Bemidji Area Schools

Grades 9-12 Applied Science Outcomes

Strand	Substrand	Standard "Understand that ...	Code	Benchmark "The student will ...
1. The Nature of Science and Engineering	1. The Practice of Science	1. Science is a way of knowing about the natural world and is characterized by emperical criteria, logical argument and skeptical review.	9.1.1.1.1	Explain the implications of the assumption that the rules of the universe are the same everywhere and these rules can be discovered by careful and systematic investigation.
			9.1.1.1.2	Understand that scientists conduct investigations for a variety of reasons, including: to discover new aspects of the natural world, to explain observed phenomena, to test the conclusions of prior investigations, or to test the predictions of current theories.
			9.1.1.1.3	Explain how the traditions and norms of science define the bounds of professional scientific practice and reveal instances of scientific error or misconduct. *For example:* The use of peer review, publications and presentations.
			9.1.1.1.4	Explain how societal and scientific ethics impact research practices. *For example:* Research involving human subjects may be conducted only with the informed consent of the subjects.
			9.1.1.1.5	Identify sources of bias and explain how bias might influence the direction of research and the interpretation of data. *For example:* How funding of research can influence questions studied, procedures used, analysis of data, and communication of results.
			9.1.1.1.6	Describe how changes in scientific knowledge generally occur in incremental steps that include and build on earlier knowledge.
			9.1.1.1.7	Explain how scientific and technological innovations-as well as new evidence-can challenge portions of, or entire accepted theories and models including, but not limited to: cell theory, atomic theory, theory of evolution, plate tectonic theory, germ theory of disease, and the big bang theory.
		2. Scientific inquiry uses multiple interrelated processes to pose and investigate questions about the natural world.	9.1.1.2.1	Formulate a testable hypothesis, design and conduct an experiment to test the hypothesis, analyze the data, consider alternative explanations, and draw conclusions supported by evidence from the investigation.
			9.1.1.2.2	Evaluate the explanations proposed by others by examining and comparing evidence, identifying faulty reasoning, pointing out statements that go beyond the scientifically acceptable evidence, and suggesting alternative scientific explanations.

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1. The Nature of Science and Engineering	1. The Practice of Science	2. Scientific inquiry uses multiple interrelated processes to pose and investigate questions about the natural world.	9.1.1.2.3	Identify the critical assumptions and logic used in a line of reasoning to judge the validity of a claim.
			9.1.1.2.4	Use primary sources or scientific writings to identify and explain how different types of questions and their associated methodologies are used by scientists for investigations in different disciplines..
	2. The Practice of Engineering	1. Engineering is a way of addressing human needs by applying science concepts and mathematical techniques to develop new products, tools, processes and systems.	9.1.2.1.1	Understand that engineering designs and products are often continually checked and critiqued for alternatives, risks, costs and benefits, so that subsequent designs are refined and improved. *For example:* If the price of an essential raw material changes, the product design may need to be changed.
			9.1.2.1.2	Recognize that risk analysis is used to determine the potential positive and negative consequences of using a new technology or design, including the evaluation of causes and effects of failures. *For example:* Risks and benefits associated with using lithium batteries.
			9.1.2.1.3	Explain and give examples of how, in the design of a device, engineers consider how it is to be manufactured, operated, maintained, replaced and disposed of.
		2. Engineering design is an analytical and creative process of devising a solution to meet a need or solve a specific problem.	9.1.2.2.1	Identify a problem and the associated constraints on possible design solutions. *For example:* Constraints can include time, money, scientific knowledge and available technology.
			9.1.2.2.2	Develop possible solutions to an engineering problem and evaluate them using conceptual, physical and mathematical models to determine the extent to which the solutions meet the design specifications. *For example:* Develop a prototype to test the quality, efficiency and productivitiy of a product.

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1. The Nature of Science and Engineering	3. Interactions Among Science, Technology, Engineering, Mathematics, and Society	1. Natural and designed systems are made up of components that act within a system and interact with other systems.	9.1.3.1.1	Describe a system, including specifications of boundaries and subsystems, relationships to other systems, and identification of inputs and expected outputs. *For example:* A power plant or ecosystem.
			9.1.3.1.2	Identify properties of a system that are different from those of its parts but appear because of the interaction of those parts.
			9.1.3.1.3	Describe how positive and/or negative feedback occur in systems. *For example:* The greenhouse effect
		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.	9.1.3.2.1	Provide examples of how diverse cultures, including natives from all of the Americas, have contributed scientific and mathematical ideas and technological inventions. *For example:* Native American understanding of ecology; Lisa Meitner's contribution to understanding radioactivity; Tesla's ideas and inventions relating to electricity; Watson, Crick and Franklin's discovery of the structure of DNA; or how George Washington Carver's ideas changed land use
			9.1.3.2.2	Analyze possible careers in science and engineering in terms of education requirements, working practices and rewards.
		3. Science and engineering operate in the context of society and both influence and are influenced by this context.	9.1.3.3.1	Describe how values and constraints affect science and engineering. *For example:* Economic, environmental, social, political, ethical, health, safety, and sustainability issues.
			9.1.3.3.2	Communicate, justify, and defend the procedures and results of a scientific inquiry or engineering design project using verbal, graphic, quantitative, virtual, or written means.
		4. Science, technology, engineering, and mathematics rely on each other to enhance knowledge and understanding.	9.1.3.4.1	Describe how technological problems and advances often create a demand for new scientific knowledge, improved mathematics, and new technologies.

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Strand	Substrand	Standard "Understand that ...	Code	Benchmark "The student will ...
1. The Nature of Science and Engineering	3. Interactions Among Science, Technology, Engineering, Mathematics, and Society	4. Science, technology, engineering, and mathematics rely on each other to enhance knowledge and understanding.	9.1.3.4.2	Determine and use appropriate safety procedures, tools, computers and measurement instruments in science and engineering contexts. *For example:* Consideration of chemical and biological hazards in the lab.
			9.1.3.4.3	Select and use appropriate numeric, symbolic, pictorial, or graphical representation to communicate scientific ideas, procedures and experimental results.
			9.1.3.4.4	Relate the reliability of data to consistency of results, identify sources of error, and suggest ways to improve the data collection and analysis. *For example:* Use statistical analysis or error analysis to make judgments about the validity of results
			9.1.3.4.5	Demonstrate how unit consistency and dimensional analysis can guide the calculation of quantitative solutions and verification of results.
			9.1.3.4.6	Analyze the strengths and limitations of physical, conceptual, mathematical and computer models used by scientists and engineers.

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2. Physical Science	1. Matter	1. The structure of the atom determines chemical properties of elements.	9.2.1.1.1	Describe the relative charges, masses, and locations of the protons, neutrons, and electrons in an atom of an element.
			9.2.1.1.2	Describe how experimental evidence led Dalton, Rutherford, Thompson, Chadwick and Bohr to develop increasingly accurate models of the atom.
			9.2.1.1.3	Explain the arrangement of the elements on the Periodic Table, including the relationships among elements in a given column or row.
			9.2.1.1.4	Explain that isotopes of an element have different numbers of neutrons and that some are unstable and emit particles and/or radiation. *For example*: Some rock formations and building materials emit radioactive radon gas. *Another example:* The predictable rate of decay of radioactive isotopes makes it possible to estimate the age of some materials, and makes them useful in some medical procedures.
		2. Chemical reactions involve the rearrangement of atoms as chemical bonds are broken and formed through transferring or sharing of electrons and the absorption or release of energy.	9.2.1.2.1	Describe the role of valence electrons in the formation of chemical bonds.
			9.2.1.2.2	Explain how the rearrangement of atoms in a chemical reaction illustrates the law of conservation of mass.
			9.2.1.2.3	Describe a chemical reaction using words and symbolic equations. *For example:* The reaction of hydrogen gas with oxygen gas can be written: $2H2 + O2 \rightarrow 2H2O$.
			9.2.1.2.4	Relate exothermic and endothermic chemical reactions to temperature and energy changes.
	2. Motion	2. An object's mass and the forces on it affect the motion of an object.	9.2.2.2.1	Recognize that inertia is the property of an object that causes it to resist changes in motion.
			9.2.2.2.2	Explain and calculate the acceleration of an object subjected to a set of forces in one dimension (F=ma).
			9.2.2.2.3	Demonstrate that whenever one object exerts force on another, a force equal in magnitude and opposite in direction is exerted by the second object back on the first object.
			9.2.2.2.4	Use Newton's universal law of gravitation to describe and calculate the attraction between massive objects based on the distance between them. *For example:* Calculate the weight of a person on different planets using data of the mass and radius of the planets.

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2. Physical Science	3. Energy	2. Energy can be transformed within a system or transferred to other systems or the environment, but is always conserved.	9.2.3.2.1	Identify the energy forms and explain the transfers of energy involved in the operation of common devices. *For example:* Light bulbs, electric motors, automobiles or bicycles.
			9.2.3.2.2	Calculate and explain the energy, work and power involved in energy transfers in a mechanical system. *For example:* Compare walking and running up or down steps.
			9.2.3.2.3	Describe how energy is transferred through sound waves and how pitch and loudness are related to wave properties of frequency and amplitude.
			9.2.3.2.4	Explain and calculate current, voltage and resistance, and describe energy transfers in simple electric circuits.
			9.2.3.2.5	Describe how an electric current produces a magnetic force, and how this interaction is used in motors and electromagnets to produce mechanical energy.
			9.2.3.2.6	Compare fission and fusion in terms of the reactants, the products and the conversion from matter into energy. *For example:* The fusion of hydrogen produces energy in the sun. *Another example:* The use of chain reactions in nuclear reactors.
			9.2.3.2.7	Describe the properties and uses of forms of electromagnetic radiation from radio frequencies through gamma radiation. *For example:* Compare the energy of microwaves and X-rays.
	4. Human Interactions with Physical Systems	1. There are benefits, costs and risks to different means of generating and using energy.	9.2.4.1.1	Compare local and global environmental and economic advantages and disadvantages of generating electricity using various sources or energy. *For example:* Fossil fuels, nuclear fission, wind, sun or tidal energy.
			9.2.4.1.2	Describe the trade-offs involved when technological developments impact the way we use energy, natural resources, or synthetic materials. *For example:* Fluorescent light bulbs use less energy than incandescent lights, but contain toxic mercury.

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3. Earth and Space Science	1. Earth Structure and Processes	1. The relationships among earthquakes, mountains, volcanoes, fossil deposits, rock layers and ocean features provide evidence for the theory of plate tectonics.	9.3.1.1.1	Compare and contrast the interaction of tectonic plates at convergent and divergent boundaries. *For example:* Compare the kinds of magma that emerge at plate boundaries.
			9.3.1.1.2	Use modern earthquake data to explain how seismic activity is evidence for the process of subduction. *For example:* Correlate data on distribution, depth and magnitude of earthquakes with subduction zones.
			9.3.1.1.3	Describe how the pattern of magnetic reversals and rock ages on both sides of a mid-ocean ridge provides evidence of sea-floor spreading.
			9.3.1.1.4	Explain how the rock record provides evidence for plate movement. *For example:* Similarities found in fossils, certain types of rocks, or patterns of rock layers in various locations.
			9.3.1.1.5	Describe how experimental and observational evidence led to the theory of plate tectonics.
		3. By observing rock sequences and using fossils to correlate the sequences at various locations, geologic events can be inferred and geologic time can be estimated.	9.3.1.3.1	Use relative dating techniques to explain how the structures of the Earth and life on Earth have changed over short and long periods of time.
	2. Interdepen-dence Within the Earth System	1. The Earth system has internal and external sources of energy, which produce heat and drive the motion of material in the oceans, atmosphere and solid earth.	9.3.2.1.1	Compare and contrast the energy sources of the Earth, including the sun, the decay of radioactive isotopes and gravitational energy.
			9.3.2.1.2	Explain how the outward transfer of Earth's internal heat drives the convection circulation in the mantle to move tectonic plates.
		2. Global climate is determined by distribution of energy from the sun at the Earth's surface.	9.3.2.2.1	Explain how Earth's rotation, ocean currents, configuration of mountain ranges, and composition of the atmosphere influence the absorption and distribution of energy, which contributes to global climatic patterns.
			9.3.2.2.2.	Explain how evidence from the geologic record, including ice core samples, indicates that climate changes have occurred at varying rates over geologic time and continue to occur today.

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3. Earth and Space Science	3. The Universe	2. The solar system, sun, and Earth formed over billions of years.	9.3.3.2.1	Describe how the solar system formed from a nebular cloud of dust and gas 4.6 billion years ago.
			9.3.3.2.2.	Explain how the Earth evolved into its present habitable form through interactions among the solid earth, the oceans, the atmosphere and organisms.
3. Earth and Space Science	3. The Universe	2. The solar system, sun, and Earth formed over billions of years.	9.3.3.2.3.	Compare and contrast the environmental conditions that make life possible on Earth with conditions found on the other planets and moons of our solar system.
		3. The big bang theory states that the universe expanded from a hot, dense chaotic mass, after which chemical elements formed and clumped together to eventually form stars and galaxies.	9.3.3.3.1	Explain how evidence, including the Doppler shift of light from distant stars and cosmic background radiation, is used to understand the composition, early history and expansion of the universe.
			9.3.3.3.2	Explain how gravitational clumping leads to nuclear fusion, producing energy and the chemical elements of a star.
	4. Human Interactions with the Earth Systems	1. People consider potential benefits, costs and risks to make decisions on how they interact with natural systems.	9.3.4.1.1	Analyze the benefits, costs, risks and tradeoffs associated with natural hazards, including the selection of land use and engineering mitigation. *For example:* Determining land use in floodplains and areas prone to landslides.
			9.3.4.1.2	Explain how human activity and natural processes are altering the hydrosphere, biosphere, lithosphere and atmosphere, including pollution, topography and climate. *For example:* Active volcanoes and the burning of fossil fuels contribute to the greenhouse effect.