data and using evidence to develop explanations of events and phenomena **(ACSHE098)**

Scientific understandings, discoveries and inventions are used to solve problems and directly affect people's lives **(ACSHE100)**

Year 7

Science knowledge can develop through collaboration and connecting ideas across the disciplines of science **(ACSHE223)**

People use understanding and skills from across the disciplines of science in their occupations **(ACSHE224)**

Year 8

Science knowledge can develop through collaboration and connecting ideas across the disciplines of science **(ACSHE226)**

People use understanding and skills from across the disciplines of science in their occupations **(ACSHE227)**

Year 9

Advances in scientific understanding often rely on developments in technology and technological advances are often linked to scientific discoveries **(ACSHE158)**

Advances in science and emerging sciences and technologies can significantly affect people's lives, including generating new career opportunities **(ACSHE161)**

Year 10

Advances in scientific understanding often rely on developments in technology and technological advances are often linked to scientific discoveries **(ACSHE192)**

Advances in science and emerging sciences and technologies can significantly affect people's lives, including generating new career opportunities **(ACSHE195)**

Mathematics Links with Science Curriculum (Skills used in this activity)	General Capabilities	Cross-Curriculum Priorities

• Process data using simple tables • Data analysis skills (graphs) • Analysis of patterns and trends • Use of metric units	• Literacy • Numeracy • Critical and creative thinking • Personal and social capacity • ICT capability	• Sustainability

Science Achievement Standards

Year 5

By the end of Year 5, students classify substances according to their observable properties and behaviours. They explain everyday phenomena associated with the transfer of light. They describe the key features of our solar system. They analyse how the form of living things enables them to function in their environments. Students discuss how scientific developments have affected people's lives and how science knowledge develops from many people's contributions.

Students follow instructions to pose questions for investigation, predict what might happen when variables are changed, and plan investigation methods. They use equipment in ways that are safe and improve the accuracy of their observations. Students construct tables and graphs to organise and identify patterns. They use patterns in their data to suggest explanations and refer to data when they report their findings. They describe ways to improve the fairness of their methods and communicate their ideas, methods and findings using a range of texts.

Year 6

By the end of Year 6, students compare and classify different types of observable changes in materials. They analyse requirements for the transfer of electricity and describe how energy can be transformed from one form to another to generate electricity. They explain how natural events cause rapid changes to the Earth's surface. They decide and predict the effect of environmental changes on individual living things. Students explain how scientific knowledge is used in decision making and identify contributions to the development of science by people from a range of cultures.

Students follow procedures to develop investigable questions and design investigations into simple cause-and-effect relationships. They identify variables to be changed and measured and describe potential safety risks when planning methods. They collect, organise and interpret their data, identifying where improvements to their methods or research could improve the data. They describe and analyse relationships in data using graphic representations and construct multi-modal texts to communicate ideas, methods and findings.

Year 7

By the end of Year 7, students describe techniques to separate pure substances from mixtures. They represent and predict the effects of unbalanced forces, including Earth's gravity, on motion. They explain how the relative positions of the Earth, sun and moon affect phenomena on Earth. They analyse how the sustainable use of resources depends on the way they are formed and cycled through Earth systems. They predict the effect of environmental changes on feeding relationships and classify and organise diverse organisms based on observable differences. Students describe situations where scientific knowledge from different science disciplines has been used to solve a real-world problem. They explain how the solution was viewed by, and impacted on, different groups in society.

Students identify questions that can be investigated scientifically. ***They plan fair experimental methods, identify variables to be changed and measured. They select equipment that improves fairness and accuracy and describe how they considered safety. Students draw on evidence to support their conclusions***. They summarise data from different sources, describe trends and refer to the quality of their data when suggesting improvements to their methods. They communicate their ideas, methods and findings using scientific language and appropriate representations.

Year 8

By the end of Year 8, students compare physical and chemical changes and use the particle model to explain and predict the properties and behaviours of substances. They identify different forms of energy and describe how energy transfers and transformations cause change in simple systems. They compare processes of rock formation, including the time scales involved. They analyse the relationship between structure and function at cell, organ and body system levels. Students examine the different science knowledge used in occupations. They explain how evidence has led to an improved understanding of a scientific idea and describe situations in which scientists collaborate to generate solutions to contemporary problems.

Students identify and construct questions and problems that they can investigate scientifically. ***They consider safety and ethics when planning investigations, including designing field or experimental methods. They identify variables to be changed, measured and controlled***. Students construct representations of their data to reveal and analyse patterns and trends, and use these when justifying their conclusions. ***They explain how modifications to methods could improve the quality of their data and apply their own scientific knowledge and investigation findings to evaluate claims made by others***. They use appropriate language and representations to communicate science ideas, methods and findings in a range of texts types.

Year 9

By the end of Year 9, students explain chemical processes and natural radioactivity in terms of atoms and energy transfers and describe examples of important chemical reactions. They describe models of energy transfer and apply these to explain phenomena. They explain global features and events in terms of geological processes and timescales. They analyse how biological systems function and respond to external changes with reference to interdependencies, energy transfers and flows of matter. They describe social and technological factors that have influenced scientific developments and predict how future applications of science and technology may affect people's lives.

Students design questions that can be investigated using a range of inquiry skills. ***They design methods that include the control and accurate measurement of variables and systematic collection of data and describe how they considered ethics and safety. They analyse trend in data, identify relationships between variables and reveal inconsistencies in results. They analyse their methods and the quality of their data, and explain specific actions to improve the quality of their evidence***. They evaluate others 'methods and explanations from a scientific perspective and use appropriate language and representations when communicating their findings and ideas to specific audiences.

Year 10

By the end of Year 10, students analyse how the periodic table organises elements and use it to make predictions about the properties of elements. They explain how chemical reactions are used to produce particular products and how different factors influence the rate of reactions. They explain the concept of energy conservation and represent energy transfer and transformation within systems. They apply relationships between force, mass and acceleration to predict changes in the motions of objects. Students describe and analyse interactions and cycles within and between Earth's spheres. They evaluate the evidence for scientific theories that explain the origin of the universe and the diversity of life on Earth. They explain the processes that underpin heredity and evolution. Students analyse how the models and theories they use have developed over time and discuss the factors that prompted their view.

Students develop questions and hypotheses and independently design and improve appropriate methods of investigation, including field work and laboratory experimentation. They explain how they have considered reliability, safety, fairness and ethical actions in their methods and identify where digital technologies can be used to enhance the quality of their data. When analysing data, selecting evidence and developing and justifying conclusions, they identify alternative explanations for findings and explain any sources of uncertainty. Students evaluate the validity and reliability of claims made in secondary sources with reference to currently held scientific views, the quality of methodology and the evidence cited. They construct evidence-based arguments and select appropriate representations and text types to communicate science ideas for specific purposes.