Elementary Engineering in the 2009 Minnesota Academic Standards in Science

	Strand	Substrand	Standard Understand that...	Code	Benchmark	Connections to Engineering: Comments from The Works Activities in bold type can be done by The Works
K	1. The Nature of Science and Engineering	1. The Practice of Science	2. Scientific inquiry is a set of interrelated processes used to pose questions about the natural world and investigate phenomena.	0.1.1.2.1	Use observations to develop an accurate description of a natural phenomenon and compare one's observations and descriptions with those of others.	
		2. The Practice of Engineering	1. Some objects occur in nature; others have been designed and processed by people.	0.1.2.1.1	Sort objects into two groups: those that are found in nature and those that are human made. *For example:* Cars, pencils, trees, rocks.	Engineers create things to meet human needs and wants. As your students sort, when they find something that is human made, ask: Why did people make this? What need or want did it meet? Show your students a picture of a city or the inside of a store or house and ask: What would be left is you took away all the things made by humans?
	2. Physical Science	1. Matter	1. Objects can be described in terms of the materials they are made of and their physical properties.	0.2.1.1.1	Sort objects in terms of color, size, shape, and texture, and communicate reasoning for the sorting system.	Explore other physical properties, too: What kind of things can you pick up with a magnet? What materials conduct electricity? Which things sink and which things float? Magnet Workshop: The Works offers a 30-minute workshop about magnets appropriate for kindergarteners. As part of the workshop, students sort materials based on whether or not they are magnetic.
	3. Earth and Space Science	2. Interdepen-dence Within the Earth System	2. Weather can be described in measurable quantities and changes from day to day and with the seasons.	0.3.2.2.1	Monitor daily and seasonal changes in weather and summarize the changes. *For example:* Recording cloudiness, rain, snow and temperature.	Weather is different in different parts of the world. With your students, explore how weather affects the things people create. How are houses different in hot places and in cold places? How are roofs different in snowy places? What could you use to build a house in a forest? In a desert?
				0.3.2.2.2	Identify the sun as a source of heat and light. *For example:* Record the time of day when the sun shines into different	Have your students design and build a simple solar cooker. Measure the temperature in the shade, in the sun and in your solar cooker. Oven thermometers are useful here. Can you melt a piece of chocolate? Can you melt a marshmallow? Make a s'more in your solar

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					locations of the school and note patterns.	cooker.
	4. Life Science	1. Structure and Function in Living Systems	1. Living things are diverse with many different observable characteristics.	0.4.1.1.1	Observe and compare plants and animals.	
				0.4.1.1.2	Identify the external parts of a variety of plants and animals including humans. *For example:* Heads, legs, eyes and ears on humans and animals; flowers, stems and roots on many plants.	
				0.4.1.1.3	Differentiate between living and nonliving things. *For example:* Sort live organisms (or pictures of organisms) into groups of those that grow and reproduce and need air, food and water, and those that don't.	Engineers work with living as well as nonliving things. For example, biomedical engineers make artificial legs, joints and heart valves for people. Show your students pictures of these devices and ask why they were invented. Agricultural, chemical and industrial engineers design processes for making plants into all kinds of foods and useful products. With your students, explore what materials and products are made from plants.
		2. Interdepen-dence in Living Systems	1. Natural systems have many components that interact to maintain the living system.	0.4.2.1.1	Observe a natural system or its model and identify living and nonliving components in that system. *For example:* A wetland, prairie, garden or aquarium.	
1	1. The Nature of Science and Engineering	1. The Practice of Science	1. Scientists work as individuals and groups to investigate the natural world, emphasizing evidence and communicating with others.	1.1.1.1.1	When asked "How do you know?," students support their answer with observations. *For example:* Use observations to tell why a squirrel is a living thing.	
				1.1.1.1.2	Recognize that describing things as accurately as possible is important in science because it enables people to compare their observations with those of others.	Communication is also important in engineering. Part of the engineering design process is describing precisely how to build something. Another important part is sharing your results.

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		3. Interactions Among Science, Technology Engineering, Mathematics, and Society	1. Designed and natural systems exist in the world. These systems are made up of components that act within a system and interact with other systems.	1.1.3.1.1	Observe that many living and nonliving things are made of parts and that if a part is missing or broken, they may not function properly.	Often engineers have to take things apart to learn more about how they work, so they can create new ones. It is interesting for children to take things apart and talk about the parts and what each part does. This can be done with simple things, like a pen or a flashlight, or more complicated things like a mechanical toy, a computer keyboard, a VCR or a DVD player.
			2. Men and women throughout the history of all cultures, including Minnesota American Indian tribes and communities, have been involved in engineering design and scientific inquiry.	1.1.3.2.1	Recognize that tools are used by people, including scientists and engineers, to gather information and solve problems. *For example:* Magnifier, snowplow and calculator.	Other examples of using tools to solve problems include using a magnet to sort recycling or using a hammer to drive a nail. Many times, there are different machines that serve a similar purpose. For example, ask your students how many different ways there are to move people and things. Answers they come up with might include bicycles, boats, cars, buses and airplanes. Reading picture biographies of engineers, inventors and scientists is a good way to integrate STEM with language arts for this grade.
	3. Earth and Space Science	1. Earth Structure and Processes	3. Earth materials include solid rocks, sand, soil and water. These materials have different observable physical properties that make them useful.	1.3.1.3.1	Group or classify rocks in terms of color, shape and size.	Mining engineers figure out how to extract metals and other useful things from rocks.
				1.3.1.3.2	Describe similarities and differences between soil and rocks. *For example:* Use screens to separate components of soil and observe the samples using a magnifier.	
				1.3.1.3.3	Identify and describe large and small objects made of Earth materials.	The first tools made by early humans were made of stone. Show your students pictures of spear heads, axes and other early tools. These toolmakers were the first engineers. Long ago, Native Americans in Minnesota made stone tools. Earth materials have also been used to make houses in many cultures throughout human history. Examples

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						of this include sod houses, wigwams, and pueblos. With your students, look at pictures and read books about houses like this.
1	4. Life Science	1. Structure and Function in Living Systems	1. Living things are diverse with many different observable characteristics.	1.4.1.1.1	Describe and sort animals into groups in many ways, according to their physical characteristics and behaviors.	
		2. Interdepen-dence in Living Systems	1. Natural systems have many components that interact to maintain the living system.	1.4.2.1.1	Recognize that animals need space, water, food, shelter and air.	Environmental engineers design tools and techniques to measure air quality and water quality to find out when habitats are in trouble.
				1.4.2.1.2	Describe ways in which an animal's habitat provides for its basic needs. *For example:* Compare students' houses with animal habitats.	Ask your students to design and build a habitat for a pet or other small animal, such as a hamster cage, an ant farm or an aquarium. One example: have your students collect small twigs, rocks or pinecones and put them in a box. Clay animals could be made to complete the habitat.
		3. Evolution in Living Systems	1. Plants and animals undergo a series of orderly changes during their life cycles.	1.4.3.1.1	Demonstrate an understanding that animals pass through life cycles that include a beginning, development into adults, reproduction and eventually death. *For example:* Use live organisms or pictures to observe the changes that occur during the life cycle of butterflies, meal worms or frogs.	
				1.4.3.1.2	Recognize that animals pass through the same life cycle stages as their parents.	
2	1. The Nature of Science and Engineering	1. The Practice of Science	2. Scientific inquiry is a set of interrelated processes incorporating multiple approaches that are used to pose	2.1.1.2.1	Raise questions about the natural world and seek answers by making careful observations, noting what happens when you interact with an object, and sharing the answers with others.	Exploring properties of natural materials is important in engineering. It helps engineers determine the best way to use each object. For example, sharp stones can be used to cut, while long, flexible reeds can be used to weave baskets.

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			questions about the natural world and investigate phenomena.			
2	1. The Nature of Science and Engineering	2. The Practice of Engineering	2. Engineering design is the process of identifying problems and devising a product or solution.	2.1.2.2.1	Identify a need or problem and construct an object that helps to meet the need or solve the problem. *For example:* Design and build a tool to show wind direction. *Another example:* Design a kite and identify the materials to use.	Engage your students with a real engineering challenge! Here are some examples to try: • Design and build a box to hold valentines • Make a car with rolling wheels. • Build a model bridge, house or skyscraper. Integrating engineering: Explore how problems were solved in other cultures or other times. Communicate your design in writing and speaking. Float Your Boat Challenge: The Works offers a workshop in which students hone their engineering skills as they design and construct a boat – then see how much weight it can hold!
				2.1.2.2.2	Describe why some materials are better than others for making a particular object and how materials that are better in some ways may be worse in other ways. *For example:* Objects made of plastic or glass.	You'd want to build a roof from a material that repels water, such as straw or stone. You'd want to build a wall of something sturdy that keeps cold out and warmth in. You'd want to make a basket out of something strong and lightweight. Egg Drop Challenge: What materials would you use to package an egg to protect it from a fall of a few feet or a few stories? Offer your students materials like bubble wrap, paper, coffee filters and cardboard, and see what they come up with. (Tip: put the eggs in plastic bags before distributing them to students!)
				2.1.2.2.3	Explain how engineered or designed items from everyday life benefit people.	A good question to ask: What did people do before this or that was invented? Before light bulbs, cars, computers, television, zippers?

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	2. Physical Science	1. Matter	1. Objects can be described in terms of the materials they are made of and their physical properties.	2.2.1.1.1	Describe objects in terms of color, size, shape, weight, texture, flexibility, strength and the types of materials in the object.	Explore other physical properties, too: What kind of things can you pick up with a magnet? What kinds of things conduct electricity? Which things sink and which things float?
			2. The physical properties of materials can be changed, but not all materials respond the same way to what is done to them.	2.2.1.2.1	Observe, record and recognize that water can be a solid or a liquid and can change from one state to another and that the amount of water stays the same when it melts and freezes.	Chemistry Workshops: The Works has several chemistry workshops for school groups to explore states of matter (solids, liquids and gases), including Chemistry Challenge, Mixing Molecules and Messy Chemistry.
		2. Motion	1. The motion of an object can be described by a change in its position over time.	2.2.2.1.1	Describe an object's change in position relative to other objects or a background. *For example:* Forward, backward, going up, going down.	
				2.2.2.1.2	Demonstrate that objects move in a variety of ways, including a straight line, a curve, a circle, back and forth, and at different speeds. *For example:* Spinning toy and rocking toy. *Another example:* Construct objects that will move in a straight line or a curve such as a marble or toy car on a track.	Other ideas include: Marble run: Second graders often enjoy making marble runs. Find materials such as paper towel tubes and cardboard, and make a track that takes a marble at least one minute to run. Catapult: Have your students use clothespins, rubber bands and other materials to design and build a machine that shoots marshmallows. Does the marshmallow move in a straight line or a circle or a curve? Paper airplane: Have your students make paper airplanes. Throw them. Do they move in a straight line, a circle or a curve?

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2	2. Physical Science	2. Motion	2. The motion of an object can be changed by push or pull forces.	2.2.2.2.1	Describe how push and pull forces can make objects move. *For example:* Push and pull objects on smooth and rough surfaces.	Cars and Ramps: Have your students make a car that rolls down a ramp. What is pulling the car? (Gravity.) Try out different surfaces for the ramp: smooth foil paper, a strip of carpet or other materials. This is also a good project for practicing measurement. Use a large piece of foam core for a ramp and let the students see how far a car will go when the ramp at steep angle versus a shallow one. K'nex Ramp: The Works museum has an exhibit where students can use the building material K'nex to design and build cars, then race them against each other down a ramp with a timer that measures to the hundredth of a second.
				2.2.2.2.2	Describe how things near Earth fall to the ground unless something holds them up.	
	3. Earth and Space Science	2. Interdepen-dence Within the Earth System	2. Weather can be described in measurable quantities and changes from day to day and with the seasons.	2.3.2.2.1	Measure, record and describe weather conditions using common tools. *For example:* Temperature, precipitation, sunrise/sunset, and wind speed/direction.	Have your students design and build a simple solar cooker. Measure the temperature in the shade, in the sun and in your solar cooker. Oven thermometers are handy here. Can you melt a piece of chocolate? Can you melt a marshmallow? Make a s'more in your solar cooker. Have your students design and construct a machine to show wind speed or wind direction. Or make a machine that uses the power of the wind to do something (sail a boat, lift a weight, spin a pinwheel).
	4. Life Science	1. Structure and Function in Living Systems	1. Living things are diverse with many different observable characteristics.	2.4.1.1.1	Describe and sort plants into groups in many ways, according to their physical characteristics and behaviors.	
		2. Interdepen-dence in Living Systems	1. Natural systems have many components that interact to maintain the living system	2.4.2.1.1	Recognize that plants need space, water, food and air and they fulfill these needs in different ways.	With your students, learn about what plants need and then design and make a terrarium.

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		3. Evolution in Living Systems	1. Plants and animals undergo a series of orderly changes during their life cycles.	2.4.3.1.1	Describe the characteristics of plants at different stages of their life cycles. *For example*: Use live organisms or pictures to observe the changes that occur during the life cycles of bean plants or marigolds.	
3	1. The Nature of Science and Engineering	1. The Practice of Science	1. Scientists work as individuals and in groups, emphasizing evidence, open communication and skepticism.	3.1.1.1.1	Provide evidence to support claims other than saying "Everyone knows that," or "I just know," and question such reasons when given by others.	
3	1. The Nature of Science and Engineering	1. The Practice of Science	2. Scientific inquiry is a set of interrelated processes incorporating multiple approaches that are used to pose questions about the natural world and investigate phenomena.	3.1.1.2.1	Generate questions that can be answered when scientific knowledge is combined with knowledge gained from one's own observations or investigations. *For example:* Investigate the sounds produced by striking various objects.	
				3.1.1.2.2	Recognize that when a science investigation is done the way it was done before, even in a different place, a similar result is expected.	
				3.1.1.2.3	Maintain a record of observations, procedures and explanations, being careful to distinguish between actual observations and ideas about what was observed. *For example:* Make a chart comparing observations about the structures of plants and animals.	Engineers also need to make careful records of observations and ideas.
				3.1.1.2.4	Construct reasonable explanations based on evidence collected from observations or experiments.	

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		3. Interactions Among Science, Technology Engineering, Mathematics, and Society	2. Men and women throughout the history of all cultures, including Minnesota American Indian tribes and communities, have been involved in engineering design and scientific inquiry.	3.1.3.2.1	Understand that everybody can use evidence to learn about the natural world, identify patterns in nature, and develop tools. *For example:* Ojibwe and Dakota knowledge and use of patterns in the stars to predict and plan.	With your students, explore how different Native American cultures built dwellings, grew food, and made clothing, tools, medicines and boats. The people who invented all these things were early engineers.
				3.1.3.2.2	Recognize that the practice of science and/or engineering involves many different kinds of work and engages men and women of all ages and backgrounds.	This is a great place to integrate language and social science by reading biographies of scientists, inventors and engineers. Children can also develop oral communication skills by enacting someone they have read about. Third graders are also ready to explore the different kinds of scientists (biologist, chemist, astronomer, physicist, geologist) and different kinds of engineers and what each does: electrical, chemical, mechanical, civil, aerospace, software, environmental, agricultural, industrial, etc…
			4. Tools and mathematics help scientists and engineers see more, measure more accurately, and do things that they could not otherwise accomplish.	3.1.3.4.1	Use tools, including rulers, thermometers, magnifiers and simple balances, to improve observations and keep a record of the observations made.	Students could make their own rulers or balances.

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3	2. Physical Science	3. Energy	1. Energy appears in different forms, including sound and light.	3.2.3.1.1	Explain the relationship between the pitch of a sound, the rate of vibration of the source and factors that affect pitch. *For example:* Changing the length of a string that is plucked changes the pitch. *Another example:* Compare materials according to their ability to conduct or produce sound.	Sound Workshop: The Works offers a 60 minute workshop appropriate for third graders that discusses vibrations, sound, and different kinds of instruments. Students use real tools to create a twanging "ear harp."
				3.2.3.1.2	Explain how shadows can form in various ways.	
				3.2.3.1.3	Describe how light travels in a straight line until it is absorbed, redirected, reflected or allowed to pass through an object. *For example:* Use a flashlight, mirrors and water to demonstrate reflection and bending of light.	Make a Kaleidoscope: The Works offers a 30 minute workshop that explores reflection and symmetry. Students make their own kaleidoscope to take home. More Exploration: Visit The Works museum with your third grade class and explore many unique exhibits on optics – light, color, shadows, mirrors, reflection, refraction, optical sensors and fiber optics.
	3. Earth and Space Science	3. The Universe	1. The sun and moon have locations and movements that can be observed and described.	3.3.3.1.1	Observe and describe the daily and seasonal changes in the position of the sun and compare observations.	
				3.3.3.1.2	Recognize the pattern of apparent changes in the moon's shape and position.	With your students, learn about aerospace engineers and the Apollo missions to the moon during the 1960s. NASA hopes to establish a permanent colony on the moon in the next couple decades. What would you need to design for a lunar colony?
			2. Objects in the solar system are seen from Earth as points of light with distinctive patterns of motion.	3.3.3.2.1	Demonstrate how a large light source at a great distance looks like a small light that is much closer. *For example:* Car headlights at a distance look small compared to when they are close.	Engineers design many tools for exploring the solar system, from telescopes to rocket ships.

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				3.3.3.2.2	Recognize that the Earth is one of several planets that orbit the sun, and that the moon orbits the Earth.	Learn about the technology of space exploration, like telescopes, rocket ships and the Mars rovers. NASA has some excellent curriculum resources at www.nasa.gov/education/materials
	4. Life Science	1. Structure and Function in Living Systems	1. Living things are diverse with many different characteristics that enable them to grow, reproduce and survive.	3.4.1.1.1	Compare how the different structures of plants and animals serve various functions of growth, survival and reproduction. *For example:* Skeletons in animals and stems in plants provide strength and stability.	Engineers are often inspired by nature. Encourage your students to compare the structures of plants and animals to the structures of buildings and machines. How are truss bridges similar to bird bones? How are bird wings different from airplane wings? Compare the shape of boat hulls and shark bodies.
				3.4.1.1.2	Identify common groups of plants and animals using observable physical characteristics, structures and behaviors. *For example:* Sort animals into groups such as mammals and amphibians based on physical characteristics. *Another example:* Sort and identify common Minnesota trees based on leaf/needle characteristics.	With your students, explore all the different products made from trees – paper, wood, cloth, cardboard, oils, spices, foods, etc. – and find out how they are made. You can do this for other agricultural products, too.
3	4. Life Science	3. Evolution in Living Systems	2. Offspring are generally similar to their parents, but may have variations that can be advantageous or disadvantageous in a particular environment.	3.4.3.2.1	Give examples of likenesses between adults and offspring in plants and animals that can be inherited or acquired. *For example:* Collect samples or pictures that show similarities between adults and their young offspring.	
				3.4.3.2.2	Give examples of differences among individuals that can sometimes give an individual an advantage in survival and reproduction.	Agricultural engineers and biologists save seeds from plants that best meet human needs. This is how new and better foods are developed. For instance, Native American cultures selected the best corn plants to grow over many generations.

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4	1. The Nature of Science and Engineering	2. Practice of Engineering	1. Engineers design, create and develop structures, processes and systems that are intended to improve society and may make humans more productive.	4.1.2.1.1	Describe the positive and negative impacts that the designed world has on the natural world as more and more engineered products and services are created and used.	For example, a negative impact of plastics and packaging is that they don't decompose quickly and they sit in landfills. But on the positive side, environmental engineers are developing new ways to recycle these materials. With your students, find out how your school recycles.
			2. Engineering design is the process of identifying problems, developing multiple solutions, selecting the best possible solution, and building the product.	4.1.2.2.1	Identify and investigate a design solution and describe how it was used to solve an everyday problem. *For example:* Investigate different varieties of construction tools.	One design solution you could focus on is Velcro. With your students, learn about the history of fasteners (buttons, snaps, etc.) and explore the unique need that Velcro fills. Why was it invented? Why do we still use it?
				4.1.2.2.2	Generate ideas and possible constraints for solving a problem through engineering design. *For example:* Design and build an electromagnet to sort steel and aluminum materials for recycling.	For example, ask your students to design and build a device to rescue a small stuffed animal from a box while standing three feet away. Amusement Park Science: The Works can bring a residency to your school in which students use electricity, motors, and their creativity to design and build a unique twirling amusement park ride.
				4.1.2.2.3	Test and evaluate solutions, including advantages and disadvantages of the engineering solution, and communicate the results effectively.	See above.
		3. Interactions Among Science, Technology Engineering, Mathematics, and Society	3. The needs of any society influence the technologies that are developed and how they are used.	4.1.3.3.1	Describe a situation in which one invention led to other inventions.	With your students, learn about the history of recorded sound. You can follow the progression from wax cylinders to shellac records to vinyl records to cassette tapes to CDs to mp3 players. This is a good place to integrate history and STEM. Alternatively, you could study the invention of the battery. How many things were invented after electricity became portable?

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	2. Physical Science	1. Matter	1. Objects have observable properties that can be measured.	4.2.1.1.1	Measure temperature, volume, weight and length using appropriate tools and units.	
4	2. Physical Science	1. Matter	2. Solids, liquids and gases are states of matter that have unique properties.	4.2.1.2.1	Distinguish between solids, liquids and gases in terms of shape and volume. *For example:* Water changes shape depending on the shape of its container.	
				4.2.1.2.2	Describe how the states of matter change as a result of heating and cooling.	
		3. Energy	1. Energy appears in different forms, including heat and electromagnetism.	4.2.3.1.1	Describe the transfer of heat energy when a warm and a cool object are touching or placed near each other.	
				4.2.3.1.2	Describe how magnets can repel or attract each other and how they attract certain metal objects.	What exactly do magnets attract? How can you use this to sort recycled metals?
				4.2.3.1.3	Compare materials that are conductors and insulators of heat and/or electricity. *For example:* Glass conducts heat well, but is a poor conductor of electricity.	Use the circuits your students create in 4.2.3.2.2 to test various materials and see which conduct electricity.
			2. Energy can be transformed within a system or transferred to other systems or the environment.	4.2.3.2.1	Identify several ways to generate heat energy. *For example:* Burning a substance, rubbing hands together, or electricity flowing through wires.	Electrical engineers invent new sources of light and heat energy. Compare different kinds of light bulbs, such as incandescent and fluorescent. Which is more energy efficient? Which generates more heat?
				4.2.3.2.2	Construct a simple electrical circuit using wires, batteries and light bulbs.	Super Circuits: The Works offers a workshop about electricity appropriate for fourth graders. Students investigate the components of simple circuits and hook up some circuits of their own, then build a motor-powered fan to take home.

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				4.2.3.2.3	Demonstrate how an electric current can produce a magnetic force. *For example:* Construct an electromagnet to pick up paperclips.	
	3. Earth and Space Science	1. Earth Structure and Processes	3. Rocks are Earth materials that may vary in composition.	4.3.1.3.1	Recognize that rocks may be uniform or made of mixtures of different minerals.	
				4.3.1.3.2	Describe and classify minerals based on their physical properties. *For example:* Streak, luster, hardness, reaction to vinegar.	
		2. Interdepen-dence Within the Earth System	3. Water circulates through the Earth's crust, oceans and atmosphere in what is known as the water cycle.	4.3.2.3.1	Identify where water collects on Earth, including atmosphere, ground and surface water, and describe how water moves through the Earth system using the processes of evaporation, condensation and precipitation.	
	3. Earth and Space Science	4. Human Interactions with Earth Systems	1. In order to improve their existence, humans interact with and influence Earth systems.	4.3.4.1.1	Describe how the methods people utilize to obtain and use water in their homes and communities can affect water supply and quality.	Not everyone on this planet has access to clean, safe water to drink. This is a real world challenge for engineers. Fourth graders can design water filters and pumps and learn about the global issue of safe water. This website has good directions to get to started: http://library.thinkquest.org/04apr/00222/filter.htm With your students, you can also visit or learn about municipal water treatment plants, which rely on a wide range of biological engineering.
4	4. Life Science	4. Human Interactions with Living Systems	2. Microorganisms can get inside one's body and they may keep it from working properly.	4.4.4.2.1	Recognize that the body has defense systems against germs, including tears, saliva, skin and blood.	Engineers and scientist create products (antibacterial cleaners, antibacterial salve, etc.) to explore and prevent infection and disease.
				4.4.4.2.2	Give examples of diseases that can be prevented by vaccination.	With your students, learn about the engineers and scientists who invented different vaccines.

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5	1. The Nature of Science and Engineering	1. The Practice of Science	1. Science is a way of knowing about the natural world, is done by individuals and groups, and is characterized by empirical criteria, logical argument and skeptical review.	5.1.1.1.1	Explain why evidence, clear communication, accurate record keeping, replication by others, and openness to scrutiny are an essential part of doing science.	All these are important in engineering as well. People's lives depend on many engineered products – from airplanes to heart valves to bridges – so engineers must test products accurately and rigorously.
				5.1.1.1.2	Recognize that when scientific investigations are replicated they generally produce the same results, and when results differ significantly, it is important to investigate what may have caused such differences. *For example:* Measurement errors, equipment failures, or uncontrolled variables.	
				5.1.1.1.3	Understand that different explanations for the same observations usually lead to making more observations and trying to resolve the differences.	
				5.1.1.1.4	Understand that different models can be used to represent natural phenomena and these models have limitations about what they can explain. *For example:* Different kinds of maps of a region provide different information about the land surface.	
			2. Scientific inquiry requires identification of assumptions, use of critical and logical thinking, and	5.1.1.2.1	Generate a scientific question and plan an appropriate scientific investigation, such as systematic observations, field studies, open-ended exploration or controlled experiments to answer the question.	

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			consideration of alternative explanations.	5.1.1.2.2	Identify and collect relevant evidence, make systematic observations and accurate measurements, and identify variables in a scientific investigation.	
				5.1.1.2.3	Conduct or critique an experiment, noting when the experiment might not be fair because some of the things that might change the outcome are not kept the same, or that the experiment is not repeated enough times to provide valid results.	
5	1. Nature of Science and Engineering	3. Interactions Among Science, Technology Engineering, Mathematics, and Society	2. Men and women throughout the history of all cultures, including Minnesota American Indian tribes and communities, have been involved in engineering design and scientific inquiry.	5.1.3.2.1	Describe how science and engineering influence and are influenced by local traditions and beliefs. *For example:* Sustainable agriculture practices used by many cultures.	Integrate STEM with history: explore the building of the pyramids or large cathedrals. What motivated the architects to design these structures? What new discoveries did they make in engineering?
			4. Tools and mathematics help scientists and engineers see more, measure more accurately, and do things that they could not otherwise accomplish.	5.1.3.4.1	Use appropriate tools and techniques in gathering, analyzing and interpreting data. *For example:* Spring scale, metric measurements, tables, mean/median/range, spreadsheets, and appropriate graphs.	
				5.1.3.4.2	Create and analyze different kinds of maps of the student's community and of Minnesota. *For example:* Weather maps, city maps, aerial photos, regional maps or online map resources.	5th graders can learn about zoning and can design cities. For more information on this, contact Emily at 952-848-4857 or emily@theworks.org.

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	2. Physical Science	2. Motion	1. An object's motion is affected by forces and can be described by the object's speed and the direction it is moving.	5.2.2.1.1	Give examples of simple machines and demonstrate how they change the input and output of forces and motion.	The Works hands-on museum has many exhibits about simple machines, ranging from giant pulleys to wedges, ramps, levers and gears. Catapult: The Works offers a two-hour workshop appropriate for fifth graders in which students explore levers and pivots, then make their own wooden catapult to take home. Students can change variables such as the pivot point, size and strength of rubber bands, etc. Back in the classroom, you can experiment with these variables and chart the results. How far can you shoot? How high? How accurately?
				5.2.2.1.2	Identify the force that starts something moving or changes its speed or direction of motion. *For example:* Friction slows down a moving skateboard.	
				5.2.2.1.3	Demonstrate that a greater force on an object can produce a greater change in motion.	
	3. Earth and Space Science	1. Earth Structure and Processes	2. The surface of the Earth changes. Some changes are due to slow processes and some changes are due to rapid processes.	5.3.1.2.1	Explain how, over time, rocks weather and combine with organic matter to form soil.	
				5.3.1.2.2	Explain how slow processes, such as water erosion, and rapid processes, such as landslides and volcanic eruptions, form features of the Earth's surface.	With your students, learn how engineers work to predict extreme weather and natural disasters like tornados and earthquakes.

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5	3. Earth and Space Science	4. Human Interaction with Earth Systems	1. In order to maintain and improve their existence, humans interact with and influence Earth systems.	5.3.4.1.1	Identify renewable and non-renewable energy and material resources that are found in Minnesota and describe how they are used. *For example:* Water, iron ore, granite, sand and gravel, wind and forests.	KidWind has excellent curriculum materials and great hands-on engineering projects on wind energy online. Visit their website at http://www.kidwind.org/
				5.3.4.1.2	Give examples of how mineral and energy resources are obtained and processed and how that processing modifies their properties to make them more useful. *For example:* Iron ore, biofuels, or coal.	
				5.3.4.1.3	Compare the impact of individual decisions on natural systems. *For example:* Choosing paper or plastic bags impacts landfills as well as ocean life cycles.	Egg Drop Challenge: What *recyclable* materials would you use to package an egg to protect it from a fall of a few feet or a few stories? Offer your students materials like paper, recyclable packing materials and cardboard, and see what they come up with. (Tip: put the eggs in plastic bags before distributing them to students!)
	4. Life Science	1. Structure and Function in Living Systems	1. Living things are diverse with many different characteristics that enable them to grow, reproduce and survive.	5.4.1.1.1	Describe how plant and animal structures and their functions provide an advantage for survival in a given natural system. *For example:* Compare the physical characteristics of plants or animals from widely different environments, such as desert versus tropical, and explore how each has adapted to its environment.	
		2. Interdepen-dence in Living Systems	1. Natural systems have many parts that interact to maintain the living system.	5.4.2.1.1	Describe a natural system in Minnesota, such as a wetland, prairie or garden, in terms of the relationships among its living and nonliving parts, as well as inputs and outputs. *For example:* Design and construct a	Use the engineering design process to design and make a habitat for a plant or animal. The Works' engineering design process can be found on our website, www.theworks.org, under the "Teachers" tab.

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					habitat for a living organism that meets its need for food, air and water.	
				5.4.2.1.2	Explain what would happen to a system such as a wetland, prairie or garden if one of its parts were changed. *For example:* Investigate how road salt runoff affects plants, insects and other parts of an ecosystem. *Another example:* Investigate how an invasive species changes an ecosystem.	Explore Acid and Base chemistry and the effect of "acid rain" on ecosystems. Acids and Bases: The Works offers a workshop on acids and bases appropriates for fifth graders. Students make their own indicator and test the pH of household products.
		4. Human Interactions with Living Systems	1. Humans change environments in ways that can be either beneficial or harmful to themselves and other organisms.	5.4.4.1.1	Give examples of beneficial and harmful human interaction with natural systems. *For example:* Recreation, pollution, or wildlife management.	
6	1. The Nature of Science and Engineering	2. The Practice of Engineering	1. Engineers create, develop and manufacture machines, structures, processes and systems that impact society and may make humans more productive.	6.1.2.1.1	Identify a common engineered system and evaluate its impact on the daily life of humans. *For example:* Refrigeration, cell phone or automobile.	
				6.1.2.1.2	Recognize that there is no perfect design and that new technologies have consequences that may increase some risks and decrease others. *For example:* Seat belts and airbags.	One example of this is the harmful effects that some new technologies can have on the environment. With your students, discuss the benefits of quick car and plane travel vs. the cost of releasing CO2 into the atmosphere. Another example to explore is medicine. Some medications might be effective but very expensive and hard to obtain, while others that are cheaper might not

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						be as effective, or might have unpleasant side effects.
				6.1.2.1.3	Describe the trade-offs in using manufactured products in terms of features, performance, durability and cost.	
				6.1.2.1.4	Explain the importance of learning from past failures, in order to inform future designs of similar products or systems. *For example:* Space shuttle or bridge design.	Engineers always learn from others - that's part of the engineering design process. With your students, learn about the failure of the Tacoma Narrows Bridge ("Galloping Gertie"). Engineers learned a lot from this disaster. Also check out the book *Fantastic Feats and Failures* written by the editors of YES Mag.
			2. Engineering design is the process of devising products, processes and systems that address a need, capitalize on an opportunity, or solve a specific problem.	6.1.2.2.1	Apply and document an engineering design process that includes identifying criteria and constraints, making representations, testing and evaluation, and refining the design as needed to construct a product or system that solves a problem. *For example:* Investigate how energy changes from one form to another by designing and constructing a simple roller coaster for a marble.	These steps are often referred to as the engineering design process. See a diagram of this process on The Works' website, www.theworks.org, under the "Teachers" tab. Pasta Bridges Design Challenge: The Works offers a 60 or 90 minute design challenge workshop appropriate for sixth graders. Students will design and build bridges using only raw pasta and hot glue. Then test the bridges to see how much weight they hold! See Teaching Resources on The Works' website for many ideas for more engineering challenges. Design Squad has many excellent challenges that you can download for free.

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		3. Interactions Among Science, Technology, Engineering, Mathematics and Society	1. Designed and natural systems exist in the world. These systems consist of components that act within the system and interact with other systems.	6.1.3.1.1	Describe a system in terms of its subsystems and parts, as well as its inputs, processes and outputs.	Sixth graders can take apart complex machines such VCRs, computers, keyboards, telephones, etc. A lot of websites can tell you what you will find inside those gadgets. For example, check out: http://www.howstuffworks.com/vcr.htm Be sure to recycle the circuit board properly.
				6.1.3.1.2	Distinguish between open and closed systems. *For example:* Kinetic and potential energy are conserved in a closed system, but are not conserved when frictional heating is considered.	
6	1. The Nature of Science and Engineering	3. Interactions Among Science, Technology, Engineering, Mathematics and Society	4. Current and emerging technologies have enabled humans to develop and use models to understand and communicate how natural and designed systems work and interact.	6.1.3.4.1	Determine and use appropriate safe procedures, tools, measurements, graphs and mathematical analyses to describe and investigate natural and designed systems in a physical science context.	
				6.1.3.4.2	Demonstrate the conversion of units within the Systeme Internationale (SI, or metric) and estimate the magnitude of common objects and quantities using metric units.	

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	2. Physical Science	1. Matter	1. Pure substances can be identified by properties which are independent of the sample of the substance and can be explained by a model of matter that is composed of small particles.	6.2.1.1.1	Explain density, dissolving, compression, diffusion and thermal expansion using the particle model of matter.	
			2. Substances can undergo physical changes which do not change the composition or the total mass of the substance in a closed system.	6.2.1.2.1	Identify evidence of physical changes, including changing phase or shape, and dissolving in other materials.	
				6.2.1.2.2	Describe how mass is conserved during a physical change in a closed system. *For example:* The mass of an ice cube does not change when it melts.	
				6.2.1.2.3	Use the relationship between heat and the motion and arrangement of particles in solids, liquids and gases to explain melting, freezing, boiling and evaporation.	
		2. Motion	1. The motion of an object can be described in terms of position, direction and speed.	6.2.2.1.1	Measure and calculate the speed of an object that is traveling in a straight line.	
				6.2.2.1.2	Graph an object's position as a function of time and an object's speed as a function of time for an object traveling in a straight line and use the graphs to describe the object's motion.	

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6	2. Physical Science	2. Motion	2. Forces have magnitude and direction and govern the motion of objects.	6.2.2.2.1	Recognize that when the forces acting on an object are balanced, the object remains at rest or continues to move at a constant speed in a straight line, and that unbalanced forces cause a change in the speed or direction of the motion of an object.	
				6.2.2.2.2	Identify the forces acting on an object and describe how the sum of the forces affects the motion of the object. *For example:* Forces acting on a book on a table or a car on the road.	
				6.2.2.2.3	Recognize that some forces between objects act when the objects are in direct contact and others, such as magnetic, electrical and gravitational forces can act from a distance.	
				6.2.2.2.4	Distinguish between mass and weight.	
		3. Energy	1. Waves involve the transfer of energy without the transfer of matter.	6.2.3.1.1	Describe properties of waves, including speed, wavelength, frequency and amplitude.	
				6.2.3.1.2	Explain how the vibration of particles in air and other materials results in the transfer of energy through sound waves.	
				6.2.3.1.3	Use wave properties of light to explain reflection, refraction and the color spectrum.	
			2. Energy can be transformed within a system or transferred to other systems or the environment.	6.2.3.2.1	Differentiate between kinetic and potential energy and analyze situations where kinetic energy is converted to potential energy and vice versa.	

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				6.2.3.2.2	Trace the changes of energy forms, including thermal, electrical, chemical, mechanical or others as energy is used in devices. *For example:* A bicycle, light bulb or automobile.	Explore how motors convert electrical energy to mechanical energy and how turbines convert mechanical energy to electrical energy. Build a wind turbine – KidWind has great resources for this: http://www.kidwind.org/ Motor Power: The Works offers a 60-minute workshop about motors appropriate for sixth graders. Students learn what's inside a motor, see how motors convert electrical energy to mechanical energy, and experiment with "the world's simplest motor." Students make and take home a motor-powered fan.
				6.2.3.2.3	Describe how energy is transferred in conduction, convection and radiation.	Challenge your students to design, build and test a solar oven. Can you cook a marshmallow in only 10 minutes on a sunny day? For inspiration, look here: http://solarcooking.org/plans/