OVERVIEW OF THE PERFORMANCE STANDARDS
Middle School

The middle school standards are set at a level of performance approximately equivalent to the end of eighth grade. It is expected that some students might achieve this level earlier and others later than this grade. (See "Deciding what constitutes a standard-setting performance," page 10.)

Science

S1 Physical Sciences Concepts

S1a Demonstrates understanding of properties and changes of properties in matter.

S1b Demonstrates understanding of position and motion and forces.

S1c Demonstrates understanding of transfer of energy and the nature of a chemical reaction.

S2 Life Sciences Concepts

S2a Demonstrates understanding of structure and function in living systems.

S2b Demonstrates understanding of reproduction and heredity and the role of genes and environment on trait expression.

S2c Demonstrates understanding of regulation and behavior and response to environmental stimuli.

S2d Demonstrates understanding of populations and ecosystems and the effects of resources and energy transfer on populations.

S2e Demonstrates understanding of evolution, diversity, and adaptation of organisms.

S3 Earth and Space Sciences Concepts

S3a Demonstrates understanding of structure of the Earth system.

S3b Demonstrates understanding of Earth's history.

S3c Demonstrates understanding of Earth in the Solar System.

S3d Demonstrates understanding of natural resource management.

S4 Scientific Connections and Applications

S4a Demonstrates understanding of big ideas and unifying concepts.

S4b Demonstrates understanding of the designed world.

S4c Demonstrates understanding of health.

S4d Demonstrates understanding of impact of technology.

S4e Demonstrates understanding of impact of science.

S5 Scientific Thinking

S5a Frames questions to distinguish cause and effect; and identifies or controls variables.

S5b Uses concepts from Science Standards 1 to 4 to explain a variety of observations and phenomena.

S5c Uses evidence from reliable sources to develop descriptions, explanations, and models.

S5d Proposes, recognizes, analyzes, considers, and critiques alternative explanations; and distinguishes between fact and opinion.

S5e Identifies problems; proposes and implements solutions; and evaluates the accuracy, design, and outcomes of investigations.

S5f Works individually and in teams to collect and share information and ideas.

S6 Scientific Tools and Technologies

S6a Uses technology and tools to observe and measure objects, organisms, and phenomena, directly, indirectly, and remotely.

S6b Records and stores data using a variety of formats.

S6c Collects and analyzes data using concepts and techniques in Mathematics Standard 4.

S6d Acquires information from multiple sources.

S6e Recognizes sources of bias in data.

S7 Scientific Communication

S7a Represents data and results in multiple ways.

S7b Argues from evidence.

S7c Critiques published materials.

S7d Explains a scientific concept or procedure to other students.

S7e Communicates in a form suited to the purpose and the audience.

S8 Scientific Investigation

S8a Demonstrates scientific competence by completing a controlled experiment.

S8b Demonstrates scientific competence by completing fieldwork.

S8c Demonstrates scientific competence by completing a design.

S8d Demonstrates scientific competence by completing secondary research.

S1 Physical Sciences Concepts

The student demonstrates conceptual understanding by using a concept accurately to explain observations and make predictions and by representing the concept in multiple ways (through words, diagrams, graphs, or charts, as appropriate). Both aspects of understanding—explaining and representing—are required to meet this standard.

S1a The student produces evidence that demonstrates understanding of properties and changes of properties in matter, such as density and boiling point; chemical reactivity; and conservation of matter.

Examples of activities through which students might demonstrate conceptual understanding of physical sciences include:

* Use the concept of density to explain why some things float and others sink in water. 1a
* Investigate the characteristics that are necessary to obtain an electric current from an electrochemical cell of metal(s) and a fluid medium. 1a
* Explain the difference between recycling and reusing in terms of mass and energy conservation. 1a, 1c, 3a, 4b

New York State Learning Standards for Math, Science, & Technology[69]

Standard 4 Science
Physical Setting

3. Matter is made up of particles whose properties determine the observable characteristics of matter and its reactivity.

Students:

observe and describe properties of materials, such as density, conductivity, and solubility.

distinguish between chemical and physical changes.

develop their own mental models to explain common chemical reactions and changes in states of matter.

National Documents which guided New York State and New York City

NRC National Science Education Standards[70]

Standard B Physical Science
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,

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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. p. 154

Project 2061, AAAS[71]
Benchmarks for Science Literacy

Chapter 4 The Physical Setting
4D Structure of Matter

When a new material is made by combining two or more materials, it has properties that are different from the original materials. For that reason, a lot of different materials can be made from a small number of basic kinds of materials. p. 77

All matter is made up of atoms, which are far too small to see directly through a microscope. The atoms of any element are alike but are different from atoms of other elements. Atoms may stick together in well-defined molecules or may be packed together in large arrays. Different arrangements of atoms into groups compose all substances.

Equal volumes of different substances usually have different weights.

Atoms and molecules are perpetually in motion. Increased temperature means greater average energy of motion, so most substances expand when heated. In solids, the atoms are closely locked in position and can only vibrate. In liquids, the atoms or molecules have higher energy of motion, are more loosely connected, and can slide past one another; some molecules may get enough energy to escape into a gas. In gases, the atoms or molecules have still more energy of motion and are free of one another except during occasional collisions.

There are groups of elements that have similar properties, including highly reactive metals, less-reactive metals, highly reactive nonmetals (such as chlorine, fluorine, and oxygen), and some almost completely nonreactive gases (such as helium and neon). An especially important kind of reaction between substances involves combination of oxygen with something else—as in burning or rusting. Some elements don't fit into any of the categories; among them are carbon and hydrogen, essential elements of living matter.

No matter how substances within a closed system interact with one another, or how they combine or break apart, the total weight of the system remains the same. The idea of atoms explains the conservation of matter: If the number of atoms stays the same no matter how they are rearranged, then their total mass stays the same. p. 78

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S1 Physical Sciences Concepts (cont.)

The student demonstrates conceptual understanding by using a concept accurately to explain observations and make predictions and by representing the concept in multiple ways (through words, diagrams, graphs, or charts, as appropriate). Both aspects of understanding—explaining and representing—are required to meet this standard.

S1b The student produces evidence that demonstrates understanding of motions and forces, such as inertia and the net effects of balanced and unbalanced forces.

Examples of activities through which students might demonstrate conceptual understanding of physical sciences include:

* Use the concept of force to explain the roles of front and rear brakes on a bicycle. 1b, 4d
* Build a grandfather clock and explain how it works. 1b, 4d, 8c, A1a

New York State Learning Standards for Math, Science, & Technology[72]

Standard 4 Science
Physical Setting

5. Energy and matter interact through forces that result in changes in motion.

Students:

describe different patterns of motion of objects.

observe, describe, and compare effects of forces (gravity, electric current, and magnetism) on the motion of objects. p. 32

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National Documents which guided New York State and New York City

NRC National Science Education Standards[73]

Standard B Physical Science
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. p. 154

Project 2061, AAAS[74]
Benchmarks for Science Literacy

Chapter 4 The Physical Setting
4F Motion

An unbalanced force acting on an object changes its speed or direction of motion, or both. If the force acts toward a single center, the object's path may curve into an orbit around the center. p. 90

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S1 Physical Sciences Concepts (cont.)

The student demonstrates conceptual understanding by using a concept accurately to explain observations and make predictions and by representing the concept in multiple ways (through words, diagrams, graphs, or charts, as appropriate). Both aspects of understanding—explaining and representing—are required to meet this standard.

S1c The student produces evidence that demonstrates understanding of transfer of energy, such as transformation of energy as heat; light, mechanical motion, and sound; and the nature of a chemical reaction.

Examples of activities through which students might demonstrate conceptual understanding of physical sciences include:

* Explain the difference between recycling and reusing in terms of mass and energy conservation. 1a, 1c, 3a, 4b
* Conduct an energy audit of the classroom and develop procedures for reducing waste. 1c, 4a, 4b, A1b
* Evaluate the claims and potential benefits of sunglasses that are advertised to screen out ultraviolet light. 1c, 4a, 4b, 4c

New York State Learning Standards for Math, Science, & Technology[75]

Standard 4 Science
Physical Setting

4. Energy exists in many forms, and when these forms change energy is conserved.

Students:

describe the sources and identify the transformations of energy observed in everyday life.

observe and describe heating and cooling events.

observe and describe energy changes as related to chemical reactions.

observe and describe the properties of sound, light, magnetism, and electricity.

describe situations that support the principle of conservation of energy. p. 32

National Documents which guided New York State and New York City

NRC National Science Education Standards[76]

Standard B Physical Science
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.

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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. p. 155

Project 2061, AAAS[77]
Benchmarks for Science Literacy
Chapter 4 The Physical Setting
4E Energy Transformations

Most of what goes on in the universe—from exploding stars and biological growth to the operation of machines and the motion of people—involves some form of energy being transformed into another. Energy in the form of heat is almost always one of the products of an energy transformation. p. 84

4F Motion

Light from the sun is made up of a mixture of many different colors of light, even though to the eye the light looks almost white. Other things that give off or reflect light have a different mix of colors.

Something can be "seen" when light waves emitted or reflected by it enter the eye—Just as something can be "heard" when sound waves from it enter the ear.

Vibrations in materials set up wavelike disturbances that spread away from the source.

Human eyes respond to only a narrow range of wavelengths of electromagnetic radiation—visible light. Differences of wavelength within that range are perceived as differences in color. p. 90

Chapter 8 The Designed World
8C Energy Sources and Use

Energy can change from one form to another, although in the process some energy is always converted to heat. Some systems transform energy with less loss of heat than others
Electrical energy can be produced from a variety of energy sources and can be transformed into almost any other form of energy. Moreover, electricity is used to distribute energy quickly and conveniently to distant locations. p. 194

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S2 Life Sciences Concepts

The student demonstrates conceptual understanding by using a concept accurately to explain observations and make predictions and by representing the concept in multiple ways (through words, diagrams, graphs, or charts, as appropriate). Both aspects of understanding—explaining and representing—are required to meet this standard.

S2a The student produces evidence that demonstrates understanding of structure and function in living systems, such as the complementary nature of structure and function in cells, organs, tissues, organ systems, whole organisms, and ecosystems.

Examples of activities through which students might demonstrate conceptual understanding of life sciences include:

* Explain the effects of a particular disease (e.g., common cold) on an organism's internal structures and their related functions. 2a, 4a, 4c
* Use drawings to demonstrate the structure and function relationships among a group of cells, tissues, or organs. 2a, 2c
* Predict how long a plant will live planted in a closed glass jar located by a window; and explain what additional information regarding the plant and the surrounding environment would be needed to improve the prediction. 2a, 1a, 3a, 3b
* Conduct an investigation to determine the kinds of seeds best suited to germination in a hydroponic system. 2a, 2d, 2e, 4b, 8a

New York State Learning Standards for Math, Science, & Technology[78]

Standard 4 Science
The Living Environment

1. Living things are both similar to and different from each other and nonliving things.

Students:

compare and contrast the parts of plants, animals, and one-celled organisms.

explain the functioning of the major human organ systems and their interactions.

5. Organisms maintain a dynamic equilibrium that sustains life.

Students:

compare the way a variety of living specimens carry out basic life functions and maintain dynamic equilibrium.

describe the importance of major nutrients, vitamins, and minerals in maintaining health and promoting growth and explain the need for a constant input of energy for living organisms. p. 33

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National Documents which guided New York State and New York City

NRC National Science Education Standards[79]

Standard C Life Science
Structure and Function in Living Systems

Living systems at all levels of organization demonstrate the complementary nature of structure and function.

All organisms are composed of cells—the fundamental unit of life.

Cells carry on the many functions needed to sustain life.

Specialized cells perform specialized functions in multicellular organisms.

The human organism has systems for digestion, respiration, reproduction, circulation, excretion, movement, control, and coordination, and for the protection from disease.

Disease is a breakdown in structures or functions of an organism. pp. 156-157

Project 2061, AAAS[80]
Benchmarks for Science Literacy

Chapter 5 The Living Environment
5C Cells

Within cells many of the basic functions of organisms—such as extracting energy from food and getting rid of waste—are carried out. The way in which cells function is similar in all living organisms. p. 112

Chapter 6 The Human Organism
6A Human Identity

Like other animals, human beings have body systems for obtaining and providing energy, defense, reproduction, and the coordination of body functions. p. 129

6C Basic Functions

Organs and organ systems are composed of cells and help to provide all cells with basic needs.

For the body to use food for energy and building materials, the food must first be digested into molecules that are absorbed and transported to cells.

To burn food for the release of energy stored in it, oxygen must be supplied to cells, and carbon dioxide removed.

Specialized cells and the molecules they produce identify and destroy microbes that get inside the body. p. 137

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S2 Life Sciences Concepts (cont.)

The student demonstrates conceptual understanding by using a concept accurately to explain observations and make predictions and by representing the concept in multiple ways (through words, diagrams, graphs, or charts, as appropriate). Both aspects of understanding—explaining and representing—are required to meet this standard.

S2b The student produces evidence that demonstrates understanding of reproduction and heredity, such as sexual and asexual reproduction; and the role of genes and environment on trait expression.

Examples of activities through which students might demonstrate conceptual understanding of life sciences include:

* Write a story about how a person learned to overcome an inherited physical limitation. 2b, 4b
* Explain why offspring of organisms that reproduce sexually never look exactly like their parents. 2b, 2e
* Explain the lines of evidence showing that dogs and cats are related by common ancestors. 2b, 2c, 4a, 5c
* Compare and contrast historical situations where species became extinct with situations where species survived due to differences in adaptive characteristics and the degree of environmental stress or change. 2b, 2c, 2d, 2e, 4a

New York State Learning Standards for Math, Science, & Technology[81]

Standard 4 Science
The Living Environment

2. Organisms inherit genetic information in a variety of ways that result in continuity of structure and function between parents and offspring.

Students:

describe sexual and asexual mechanisms for passing genetic materials from generation to generation.

describe simple mechanisms related to the inheritance of some physical traits in offspring.

4. The continuity of life is sustained through reproduction and development.

Students:

observe and describe the variations in reproductive patterns of organisms, including asexual and sexual reproduction.

explain the role of sperm and egg cells in sexual reproduction.

observe and describe developmental patterns in selected plants and animals (e.g., insects, humans, seed bearing plants).

observe and describe cell division at the microscopic level and its macroscopic effects. p. 33

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National Documents which guided New York State and New York City

NRC National Science Education Standards[82]

Standard C Life Science
Reproduction and Heredity

Reproduction is a characteristics of all living systems; because no living organism lives forever, reproduction is essential to the continuation of every species.

In many species, including humans, females produce eggs and males produce sperm. Plants also reproduce sexually—the egg and sperm are produced in the flowers of flowering plants. An egg and sperm unite to begin development of a new individual. That new individual receives genetic information from its mother (via the egg) and its father (via the sperm). Sexually produced offspring never are identical to either of their parents.

Every organism requires a set of instructions for specifying its traits. Heredity is the passage of these instructions from one generation to another.

Heredity information is contained in genes, located in the chromosomes of each cell.

The characteristics of an organism can be described in terms of a combination of traits. Some traits are inherited and others result from interactions with the environment. p. 157

Project 2061, AAAS[83]
Benchmarks for Science Literacy

Chapter 5 The Living Environment
5B Heredity

In some kinds of organisms, all the genes come from a single parent, whereas in organisms that have seeds, typically half of the genes come from each parent.

In sexual reproduction, a single specialized cell from a female merges with a specialized cell from a male. As the fertilized egg, carrying the genetic information from each parent, multiplies to form the complete organism with about a trillion cells, the same genetic information is copied in each cell.

New varieties of cultivated plants and domestic animals have resulted from selective breeding for particular traits. p. 108

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S2 Life Sciences Concepts (cont.)

The student demonstrates conceptual understanding by using a concept accurately to explain observations and make predictions and by representing the concept in multiple ways (through words, diagrams, graphs, or charts, as appropriate). Both aspects of understanding—explaining and representing—are required to meet this standard.

S2c The student produces evidence that demonstrates understanding of regulation and behavior, such as senses and behavior; and response to environmental stimuli.

Examples of activities through which students might demonstrate conceptual understanding of life sciences include:

* Use drawings to demonstrate the structure and function relationships among a group of cells, tissues, or organs. 2a, 2c
* Earn the Bird Study Merit Badge (Boy Scouts of America) or complete the Plant Culture Project (Girl Scouts of the U.S.A.) and explain how it helped you to understand animal behavior, ecology, or regulation. 2c, 2d, 2e, 4a
* Explain the physiology of sneezes, tears, or what happens when people laugh. 2c
* Explain the lines of evidence showing that dogs and cats are related by common ancestors. 2b, 2c, 4a, 5c
* Compare and contrast historical situations where species became extinct with situations where species survived due to differences in adaptive characteristics and the degree of environmental stress or change. 2b, 2c, 2d, 2e, 4a

New York State Learning Standards for Math, Science, & Technology[84]

Standard 4 Science
The Living Environment

5. Organisms maintain a dynamic equilibrium that sustains life.

Students:
compare the way a variety of living specimens carry out basic life functions and maintain dynamic equilibrium. p. 33

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National Documents which guided New York State and New York City

NRC National Science Education Standards[85]

Standard C Life Science
Regulation and Behavior

All organisms must be able to obtain and use resources, grow, reproduce and maintain stable internal conditions while living in a constantly changing external environment.

Regulation of an organism's internal environment involves sensing the internal environment and changing physiological activities to keep conditions within the range required to survive.

Behavior is one kind of response an organism can make to an internal or environmental stimulus.

An organism's behavior evolves through adaptation to its environment. How a species moves, obtains food, reproduces, and responds to danger are based in the species' evolutionary history. p. 157

Project 2061, AAAS[86]
Benchmarks for Science Literacy

Chapter 6 The Human Organism
6A Human Identity

Specialized roles of individuals within other species are genetically programmed, whereas human beings are able to invent and modify a wider range of social behaviors. p. 130

6C Basic Functions

Hormones are chemicals from glands that affect other body parts. They are involved in helping the body respond to danger and in regulating human growth, development, and reproduction.

Interactions among the senses, nerves, and brain make possible the learning that enables human beings to cope with changes in their environment. p. 137

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S2 Life Sciences Concepts (cont.)

The student demonstrates conceptual understanding by using a concept accurately to explain observations and make predictions and by representing the concept in multiple ways (through words, diagrams, graphs, or charts, as appropriate). Both aspects of understanding—explaining and representing—are required to meet this standard.

S2d The student produces evidence that demonstrates understanding of populations and ecosystems, such as the roles of producers, consumers, and decomposers in a food web; and the effects of resources and energy transfer on populations.

Examples of activities through which students might demonstrate conceptual understanding of life sciences include:

* Earn the Bird Study Merit Badge (Boy Scouts of America) or complete the Plant Culture Project (Girl Scouts of the U.S.A.) and explain how it helped you to understand animal behavior, ecology, or regulation. 2c, 2d, 2e, 4a
* Identify a pest in the immediate environment; and use an understanding of food webs to propose and test a way to eliminate the pest without introducing environmental poisons. 2d, 2e, 1c, 4b, 4c, 4d, 4e
* Conduct an investigation to determine the kinds of seeds best suited to germination in a hydroponic system. 2a, 2d, 2e, 4b, 8a
* Compare and contrast historical situations where species became extinct with situations where species survived due to differences in adaptive characteristics and the degree of environmental stress or change. 2b, 2c, 2d, 2e, 4a

New York State Learning Standards for Math, Science, & Technology[87]

Standard 4 Science
The Living Environment

6. Plants and animals depend on each other and their physical environment.

Students:

describe the flow of energy and matter through food chains and food webs

provide evidence that green plants make food and explain the significance of this process to other organisms. p. 33

National Documents which guided New York State and New York City

NRC National Science Education Standards[88]

Standard C Life Science
Populations and Ecosystems

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A population consists of all individuals of a species that occur together at a given place and time. All populations living together and the physical factors with which they interact compose an ecosystem.

Populations of organisms can be categorized by the function they serve in the ecosystem. Plants and some micro-organisms are producers—they make their own food. All animals, including humans, are consumers, which obtain food by eating other organisms. Decomposers, primarily bacteria and fungi, are consumers that use waste materials and dead organisms for food. Food webs identify the relationships among producers, consumers, and decomposers in an ecosystem.

For ecosystems, the major source of energy is sunlight.

The number of organisms an ecosystem can support depends on the resources and abiotic factors, such as quantity of light and water, range of temperatures, and soil composition. p. 157-158

Project 2061, AAAS[89]
Benchmarks for Science Literacy
Chapter 5 The Living Environment
5A Diversity of Life

One of the most general distinctions among organisms is between plants, which use sunlight to make their own food, and animals, which consume energy–rich foods.

All organisms, including the human species, are part of and depend on two main global food webs. One includes microscopic ocean plants, the animals that feed on them, and finally the animals that feed on those animals. p. 104

5D Interdependence of Life

In all environments—freshwater, marine, forest, grassland, mountain, and others—organisms with similar needs may compete with one another for resources including food, space, water, air, and shelter.

Two types of organisms may interact with each other in several ways: They may be in a producer/consumer, predator/prey, or parasite/host relationship. Or one organism may scavenge or decompose another. p. 117

5E The Flow of Matter and Energy

Food provides molecules that serves as fuel and building material for all organisms. Plants use the energy from light to make sugars out of carbon dioxide and water.

Over a long time, matter is transferred from one organism to another repeatedly and between organisms and their physical environment.

Energy can change from one form to another in living things. p. 120

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S2 Life Sciences Concepts (cont.)

The student demonstrates conceptual understanding by using a concept accurately to explain observations and make predictions and by representing the concept in multiple ways (through words, diagrams, graphs, or charts, as appropriate). Both aspects of understanding—explaining and representing—are required to meet this standard.

S2e The student produces evidence that demonstrates understanding of evolution, diversity, and adaptation of organisms, such as common ancestry, speciation, adaptation, variation, and extinction.

Examples of activities through which students might demonstrate conceptual understanding of life sciences include:

* Explain why offspring of organisms that reproduce sexually never look exactly like their parents. 2b, 2e
* Earn the Bird Study Merit Badge (Boy Scouts of America) or complete the Plant Culture Project (Girl Scouts of the U.S.A.) and explain how it helped you to understand animal behavior, ecology, or regulation. 2c, 2d, 2e, 4a
* Identify a pest in the immediate environment; and use an understanding of food webs to propose and test a way to eliminate the pest without introducing environmental poisons. 2d, 2e, 1c, 4b, 4c, 4d, 4e
* Conduct an investigation to determine the kinds of seeds best suited to germination in a hydroponic system. 2a, 2d, 2e, 4b, 8a
* Compare and contrast historical situations where species became extinct with situations where species survived due to differences in adaptive characteristics and the degree of environmental stress or change. 2b, 2c, 2d, 2e, 4a

New York State Learning Standards for Math, Science, & Technology[90]

Standard 4 Science
The Living Environment

3. Individual organisms and species change over time.

Students:

describe sources of variation in organisms and their structures and relate the variations to survival.

describe factors responsible for competition within species and the significance of that competition.

7. Human decisions and activities have had a profound impact on the physical and living environment.

Students:

describe how living things, including humans, depend upon the living and nonliving environment for their survival.

describe the effects of environmental changes on humans and other populations. p. 33

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National Documents which guided New York State and New York City

NRC National Science Education Standards[91]

Standard C Life Science
Diversity and Adaptations of Organisms

Millions of species of animals, plants, and microorganisms are alive today. Although different species might look dissimilar, the unity among organisms becomes apparent from an analysis of internal structures, the similarity of their chemical processes, and the evidence of common ancestry.

Biological evolution accounts for the diversity of species developed through gradual processes over many generations. Biological adaptations include changes in structures, behaviors, or physiology that enhance survival and reproductive success in a particular environment.

Extinction of a species occurs when the environment changes and the adaptive characteristics of a species are insufficient to allow its survival. p. 158

Project 2061, AAAS[92]
Benchmarks for Science Literacy

Chapter 5 The Living Environment
5A Diversity of Life

One of the most general distinctions among organisms is between plants, which use sunlight to make their own food, and animals, which consume energy-rich foods.

Animals and plants have a great variety of the body plans and internal structures that contribute to their being able to make or find food and reproduce.

In classifying organisms, biologists consider details of internal and external structures to be more important than behavior or general appearance.

For sexually reproducing organisms, a species includes all organisms that can mate with one another to produce fertile offspring. p. 104

5F Evolution of Life

Small differences between parents and offspring can accumulate (selective breeding) in successive generations so that descendants are very different from their ancestors.

Individual organisms with certain traits are more likely than others to survive and have offspring.

Many thousands of sedimentary rock layers provide evidence for the long history of the earth, and of changing life forms whose remains are found in rocks. p. 124

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S3 Earth and Space Sciences Concepts

The student demonstrates conceptual understanding by using a concept accurately to explain observations and make predictions and by representing the concept in multiple ways (through words, diagrams, graphs, or charts, as appropriate). Both aspects of understanding—explaining and representing—are required to meet this standard.

S3a The student produces evidence that demonstrates understanding of structure of the Earth system, such as crustal plates and land forms; water and rock cycles; oceans, weather, and climate.

Examples of activities through which students might demonstrate conceptual understanding of Earth and space sciences include:

* Explain how earthquakes, volcanoes, and sea-floor spreading have a common cause. 3a, 3b, 4a, 4c
* Write a story that describes what happens to a drop of water and the physical environment through which it flows as it travels from a lake to a river via the Earth's atmosphere. 3a, 3c, 1a, 4a
* Complete the Geology Project (Girl Scouts of the U.S.A.) or earn the Astronomy Merit Badge (Boy Scouts of America) and explain what it helped you to understand about Earth processes and structures; fossil evidence; or aspects of the Solar System. 3a, 3b, 3c

New York State Learning Standards for Math, Science, & Technology[93]

Standard 4 Science
Physical Setting

2. Many of the phenomena that we observe on earth involve interactions among components of air, water and land.

Students:

explain how the atmosphere (air), hydrosphere (water) and lithosphere (land) interact , evolve, and change.

describe volcano and earthquake patterns, the rock, and weather. p. 34

National Documents which guided New York State and New York City

NRC National Science Education Standards[94]

Standard D Earth and Space Science
Structure of the Earth System

The solid earth is layered with a lithosphere; hot, convecting mantle; and dense metallic core.

Lithospheric plates on the scales of continents and oceans constantly move at rates of centimeters per year in response to movements in the mantle.

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Land forms are the result of a combination of constructive and destructive forces. Constructive forces include crustal deformation, volcanic eruption, and deposition of sediment, while destructive forces include weathering an erosion.

Water circulates through the crust, oceans, and atmosphere in what is known as the "water cycle." Water evaporates from the earth's surface, rises and cools as it moves to higher elevations, condenses as rain or snow and falls to the surface where it collects in lakes oceans, soil, and in rocks underground.

Some changes in the solid earth can be described as the "rock cycle." Old rocks at the earth's surface weather, forming sediments that are buried, then compacted, heated, and often re crystallized into new rock. Eventually, those new rocks may be brought to the surface by the forces that drive plate motions, and the rock cycle continues.

Soil consists of weathered rocks and decomposed organic material from dead plants, animals, and bacteria. Soils are often found in layers, with each having a different chemical composition and texture.

Water, which covers the majority of the earth's surface, circulates through the crust, oceans, and atmosphere in what is known as the "water cycle."

Water is a solvent. As it passes through the "water cycle" it dissolves minerals and gases and carries them to the oceans.

The atmosphere is a mixture of nitrogen, oxygen, ad trace gases that include water vapor. The atmosphere has different properties at different elevations.

Clouds, formed by the condensation of water vapor, affect weather and climate.

Global patterns of atmospheric movements influence local weather. p. 159-160

Project 2061, AAAS[95]
Benchmarks for Science Literacy
Chapter 4 The Physical Setting
4B The Earth

The earth is mostly rock. Three-fourths of its surface is covered by a relatively thin layer of water (some of it frozen), and the entire planet is surrounded by a relatively thin blanket of air. It is the only body is the solar system that appears able to support life. The other planets have compositions and conditions very different from the earth's.

Climates have sometimes changed abruptly in the past as a result of changes in the earth's crust, such as volcanic eruptions or impacts of huge rocks from space. Even relatively small changes in atmospheric or ocean content can have widespread effects on climate if the change lasts long enough.

The cycling of water in and out of the atmosphere plays an important role in determining climatic patterns. Water evaporates from the surface of the earth, rises and cools, condenses into rain or snow, and falls again to the surface. The water falling on land collects in rivers and lakes, soil, and porous layers of rock, and much of it flows back into the ocean. p. 69

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S3 Earth and Space Sciences Concepts (cont.)

The student demonstrates conceptual understanding by using a concept accurately to explain observations and make predictions and by representing the concept in multiple ways (through words, diagrams, graphs, or charts, as appropriate). Both aspects of understanding—explaining and representing—are required to meet this standard.

S3b The student produces evidence that demonstrates understanding of Earth's history, such as Earth processes including erosion and movement of plates; change over time and fossil evidence.

Examples of activities through which students might demonstrate conceptual understanding of Earth and space sciences include:

* Explain how earthquakes, volcanoes, and sea-floor spreading have a common cause. 3a, 3b, 4a, 4c
* Complete the Geology Project (Girl Scouts of the U.S.A.) or earn the Astronomy Merit Badge (Boy Scouts of America) and explain what it helped you to understand about Earth processes and structures; fossil evidence; or aspects of the Solar System. 3a, 3b, 3c

New York State Learning Standards for Math, Science, & Technology[96]

Standard 4 Science
Physical Setting

2. Many of the phenomena that we observe on earth involve interactions among components of air, water and land.

Students:

explain how the atmosphere (air), hydrosphere (water) and lithosphere (land) interact, evolve, and change.

describe volcano and earthquake patterns, the rock cycle, and weather and climate changes. p. 32

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National Documents which guided New York State and New York City

NRC National Science Education Standards[97]

Standard D Earth and Space Science
Earth History

The earth processes we see today, including erosion, movement of lithospheric plates, and changes in atmospheric composition are similar to those that occurred in the past. Earth history is also influenced by occasional catastrophes, such as the impact of an asteroid or comet.

Fossils provide important evidence of how life and environmental conditions have changed.

Structure of the Earth System

Living organisms have played many roles in the earth system, including affecting the composition of the atmosphere, producing some types of rocks, and contributing to the weathering of rocks. p. 160

Project 2061, AAAS[98]
Benchmarks for Science Literacy

Chapter 4 The Physical Setting
4C Processes that Shape the Earth

The interior of the earth is hot. Heat flow and movement of materials within the earth cause earthquakes ad volcanic eruptions and create mountains and ocean basins. Gas and dust form large volcanoes can change the atmosphere.

Some changes in the earth's surface are abrupt (such as earthquakes and volcanic eruptions) while other changes happen very slowly (such as uplift and wearing down of mountains). The earth's surface is shaped in part by the motion of water and wind over very long times, which act to level mountain ranges.

Sediments of sand and smaller particles (sometimes containing the remains of organisms) are gradually buried and are cemented together by dissolved minerals to form solid rock again.

Sedimentary rock buried deep enough may be reformed by pressure and heat, perhaps melting and re crystallizing into different kinds of rock. These re-formed rock layers may be forced up again to become land surface and even mountains. Subsequently this new rock too will erode. Rock bears evidence of the minerals, temperatures and forces that created it.

Thousands of layers of sedimentary rock confirm the long history of the changing surface of the earth and the changing life forms whose remains are found in successive layers. p. 73

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S3 Earth and Space Sciences Concepts (cont.)

The student demonstrates conceptual understanding by using a concept accurately to explain observations and make predictions and by representing the concept in multiple ways (through words, diagrams, graphs, or charts, as appropriate). Both aspects of understanding—explaining and representing—are required to meet this standard.

S3c The student produces evidence that demonstrates understanding of Earth in the Solar System, such as the predictable motion of planets, moons, and other objects in the Solar System including days, years, moon phases, and eclipses; and the role of the Sun as the major source of energy for phenomena on the Earth's surface.

Examples of activities through which students might demonstrate conceptual understanding of Earth and space sciences include:

* Write a story that describes what happens to a drop of water and the physical environment through which it flows as it travels from a lake to a river via the Earth's atmosphere. 3a, 3c, 1a, 4a
* Complete the Geology Project (Girl Scouts of the U.S.A.) or earn the Astronomy Merit Badge (Boy Scouts of America) and explain what it helped you to understand about Earth processes and structures; fossil evidence; or aspects of the Solar System. 3a, 3b, 3c
* Create a storybook to explain to a younger child how occasional catastrophes, such as the impact of an asteroid or comet, can influence the Earth's history. 3b, 3c, 2b, 2c, 2d, 2e
* Predict what will happen to the reading of your weight on a bathroom scale while riding in an elevator, investigate your predication, and explain why the prediction was or was not accurate. 3c, 1b
* Use the concept of gravity to explain why people can jump higher on the Moon than they can on Earth. 3c

New York State Learning Standards for Math, Science, & Technology[99]

Standard 4 Science
Physical Setting

1. The earth and celestial phenomena can be described by principles of relative motion and perspective.

Students:
explain daily, monthly, and seasonal changes on earth. p. 32

National Documents which guided New York State and New York City

NRC National Science Education Standards[100]

Standard D Earth and Space Science
Earth in the Solar System

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The earth is the third planet from the sun in a system that includes the moon, the sun, eight other planets and their moons, and smaller objects, such as asteroids and comets The sun, an average star, is the central and largest body in the solar system.

Most objects in the solar system are in regular and predictable motion. Those motions explain such phenomena as the day, the year, phases of the moon, and eclipses.

Gravity is the force that keeps planets in orbit around the sun and governs the rest of the motion in the solar system. Gravity alone holds us to the earth's surface and explains the phenomena of the tides.

The sun is the major source of energy for phenomena on the earth's surface such as growth of plants, wind, ocean currents, and the water cycle. Seasons result from variations in the amount of the sun's energy hitting the surface, due to the tilt of the earth's rotation on its axis and the length of the day. p. 160-161

Project 2061, AAAS[101]
Benchmarks for Science Literacy

Chapter 4 The Physical Setting
4A The Universe

Nine planets of vary different size, composition and surface features move around the sun in nearly circular orbits. Some planets have a great variety of moons and even flat rings of rock and ice particles orbiting around them. Some of these planets and moons show evidence of geologic activity. The earth is orbited by one moon many artificial satellites, and debris. p. 64

4B The Earth

We live on a relatively small planet, the third from the sun in the only system of planets definitely known to exist (although others similar systems may be discovered in the universe).

Everything on or anywhere near the earth is pulled toward the earth's center by gravitational force.

Because the earth turns daily on an axis that is tilted relative to the plane of the earth's yearly orbit around the sun, sunlight falls more intensely on different parts of the earth during the year. The difference in hearing of the earth's surface produces the planet's seasons and weather patterns.

The moon's orbit around the earth once in about 28 days changes what part of the moon is lighted by the sun and how much of that part can be seen from the earth--the phases of the moon.

The moon's orbit around the earth once in about 28 days changes what part of the moon is lighted by the sun and how much of that part can be seen from the earth—the phases of the moon. pp. 68-69

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S3 Earth and Space Sciences Concepts (cont.)

The student demonstrates conceptual understanding by using a concept accurately to explain observations and make predictions and by representing the concept in multiple ways (through words, diagrams, graphs, or charts, as appropriate). Both aspects of understanding—explaining and representing—are required to meet this standard.

S3d The student produces evidence that demonstrates understanding of natural resource management.

Examples of activities through which students might demonstrate conceptual understanding of Earth and space sciences include:

* Identify a place that is subject to periodic flooding, evaluate its positive and negative consequences, and study different ways of maintaining, reducing or eliminating the likelihood of flooding. 3d

New York State Learning Standards for Math, Science, & Technology[102]

Standard 4 Science
The Living Environment

7. Human decisions and activities have had a profound impact on the physical and living environment.

Students:

describe how living things, including humans, depend upon the living and non living environment for their survival.

describe the effects of environmental changes on humans and other populations. p. 33

National Documents which guided New York State and New York City

NRC National Science Education Standards[103]

Standard C Life Science
Populations and Ecosystems

The number of organisms an ecosystem can support depends on the resources available and abiotic factors, such as quantity of light and water, range of temperature, and soil composition. Given adequate biotic and abiotic resources and no disease or predators, populations (including humans) increase at rapid rates. Lack of resources and other factors, such as predation and climate, limit the growth of populations in specific niches in the ecosystem. p. 158

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Standard F Science in Personal and Social Perspectives
Personal Health

Natural environments may contain substances (for example, radon and lead) that are harmful to human beings. Maintaining environmental health involves establishing or monitoring quality standards related to use of soil, water, and air.

Populations, Resources, and Environments

When an area becomes overpopulated, the environment will become degraded due to the increased use of resources.

Causes of environmental degradation and resource depletion vary from region to region and from country to country.

Natural Hazards

Human activities also can induce hazards through resource acquisitions, urban growth, land-use decisions, and waste disposal. Such activities can accelerate many natural changes. p. 168

Project 2061, AAAS[104]
Benchmarks for Science Literacy
Chapter 4 The Physical Setting
4B The Earth

The benefits of the earth's resources—such as fresh water, air, soil, and trees—can be reduced by using them wastefully or by deliberately or inadvertently destroying them. The atmosphere and the oceans have a limited capacity to absorb wastes and recycle materials naturally. Cleaning up polluted air, water, or soil or restoring depleted soil, forests, or fishing grounds can be very difficult and costly. p. 69

4C Processes that Shape the Earth

Human activities, such as reducing the amount of forest cover, increasing the amount and variety of chemicals released into the atmosphere, and intensive farming, have changed the earth's land, oceans and atmosphere. Some of these changes have decreased the capacity of the environment to support some life forms. p. 73

Chapter 5 The Living Environment
5D Interdependence of Life

In all environments--freshwater, marine, forest, desert, grassland, mountain, and other--organisms with similar needs may compete with one another for resources, including food, space, water air, and shelter. In any particular environment, the growth ad survival of organisms depend on the physical conditions. p. 117

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S4 Scientific Connections and Applications

The student demonstrates conceptual understanding by using a concept accurately to explain observations and make predictions and by representing the concept in multiple ways (through words, diagrams, graphs, or charts, as appropriate). Both aspects of understanding—explaining and representing—are required to meet this standard.

The student produces evidence that demonstrates understanding of:

S4a Big ideas and unifying concepts, such as order and organization; models, form, and function; change and constancy; and cause and effect.

S4b The designed world, such as the reciprocal nature of science and technology; the development of agricultural techniques; and the viability of technological designs.

S4c Health, such as nutrition, exercise, and disease; effects of drugs and toxic substances; personal and environmental safety; and resources and environmental stress.

S4d Impact of technology, such as constraints and trade-offs; feedback; benefits and risks; and problems and solutions.

S4e Impact of science, such as historical and contemporary contributions; and interactions between science and society.

Examples of activities through which students might demonstrate conceptual understanding of scientific connections and applications include:

* Create a health pamphlet for a track team that travels around North America to help them adjust to altitudes different from the place where they usually train, and explain why these adjustments are necessary. 4a, 4d, 2c
* Develop a plan to modify the school's fire warning system for students with disabilities. 4b, 4d
* Analyze an automatic ice maker and explain how its design takes into account the differences in the properties of water in liquid and solid states. 4b, 4d, 1a
* Identify a pest in a local agricultural setting; and compare and contrast the risks and benefits of chemical and biological pest control. 4b, 4c, 4d, 4e, 2d
* Hypothesize why people tend to get more colds and flu in the winter and discuss ways to prevent the spread of illness. 4c, 2c
* Investigate local water quality standards and make recommendations to school officials about water quality on and near the campus. 4c, 3a, A1b

New York State Learning Standards for Math, Science, & Technology[105]

Standard 6 Interconnectedness: Common Themes

Students will understand the relationships and common themes that connect mathematics, science, and technology and apply the themes to these and other areas of learning.

Systems Thinking

1. Through systems thinking, people can recognize the commonalities that exist among all systems and how parts of a system interrelate and combine to perform specific functions. p. 52

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Models

2. Models are simplified representations of objects, structures, or systems used in analysis, explanation, interpretation, or design. p. 52

Magnitude and Scale

3. The grouping of magnitudes of size, time, frequency, and pressures or other units of measurement into a series of relative order provides a useful way to deal with the immense range and the changes in scale that affect the behavior and design of systems. p. 53

Equilibrium and Stability

4. Equilibrium is a state of stability due either to a lack of changes (static equilibrium) or a balance between opposing forces (dynamic equilibrium). p. 53

Patterns of Change

5. Identifying patterns of change is necessary for making predictions about future behavior and conditions. p. 54

Optimization

6. In order to arrive at the best solution that meets criteria within constraints, it is often necessary to make trade-offs. p.54

National Documents which guided New York State and New York City

NRC National Science Education Standards[106]

Unifying Concepts and Processes

Systems, order, and organization

Evidence, models, and explanation

Constancy, change, and measurement

Evolution and equilibrium

Form and function pp. 115-119

Standard E Science and Technology pp. 161-166

Standard F Science in Personal and Social Perspectives

Personal Health

Characteristics and Changes in Populations

Types of Resources

Changes in Environments

Science and Technology in Local Challenges pp. 166-170

Standard G History and Nature of Science pp. 170-171

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PERFORMANCE DESCRIPTIONS
Middle School Science

Project 2061, AAAS[107]
Chapter 3 The Nature of Technology pp. 41-57
Chapter 6 The Human Organism pp. 127-149
Chapter 8 The Designed World pp. 181-207
Chapter 10 Historical Perspectives pp. 237-259
Chapter 11 Common Themes
11A Systems
11B Models
11C Constancy and Change
11D Scale pp. 261-279

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S5 Scientific Thinking

The student demonstrates scientific inquiry and problem solving by using thoughtful questioning and reasoning strategies, common sense and conceptual understanding from Science Standards 1 to 4, and appropriate methods to investigate the natural world; that is, the student:

S5a Frames questions to distinguish cause and effect; and identifies or controls variables in experimental and non-experimental research settings.

S5b Uses concepts from Science Standards 1 to 4 to explain a variety of observations and phenomena.

S5c Uses evidence from reliable sources to develop descriptions, explanations, and models.

S5d Proposes, recognizes, analyzes, considers, and critiques alternative explanations; and distinguishes between fact and opinion.

S5e Identifies problems; proposes and implements solutions; and evaluates the accuracy, design, and outcomes of investigations.

S5f Works individually and in teams to collect and share information and ideas.

Examples of activities through which students might demonstrate skill in scientific thinking include:

* Investigate the results of two fellow students' plant growth experiments and recommend ways to enhance the information. 5a, 5b, 5c, 5d, 5e, 5f, 2a
* Determine if the scientific evidence in the summary data chart in Consumer Reports substantiates recommendations about the "Best Buy" for a particular purchase. 5a, 5b, 5c, 5d, 5e
* Work with another student to investigate the effects of several variables on oxygen production in an aquatic plant, e.g., nutrients, light, color of container. 5a, 5b, 5c, 5d, 5e, 5f, 2a, 2c
* Evaluate the claims and potential risks and benefits of a newly advertised "diet pill." 5b, 5c, 5d, 5e, 2c, 4c

New York State Learning Standards for Math, Science, & Technology[108]

Standard 1 Analysis, Inquiry, and Design
Scientific Inquiry

1. The central purpose of scientific inquiry is to develop explanations of natural phenomena in a continuing, creative process. p. 2
2. Beyond the use of reasoning and consensus, scientific inquiry involves the testing of proposed explanations involving the use of conventional techniques and procedures and usually requiring considerable ingenuity. p. 2
3. The observations made while testing explanations, when analyzed using conventional and invented methods, provide new insights into phenomena. p. 3

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National Documents which guided New York State and New York City

NRC National Science Education Standards[109]

Standard A Science As Inquiry

Identify questions that can be answered through scientific investigations. p. 145

Develop descriptions, explanations, predictions, and models using evidence. p. 145

Think critically and logically to make the relationships between evidence and explanations. p. 145

Recognize and analyze alternative explanations and predictions. p. 148

Scientific explanations emphasize evidence, have logically consistent arguments, and use scientific principles, models, and theories. p. 148

Project 2061, AAAS[110]

Chapter 1 The Nature of Science
1B Scientific Inquiry

If more than one variable changes at the same time in an experiment, the outcome of the experiment may not be clearly attributable to any one of the variables. It may not always be possible to prevent outside variables from influencing the outcome of an investigation (or even to identify all of the variables), but collaboration among investigators can often lead to research designs that are able to deal with such situations. p. 12

Chapter 12 Habits of Mind
12E Critical Response Skills

Notice and criticize the reasoning in arguments in which (1) fact and opinion are intermingled or the conclusions do not follow logically from the evidence given, (2) an analogy is not apt, (3) no mention is made of whether the control groups are very much like the experimental group, or (4) all members of a group (such as teenagers or chemists) are implied to have nearly identical characteristics that differ from those of other groups. p. 299

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S6 Scientific Tools and Technologies

The student demonstrates competence with the tools and technologies of science by using them to collect data, make observations, analyze results, and accomplish tasks effectively; that is, the student:

S6a Uses technology and tools (such as traditional laboratory equipment, video, and computer aids) to observe and measure objects, organisms, and phenomena, directly, indirectly, and remotely.

S6b Records and stores data using a variety of formats, such as data bases, audiotapes, and videotapes.

S6c Collects and analyzes data using concepts and techniques in Mathematics Standard 4, such as mean, median, and mode; outcome probability and reliability; and appropriate data displays.

S6d Acquires information from multiple sources, such as print, the Internet, computer data bases, and experimentation.

S6e Recognizes sources of bias in data, such as observer and sampling biases.

Examples of activities through which students might demonstrate competence with the tools and technologies of science include:

* Use a microcomputer-based investigation to compare the rates at which different carbonated beverages in a variety of containers lose their fizz. 6a, 1a, 4b, 5a
* Complete the Animal Observation Project (Girl Scouts of the U.S.A.) and teach another student how to conduct field observations. 6a, 2d
* Conduct a field research project to compare the distribution of birds near the school with a field guide for the region to see if local distributions are the same as regional. 6c, 6d, 2d
* Compare the accuracy and timeliness of local weather information from a variety of sources. 6d, 3a
* Exchange data on the acidity of rain with students from other states or countries. Figure out why the data differ, if they do. 6d, 1a, 3a
* Use electronic data bases to get current information on the health effects of long-term space travel. 6d, 3c, 4c

New York State Learning Standards for Math, Science, & Technology[111]

Standard 2 Information Systems

1. Information technology is used to retrieve, process, and communicate information and as a tool to enhance learning.

Students:

use spreadsheets and data-base software to collect, process, display, and analyze information. p. 10

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Standard 3 Mathematics
Modeling/Multiple Representation

4. Students use mathematical modeling/multiple representation to provide a means of presenting, interpreting, and communicating, and connecting mathematical information and relationships. p. 19

Measurement

5. Students use measurement in both metric and English measure to provide a major link between the abstractions of mathematics and the real world in order to describe and compare objects and data. p. 20

National Documents which guided New York State and New York City

NRC National Science Education Standards[112]

Standard A Science as Inquiry

Develop appropriate tools and techniques to gather, analyze, and interpret data. p. 145

Use mathematics in all aspects of scientific inquiry. p. 148

Project 2061, AAAS[113]
Chapter 12 Habits of Mind
12C Manipulation and Observation

Use computers to store and retrieve information in topical, alphabetical, numerical, and key-word files, and create simple files of their own devising.

Read analog and digital meters on instruments used to make direct observations of length, volume, weight, elapsed time, rates, and temperature, and choose appropriate units for reporting various magnitudes.

Use cameras and tape recorders for capturing information. p. 294

12D Communication Skills

Locate information in reference books, back issues of newspapers and magazines, compact discs, and computer databases. p. 297

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S7 Scientific Communication

The student demonstrates effective scientific communication by clearly describing aspects of the natural world using accurate data, graphs, or other appropriate media to convey depth of conceptual understanding in science; that is, the student:

S7a Represents data and results in multiple ways, such as numbers, tables, and graphs; drawings, diagrams, and artwork; and technical and creative writing.

S7b Argues from evidence, such as data produced through his or her own experimentation or by others.

S7c Critiques published materials.

S7d Explains a scientific concept or procedure to other students.

S7e Communicates in a form suited to the purpose and the audience, such as by writing instructions that others can follow; critiquing written and oral explanations; and using data to resolve disagreements.

Examples of activities through which students might demonstrate competence in scientific communication include:

* Earn the Drafting Merit Badge. (Boy Scouts of America) 7a, 4b, 5c, 6a
* Write an advertisement for a hair care product that explains the chemistry of how it works. 7b, 1a, 4b, 4c, 5d
* Analyze and give a speech about a ballot initiative on toxic chemicals. 7c, 1a, 2c, 3a, 4b, 5d, 6d
* Critique a USA Today article which reports that eating hot dogs in childhood causes adult leukemia. 7c, 2c, 4c, 5d
* Write a review of an episode of Beakman's World. 7c, 5d, 6d
* Make an animated video illustrating how white blood cells protect the body from infectious agents. 7d, 2a, 2c, 4c, 5c

New York State Learning Standards for Math, Science, & Technology[114]

Standard 1 Analysis, Inquiry, and Design
Scientific Inquiry

3. The observations made while testing explanations, when analyzed using conventional and invented methods, provide new insights into phenomena.

Students:

design charts, tables, graphs, and other representations of observations in conventional and creative ways to help them address their research question or hypothesis. p. 5

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National Documents which guided New York State and New York City

NRC National Science Education Standards[115]

Standard A Science as Inquiry

Think critically and logically to make the relationships between evidence and explanations. p. 145

Communicate scientific procedures and explanations. p. 148

Project 2061, AAAS[116]

Chapter 9 The Mathematical World
9B Symbolic Relationships

Graphs can show a variety of possible relationships between two variables. p. 219

Chapter 12 Habits of Mind
12D Communication Skills

Organize information in simple tables and graphs and identify relationships they reveal. p. 297

12E Critical Response Skills

Question claims based on vague attributions (such as "Leading doctors say...") or on statements made by celebrities or others outside the area of their particular expertise.

Be skeptical of arguments based on very small samples of data, biased samples, or samples for which there was no control sample. p. 299

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S8 Scientific Investigation

The student demonstrates scientific competence by completing projects drawn from the following kinds of investigations, including at least one full investigation each year and, over the course of middle school, investigations that integrate several aspects of Science Standards 1 to 7 and represent all four of the kinds of investigation:

S8a Controlled experiment.

S8b Fieldwork.

S8c Design.

S8d Secondary research, such as use of others' data.

A single project may draw on more than one kind of investigation.
A full investigation includes:

- **Questions that can be studied using the resources available.**
- **Procedures that are safe, humane, and ethical; and that respect privacy and property rights.**
- **Data that have been collected and recorded (see also Science Standard 6) in ways that others can verify, and analyzed using skills expected at this grade level (see also Mathematics Standard 4).**
- **Data and results that have been represented (see also Science Standard 7) in ways that fit the context.**
- **Recommendations, decisions, and conclusions based on evidence.**
- **Acknowledgment of references and contributions of others.**
- **Results that are communicated appropriately to audiences.**
- **Reflection and defense of conclusions and recommendations from other sources and peer review.**

Examples of projects through which students might demonstrate competence in scientific investigation include:

* Analyze de-icers for relative effectiveness, cost, and environmental impact. 8a, 1a, 3d, 4d
* Study different methods for cooking chicken considering health and aesthetics. 8a, 8c, 4c
* Conduct a field study of monument degradation over time at a local cemetery. 8b, 1a, 3a
* Adopt a stream and use that location to study habitat and water quality over time. 8b, 2d, 3a
* Design a protective container for an uncooked egg using the concepts of force, motion, gravity, and acceleration and test the design by dropping the container (egg enclosed) from a one-story building. 8c, 1a, 1b
* Research local climate changes over the last century. 8d, 3a

New York State Learning Standards for Math, Science, & Technology[117]

Standard 1 Analysis, Inquiry, and Design

Scientific Inquiry

1. The central purpose of scientific inquiry is to develop explanations of natural phenomena in a continuing, creative process.
2. Beyond the use of reasoning and consensus, scientific inquiry involves the testing of proposed explanations involving the use of conventional techniques and procedures and usually requiring considerable ingenuity. p. 4
3. The observations made while testing explanations, when analyzed using conventional and invented methods, provide new insights into phenomena. p. 5

Engineering Design

1. Engineering design is an iterative process involving modeling and optimization finding the best solution within given constraints which is used to develop technological solutions to problems within given constraints. p. 5

National Documents which guided New York State and New York City

NRC National Science Education Standards[118]

Standard A Science as Inquiry

Design and conduct a scientific investigation. Students should develop general abilities, such as systematic observation, making accurate measurements, and identifying and controlling variables. They should also develop the ability to clarify their ideas that are influencing and guiding inquiry, and to understand how those ideas compare with current scientific knowledge. Students learn to formulate questions, design investigations, execute investigations, interpret data, use evidence to generate explanations, propose alternative explanations, and critique explanations and procedures. p. 145

Standard E Science and Technology

Identify a problem or design an opportunity.

Propose designs and choose between alternative solutions.

Implement a proposed solution.

Evaluate the solution and its consequences.

Communicate the problem, process, and solution. p. 192

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Project 2061, AAAS[119]
Chapter 1 The Nature of Science
1B Scientific Inquiry

Scientists differ greatly in what phenomena they study and how they go about their work. Although there is no fixed set of steps that all scientists follow, scientific investigations usually involve the collection of relevant evidence, the use of logical reasoning, and the application of imagination in devising hypotheses and explanations to make sense of the collected evidence. p. 12

Chapter 3 The Nature of Technology
3B Design and Systems

Design usually requires taking constraints into account. Some constraints, such as gravity or the properties of materials to be used, are unavoidable. Other constraints, including economic, political, social, ethical, and aesthetic ones, limit choices. p. 51

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Work Sample & Commentary: *Mechanical Nut*
Middle School Science

The task[120]

After a unit on motion and forces, students were asked to move a mechanical nut in a horizontal direction as far as possible without directly rolling, throwing, pushing, or sliding the nut itself. The students were given limited materials (cardboard tube, small plastic container with cap, 70 cm of ramp, cotton, small pebbles, and meter sticks) to accomplish the task. Additional "challenge" tasks were assigned, such as moving the nut exactly one meter. After recording observations and results of various experiments, the students were required to complete a written report including the following sections: title, purpose (hypothesis), materials, procedure, results, and conclusion.

Circumstances of performance

This sample of student work was produced under the following conditions:

alone	√ in a group
√ in class	√ as homework
√ with teacher feedback	with peer feedback
timed	√ opportunity for revision

This work sample illustrates a standard-setting performance for the following parts of the standards:[121]

S1b Physical Sciences Concepts: Motions and forces.

S5b Scientific Thinking: Use concepts from Science Standards 1 to 4.

S5e Scientific Thinking: Identify problems; propose and implement solutions; and evaluate the accuracy, design, and outcomes of investigations.

S5f Scientific Thinking: Work individually and in teams.

S7e Scientific Communication: Communicate in a form suited to the purpose and the audience.

What the work shows

S1b Physical Sciences Concepts: The student produces evidence that demonstrates understanding of motions and forces, such as inertia and the net effects of balanced and unbalanced forces.

(A) In the results, the students identify forces acting in this system, and describe the effects of those forces. The students correctly state that gravity pulls the mechanical nut down, affecting its motion. The students correctly identify how friction changes the motion of the nut.

(B) The students' conclusion correctly describes how different forces affect the movement of the mechanical nut. The students describe how balanced and unbalanced forces act upon the nut in terms of changes in direction and/or speed.

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[120] For related work on Force and Motion, see "Come Back Can", page 60, and "The Challenger Disaster", page 368.
[121] The quotations from the Science performance descriptions in this commentary are excerpted. The complete performance descriptions are shown on pages 152-187.

S5b Scientific Thinking: The student uses concepts from Science Standards 1 to 4 to explain a variety of observations and phenomena.

(A) The students correctly identify and describe the effects of friction on motion.

(B) The students correctly identify and describe the effects of gravity on the mechanical nut.

S5c Scientific Thinking: The student identifies problems; proposes and implements solutions; and evaluates the accuracy, design, and outcomes of investigation.

(A) The students evaluate the successful outcomes of their procedural designs, and provide insight into the reasoning behind specific details of each procedure.

(C) (D) (E) (F) (G) The students identify five problems (numbered by the students themselves as A through E) and design and implement a procedure that solves each problem.

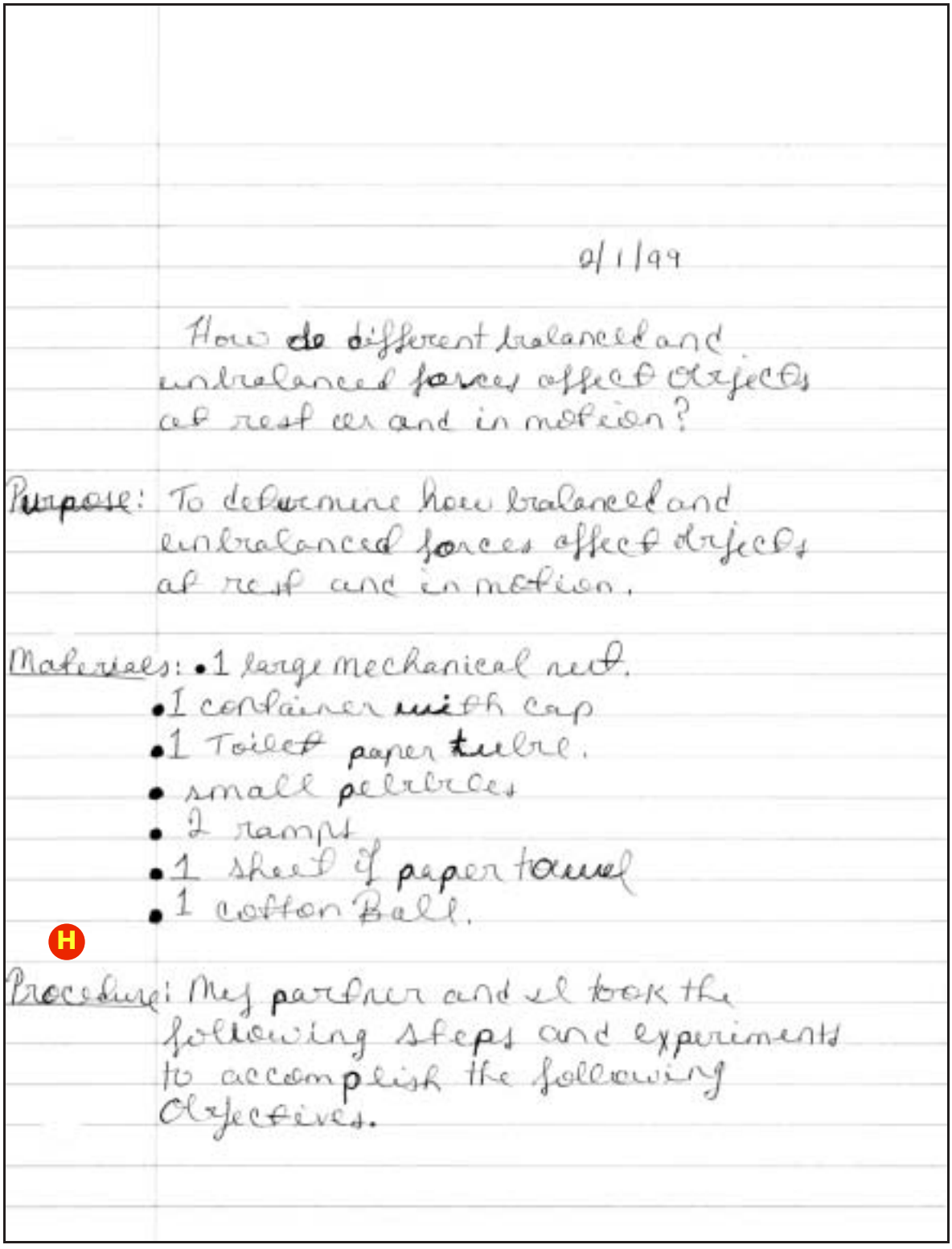
S5f Scientific Thinking: The student works individually and in teams to collect and share information and ideas.

(A) In the results, the student who recorded for the team states overtly that the work was done as a team. Phrasing such as "My partner and I…" and "…we used…" makes it clear that the students worked cooperatively throughout the development of experiments and presentations.

(H) The student prefaces the activities with a statement that the procedure is being carried out in partnership with another student.

S7e Scientific Communication: The student communicates in a form suited to the purpose and the audience, such as by writing instructions that others can follow….

(C) (D) (E) The students presented a written report that pairs each problem with a plan and a diagram of the set-up. Three plans are clear, concise and accurate representations of the procedures, and they meet the standard. (The remaining two pairs require some minor clarification for replication by other students.) The students created a report that demonstrates an organized structure appropriate to the purpose, audience and context, and excludes extraneous and inappropriate information.



2/1/99

How do different balanced and unbalanced forces affect objects at rest or and in motion?

Purpose: To determine how balanced and unbalanced forces affect objects at rest and in motion.

Materials: • 1 large mechanical nut.
• 1 container with cap
• 1 Toilet paper tube.
• small pebbles
• 2 ramps
• 1 sheet of paper towel
• 1 cotton Ball.

H

Procedure: My partner and el took the following steps and experiments to accomplish the following objectives.

2

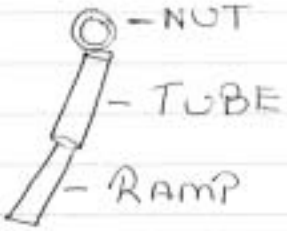
C

1. Make a large Mechanical nut move horizontally as far as possible without pushing, sliding, or throwing it. The nut may be lifted Vertically. (up).

Plan (A)

- Take the large mechanical nut, tube and ramp.
- Hold the tube and ramp together 1 meter up in the air, Start it.
- Take the large Mechanical nut and drop it down the tube.

PLAN (A):



RAMP DROP

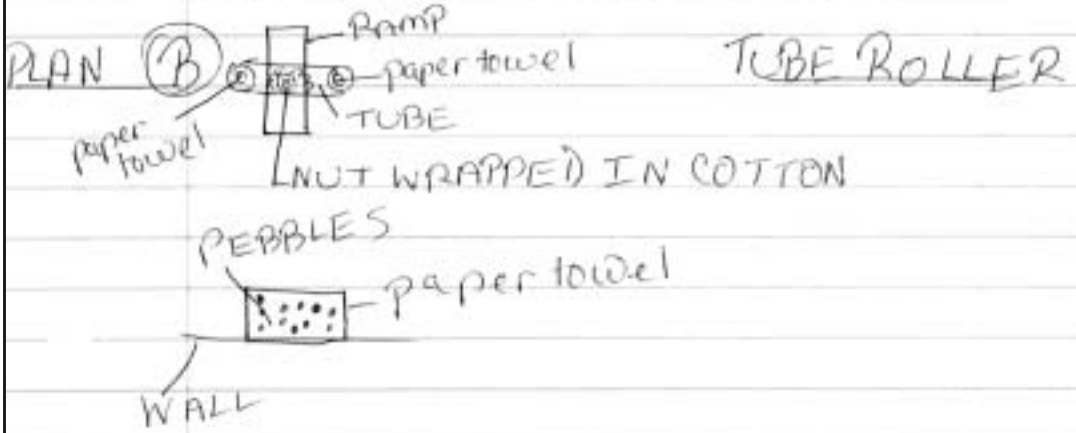
D

2. Make a large Mechanical nut move exactly 1 meter.

3

Plan (B)

- Take the large Mechanecal nut and wrap it in cotton.
- Put the nut in the tube and rip ½ of 1 sheet of papertowel.
- Take the half of the papertowel and rip it in ½ again stuff it in each side of the tube.
- Measure on the floor 1 meter from the wall.
- Put the other half of the paper towel against the wall and put the pebbles on top. Take the ramp and stand it at the starting point.
- Roll the tube down the ramp.



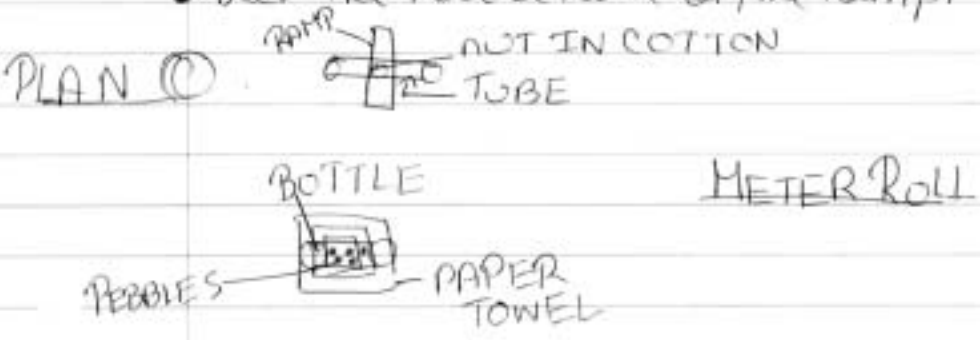
4

E

B Make a large mechanical nut move exactly 1 meter without pushing, sliding, throwing, rolling it or using the wall.

Plan C

- Wrap the nut in cotton and put it in the tube.
- Take ½ of the paper towel, rip it in ½ then stuff it in both sides of the tube.
- fold the rest of the paper towel up.
- fill the bottle with pebbles, cover it and rest it on the folded paper towel.
- Let the tube roll on the ramp.



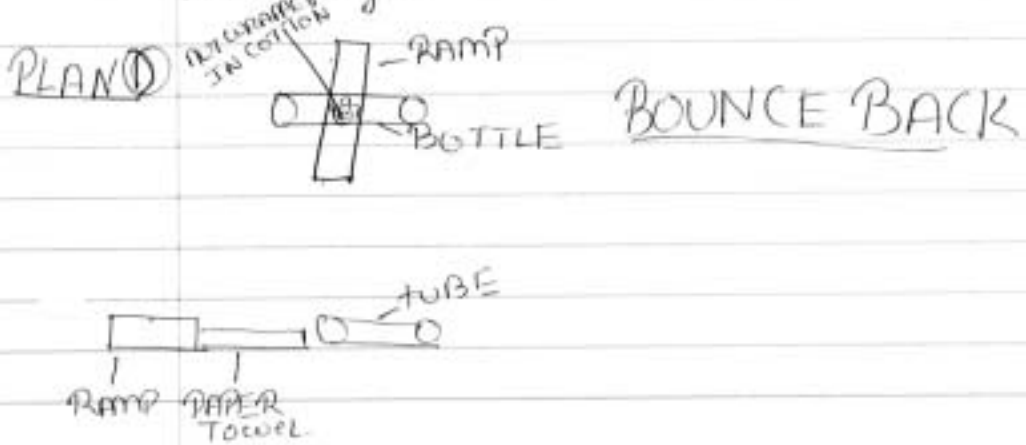
5

F

④ Make a large mechanical nut move in one direction, stop and move in the other direction.

Plan (1)

- Wrap the nut in cotton and stuff it in the bottle.
- Take the tube and the paper towel. Stuff the paper towel in one end of the tube.
- Take the other end of the paper towel in the ramp.
- Set up the ramp, paper towel and tube so that it is in front of the ramp and the bottle.
- Take the ramp, slant it and let the bottle go.



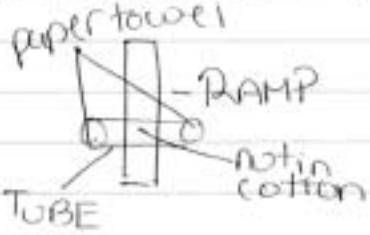
6

G ⑤ Make a large mechanical nut move and return to the exact starting point.

Plan (E)

- wrap the nut in cotton and stuff it in the tube.
- Rip the paper towel in half and stuff it in each side of the tube.
- Measure one foot on the floor from the teachers desk.

PLAN (E)



TEACHERS DESK

EXACT BOUNCE

A

7

Results: Plans A through E were successful. For plan A, the nut drops down the tube because of gravity. In plan B, you may ask yourself why my partner and I put pebbles on the papertowel. The answer was to create friction, for a full and complete stop. The friction between the tube and the pebbles slowed the tube down. If the pebbles were not there, the tube would just bounce right back.

Plan C, the folded piece of papertowel was to act as a wall, or a stoppage.

In plan D, the soft paper towel in between the ramp and tube made the bottle bounce back.

For plan E, we used the teachers desk because it was hard and we needed more bounce than just the paper towel.

B

8

Conclusion: Gravity pulled down on the nut until something blocked it which was the floor. Gravity (a pull) affected this object in motion until it stopped. This is an example of balanced forces at work.

An example of unbalanced forces and how they affect an object at rest and in motion, is in plan E. In plan E, when the tube rolls down the ramp, it hits the desk and bounces right back, ⇨ ⇦ and stays still. The force pushed equally ⇨ ⇦ on each side so when it bounces back it stays still.

In conclusion, balanced and unbalanced forces affect objects in motion or at rest.

Gravity can affect objects by pulling the object down or pushing it down. Friction can either keep an object in motion or at rest.