Physical Science

Content Standard B:

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

- **Properties and changes of properties in matter**
- **Motions and forces**
- **Transfer of energy**

Content Summary

National Science Education Content Standards

K-4

Properties of objects and materials

Position and motion of objects

Light, heat, electricity, and magnetism

5-8

Properties and changes of properties in matter

Motions and forces

Transfer of energy

9-12

Structure of atoms

Structure and properties of matter

Chemical reactions

Motions and forces

Conservation of energy and increase in disorder

Interactions of matter and energy

Minnesota Graduation Standards

Primary Level

Direct Science Experience:

Understand basic science concepts through direct experience

Intermediate Level

Living and Non-living Systems:

Understand how individuals and objects interact in life, earth/space systems and physical systems

Middle Level

Physical Systems:

Evaluate interactions between physical systems encountered in everyday life

High School Level

Concepts in Chemistry:

Understand concepts, theories and principles in chemistry through investigation and analysis

Concepts in Physics:

Understand physics through interactions of matter, forces and energy

Focus K-12

Grade	Early	Late
K-4	The focus of instruction early in this grade range is on providing opportunities for all students to develop an awareness and understanding of the characteristics of objects and materials that they encounter daily through observation, manipulation, and classification.	The focus of instruction later in this grade range is on providing opportunities for all students to observe, describe, and measure properties of objects, the way they change over time, and changes that occur when objects interact.
5-8	The focus of instruction early in this grade range is on providing opportunities for all students to move from understandings about the properties of objects to the characteristic properties of the substances from which objects are made. Basic concepts of force, motion and energy transfer are introduced and explored.	The focus of instruction later in this grade range is on providing opportunities for all students to develop an operational understanding of elements and compounds and characteristic properties of common substances. The concepts of force, motion, and energy are developed through a variety of quantitative experiences.
9-12	The focus of instruction in *chemistry* for all students at the high school level is on providing opportunities to develop an understanding of the relationship among the properties and structure of matter and to explore a variety of chemical reactions and their applications. The focus of instruction in *physics* for all students at the high school level is on providing opportunities to explore, develop, and use physical, conceptual and mathematical models as they develop qualitative and quantitative understanding of force, motion, energy, and matter, and apply their understandings to a variety of situations.	The focus of instruction for students pursuing further study in *chemistry* is on providing opportunities for students to develop a deeper understanding of atomic structure, explore the complex relationships among the structure and properties of matter, including mathematical relationships, and apply their understandings to a variety of situations. The focus of instruction for students pursuing further study in *physics* is on providing opportunities to explore, develop, and use conceptual and mathematical models as they develop a deeper understanding of force, motion, energy, and matter, and apply their understandings to a variety of situations.

Close-up 5-8

The focus of instruction early in this grade range is on providing opportunities for all students to move from understandings about the properties of objects to the characteristic properties of the substances from which the objects are made. Basic concepts of force, motion, and energy transfer are introduced and explored.

Students continue to develop their understandings related to sorting and ordering objects and materials according to their properties. They conduct investigations which enable them to determine which properties are unique to individual objects and which are characteristic of the materials from which the objects were made. They begin to separate one substance from another using filtration, evaporation, and other simple separation techniques. By experimenting with simple chemical reactions, students learn that new products can be produced with different characteristics. The teacher provides opportunities for investigations that explore concepts related to force and motion. Students build on their previous experiences with light, sound, electricity, magnetism, and motion of objects to begin to make connections among these phenomena. The concept of energy transfer is developed as students discover that most changes involve energy and that heat flows from warmer objects or places to cooler ones. Students and teachers observe established science safety procedures.

The focus of instruction later in this grade range is on providing opportunities for all students to develop an operational understanding of elements and compounds and characteristic properties of common substances. The concepts of force, motion, and energy are developed through a variety of quantitative experiences.

All students begin to understand that substances have properties that are independent of the amount, size, and shape of the sample. They observe and measure characteristic properties such as boiling points, melting points, solubility, and density in order to distinguish and separate one substance from another. Students discover that substances react chemically in characteristic ways with other substances to form new substances with different characteristic properties. Students begin to use the terms elements and compounds, but few students at this level can comprehend the idea of atomic and molecular particles. Through quantitative investigations, students begin to explore conservation of mass. A variety of experiences with electrical circuits, light, heat, sound, and motion are required to further their understanding of the transfer of energy. Students begin to move from qualitative to quantitative understandings about forces as they design and conduct investigations using familiar objects. Students and teachers observe established science safety procedures.

On Location 5-8

Mr. A illustrates the spirit of inquiry by allowing students to pursue their own interests within a given framework. He guides their work, yet requires exploration. Substantial physical science content is learned within the context of inquiry.

Mr. A's middle level science course includes a four-week investigation of soda-pop cans. It begins with students brainstorming what they want to know about pop cans. Some want to know about how much pressure pop cans can withstand. Some want to know how much and what kind of gas is given off when the pop cans are opened. Others are interested in why some pop cans sink and some float. Mr. A lists all questions on the board and may rephrase some.

Because Mr. A has determined that students will understand characteristic properties and concepts related to pressure, force, and density after completing this unit, he circles for study those questions which address those concepts. Questions about taste tests and aesthetics of the color of pop are not included because research on those will not accomplish the outcomes of the unit.

Some topics of study chosen by students include determining the number of Newtons needed to crush a can, finding the amount of carbonation in different types of soda, the loss of carbonation over time, differences in density, carbonation, and thickness (viscosity) of light and dark soda, boiling and freezing temperatures of different types of soda, analysis of colors in soda by chromatography, determining sugar content, and comparing the density of diet and regular soda.

To begin their investigations, the students work in small cooperative groups to design their own procedures to address at least three questions of their choice from the approved list. Students write draft procedures that take into account what data they need, observations they must make, what the variables and controls will be, and what equipment they will use to make measurements. Mr. A notes which questions each group of students is addressing in order to supply them with supplementary activities and experiments. Students sometimes develop their own procedures and at other times seek out procedures from other sources such as hand-outs or textbooks that are available in the classroom.

Students keep detailed lab notebooks throughout the unit. Mr. A helps students to refine their procedures and repeat them to verify findings and develop scientific explanations and models. Findings are discussed, sources of experimental error are questioned, and alternative explanations are explored. Mr. A works with students to check textbooks and other sources to compare current theory about changes in state, pressure, force, and density with their results. Finally, students write reports on their investigations and give oral presentations to the class. The reports are published in a journal called "Popular Soda."

Other units in Mr. A's curriculum are structured in a similar way and he directs students to investigate a variety of topics to ensure that students have an opportunity to learn all the required physical science content prior to the end of the term.

National Science Education Content Standards

5-8 Content Standard B

Properties and Changes of Properties in Matter	• A substance has characteristic properties, such as density, a boiling point, and solubility, all of which are independent of the amount of the sample. A mixture of substances often can be separated into the original substances using one or more of the characteristic properties. • Substances react chemically in characteristic ways with other substances to form new substances (compounds) with different characteristic properties. In chemical reactions, the total mass is conserved. Substances often are placed in categories or groups if they react in similar ways; metals is an example of such a group. • Chemical elements do not break down during normal laboratory reactions involving such treatments as heating, exposure to electric current, or reaction with acids. There are more than 100 known elements that combine in a multitude of ways to produce compounds, which account for the living and nonliving substances that we encounter.
Motions and Forces	• The motion of an object can be described by its position, direction of motion, and speed. That motion can be measured and represented on a graph. • An object that is not being subjected to a force will continue to move at a constant speed and in a straight line. • If more than one force acts on an object along a straight line, then the forces will reinforce or cancel one another, depending on their direction and magnitude. Unbalanced forces will cause changes in the speed or direction of an object's motion.
Transfer of Energy	• Energy is a property of many substances and is associated with heat, light, electricity, mechanical motion, sound, nuclei, and the nature of a chemical. Energy is transferred in many ways. • Heat moves in predictable ways, flowing from warmer objects to cooler ones, until both reach the same temperature. • Light interacts with matter by transmission (including refraction), absorption, or scattering (including reflection). To see an object, light from that object—emitted by or scattered from it—must enter the eye. • Electrical circuits provide a means of transferring electrical energy when heat, light, sound, and chemical changes are produced. • In most chemical and nuclear reactions, energy is transferred into or out of a system. Heat, light, mechanical motion, or electricity might all be involved in such transfers. • The sun is a major source of energy for changes on the earth's surface. The sun loses energy by emitting light. A tiny fraction of that light reaches the earth, transferring energy from the sun to the earth. The sun's energy arrives as light with a range of wavelengths, consisting of visible light, infrared, and ultraviolet radiation.

Minnesota Graduation Standards

Intermediate Level

Living and Non-Living Systems:

Understand how individuals and objects interact in life, earth/space systems and physical systems.

What students should know:

1. Understand characteristics of organisms:
   a. plants
   b. animals
   c. micro-organisms
2. Understand basic structures and functions of the human body
3. Understand cycles and patterns in:
   a. living organisms
   b. earth systems
   c. physical systems
4. Understand how human behavior and technology impact the environment
5. Understand characteristics of the physical world (e.g., land forms, solar system, electro-magnetism, chemical reactions)

What students should do:

1. Measure and classify objects, organisms, and materials on the basis of their properties and relationships
2. Make systematic observations of objects, events and/or phenomena:
   a. record data
   b. predict change
3. Create a model to illustrate a concept, law, theory or principle
4. Identify personal behaviors and use of materials which have a positive impact on the environment

In Addition:

1. Performance packages should include tasks which address earth, life and physical science.
2. Whenever possible this standard should be combined with the Inquiry standard.
3. Tasks should be related to students' environment.
4. Students must demonstrate basic safety procedures and skills when using tools and equipment.

Physical Systems:

Evaluate interactions between physical systems encountered in everyday life.

What students should know:

1. Understand the fundamental laws and concepts of the physical world including:
   a. properties of matter
   b. physical and chemical changes
   c. transfer of energy (e.g., solar radiation, convection, electrical circuits)
   d. force and motion

What students should do:

1. Formulate questions to be answered based on systematic observations
2. Design and conduct investigations and field studies
3. Analyze data to support or refute hypotheses:
   a. identify patterns in data
   b. compare results to known scientific theories, current models and/or personal experience
   c. consider multiple interpretations of data
4. Describe how a premise (e.g., medical procedure, invention, claim) is supported by scientific concepts, principles, theories or laws
5. Create a model to illustrate a contemporary or historical concept, principle, theory or law

In Addition:

1. Students should work with teacher guidance.
2. This standard should be paired with an Inquiry standard whenever appropriate.
3. When possible, students should be given opportunities to work in authentic settings.
4. Students must demonstrate basic safety procedures and skills when using tools and equipment.