

Summary of Science and Technology/Engineering Content Changes by Grade Span and Discipline

The lists below describe changes in **content** made to science and technology/engineering standards from the 2001/2006 standards (current) to the revised standards (10/20/15). Changes can broadly be characterized as: 1. Changes in focus that reflect changes in science and engineering, and 2. Changes in focus that reflect needs of citizenship and college and career readiness. Many of these changes reflect recommendations from the National Research Council, as articulated in the Framework for K-12 Science Education (2010) and from professional experience and public input from Massachusetts educators and representatives of educational and science communities. Some changes represent content moved from one grade span to another (indicated when appropriate); other changes are deletions or additions. Changes are organized by elementary, middle, and high school, as well as by discipline.

Elementary School: Grades PreK-5

Content in the 2001/6 PreK-5 standards that is **not included** in the revised 2015 PreK-5 standards

Earth and Space Science

- Air is a mixture of gasses all around us; wind is moving air
- Examples of minerals and tests for mineral properties
- Categories of rocks and processes that create them (in later grades)
- Properties of soil
- How global patterns influence local weather (in later grades)
- Cycling of water in and out of the atmosphere and its effect on climate (in later grades)

Life Science

- Seasonal appearance changes in plants and animals
- Adaptation over time (in later grades)
- Behavior as instinctive vs. behavior as learned, and response to stimuli
- Plant behaviors

Physical Science

- Magnetic energy (in later grades)
- Electrical circuits; electricity can produce light, heat, and sound (in later grades)
- Electromagnets (in later grades)
- Refraction of light (in later grades)

Technology/Engineering

- Simple machines; difference between simple and complex machines
- Humans and animals use parts of the body as tools
- Lists of specific tools to know
- Contexts of shelter, storage, or convenience
- Natural systems vs. mechanical systems designed to serve similar purposes

Earth and Space Science

Earth's Place in the Universe

- Sun is a star that appears larger and brighter than other stars because it is closer to earth

Earth's Systems

- Weather's impact on living things
- Developing solutions to slow or prevent wind or water from changing the landform
- Mapping of Earth's landforms, bodies of water; placement of volcanoes and earthquakes (moved from later grades)
- Effect of wind and water on landforms (moved from later grades)
- Amounts and percentages of water in various bodies of water; the availability of fresh water in the earth's biosphere

Earth and Human Activity

- Local resources that humans use to meet their needs
- Impact of people's actions on the environment
- Purpose of weather forecasting
- Reducing the amount of natural resources used by people and communities
- Solution designs that reduce the impact of weather-related or naturally occurring hazards
- Testing of a simple water filtration system
- Renewable and non-renewable energy sources (moved from later grades)

Life Science

Ecosystems: Interactions, Energy, and Dynamics

- Comparing decomposition in composter designs
- Model the movement of matter through the ecosystem (moved from later grades)

Heredity: Inheritance and Variation of Traits

- Observe differences and similarities between themselves and friends
- Inherited traits of plants and animals (moved from later grades)

Biological Evolution: Unity and Diversity

- Compare different kinds of living things within and between different areas
- Survival of organisms relative to an environment
- Population survival depends on reproduction

Physical Science

Matter and Its Interactions

- Weight of matter is conserved regardless of change that occurs when heating, cooling, or combining substances (moved from later grades)
- Mixing of two or more substances results in new substances with new properties (moved from later grades)
- Material properties do not change no matter how small the pieces

Motion and Stability: Forces and Interactions

- Effect of multiple forces on an object; balanced and unbalanced forces
- Gravitational force (moved from later grades)

Energy

- Relating an object's speed to its energy
- Effects of friction on relative temperature and speed of objects

Waves and Their Application in Technologies for Information Transfer

- Characteristics of waves (moved from later grades)
- Ways to transfer information (moved from later grades)
- Relationships between the size and shape of objects, their shadows and the light source

Technology/Engineering

Engineering Design

- Testing objects designed to solve the same design problem to compare strengths and weaknesses
- Solving design problems based on criteria and constraints (moved from later grades)
- Test a model or prototype with controlled variables and consideration of failure points

Technological Systems

- Technology is any modification of work done to fulfill human needs and wants
- Parts of technological products purposely relate to other parts

Middle School: Grades 6-8

Content in the 2001/6 grade 6-8 standards that is **not included** in the revised 2015 grade 6-8 standards

Earth and Space Science

- Formation of planets, stars, and the solar system
- Mapping Earth's physical features (in earlier grades)
- Contour maps
- Properties and conditions of objects in the solar system
- Layers of the earth (in later grades)
- Global patterns of atmospheric movement

Life Science

- Classification of organisms by kingdoms
- Cells carry out all functions of life (in later grades)
- Comparison of plant and animal cells
- Reproduction and immune systems (in later grades)
- Humans have 30,000 genes and 23 chromosomes
- Diversity of organisms (in later grades)
- Formula for photosynthesis (in later grades)

Physical Science

- Differentiate weight and mass
- Sensitivity of measuring tools
- Distance vs. time graphs (in later grades)
- Equilibrium (in later grades)

Technology/Engineering

- Identifying specific tools and purposes
- Retrieval and destination components of a communication system
- Types of communication technologies
- Use of symbols and icons in communicating messages
- Operation of transportation systems and devices in various environments
- Specific types of bridges; effect of structural shapes on bridge performance
- Specific types of forces on bridges (in later grades)
- Universal systems model
- Forces on a vehicle (in later grades)
- Custom and mass production (in later grades)
- Mass produced, interchangeable parts, and automation
- Definition of a manufacturing organization
- Adaptive and assistive devices, and bioengineered products

Earth and Space Science

Earth's Place in the Universe

- Sun-Earth-moon relationships (moved from later grades)
- Dating methods to measure geologic time, including Law of Superposition and Crosscutting Relationships (moved from later grades)

Earth's Systems

- Categories of rocks and processes involved in their development; rock cycle (moved from earlier and later grades)
- Tectonic plate movement and volcanic activity, generation of ocean seafloor and mountain building (moved from later grades)
- Hydrologic cycle through Earth's hydrosphere (moved from earlier and later grades)
- Weather patterns and relationships in air mass interactions (moved from earlier and later grades)

Earth and Human Activity

- Earth's uneven distribution of mineral and fossil fuel resources as a result of geologic processes
- Mitigating impact of increases in human population and consumption of natural resources
- Role of human activities in rising global temperature
- Forecasting future catastrophic events (moved from earlier grades)

Life Science

From Molecules to Organisms: Structures and Processes

- Characteristic animal behavior and plant structures increase odds of successful reproduction
- Environmental and genetic factors influence growth of organisms
- Food molecules are broken down to support growth and/or release of energy (moved from later grades)

Ecosystems: Interactions, Energy, and Dynamics

- Cycling of matter through an ecosystem
- Protecting an ecosystem
- Impact of changes in biodiversity on availability of resources for human use

Hereditary: Inheritance and Variation of Traits

- Impact of mutations on proteins and traits (moved from later grades)
- Genes hold instructions for proteins, which affect traits

Biological Evolution: Unity and Diversity

- Artificial selection

Physical Science

Matter and Its Interactions

- Properties of interacting substances before and after to determine if chemical reaction occurred (moved from later grades)
- Effect of thermal energy on particle motion, relative spatial arrangement, and state of pure substance (moved from later grades)
- Substances are rearranged during a chemical reaction (moved from later grades)
- Exothermic and endothermic reactions (moved from later grades)

Motion and Stability: Forces and Interaction

- Newton's Third Law of Motion (moved from later grades)
- Change in motion depends on net force and mass of object; Newton's First and Second Laws of Motion (moved from later grades)
- Effects of distance and magnitude of electric charge and current on electric force (moved from later grades)
- Existence of fields between mass, magnetic and electrically charged objects

Waves and Their Applications in Technologies for Information Transfer

- Wave patterns and properties (moved from later grades)
- Encoding and transmission of information through digitized signals
- Principles of reflection and transmission of waves (moved from later grades)

Technology/Engineering

Engineering Design

- Criteria and constraints of design problems for successful solution

Materials Tools and Manufacturing

- Effect of physical processes on the composition and properties of materials
- Analyzing features of a designed object to infer function
- Materials can be transformed into products by humans and computers

Energy and Power Technology

- Energy conversion through mechanical means by a machine to do work (moved from later grades)

High School: Earth and Space Science (ESS)

Content in the 2001/6 ESS standards that is **not included** in the revised 2015 ESS standards

Earth's Place in the Universe

- Formation of the solar system

Earth's Systems

- Impact of electromagnetic radiation on life on Earth
- Global atmospheric currents/circulation patterns
- Specific ocean currents (Labrador Current, Gulf Stream)
- Definition of watershed
- Physical properties of common minerals
- Locating earthquake epicenters
- Richter scale

Earth and Human Activity

- Specific energy resources

Content in the 2001/6 ESS standards that is **added** to the revised 2015 ESS standards

Earth's Place in the Universe

- Life span of the sun as a function of nuclear fusion
- Nuclear fusion in stars produce elements from He (helium) to Fe (iron)
- Relative ages of continental and oceanic rocks
- Effect of long-term changes in Earth's tilt and orbit on climate changes

Earth's Systems

- Factors that influence climate change

Earth and Human Activity

- Availability of key natural resources and changes in climate influence human activity
- Design solutions for using, conserving and recycling energy based on economic, social and environmental cost-benefit ratios
- Sustainability of human populations and biodiversity related to the management of natural resources
- Global climate models predict the current rate of global/regional climate change and future impacts to Earth systems

High School: Biology

Content in the 2001/6 biology standards that is **not included** in the revised 2015 biology standards

Molecules to Organisms: Structures and Processes

- Primary structures of carbohydrates, lipids, and nucleic acids
- Some cell parts: nuclear envelope, nucleolus, cytoplasm, endoplasmic reticulum, Golgi apparatus, lysosome, vacuole, cytoskeleton, centriole, cilium, flagellum, pseudopod
- Specific processes involving the cell membrane: diffusion, osmosis, facilitated diffusion, active transport
- Comparing genetic material of a virus and a cell
- Basic structure of DNA and the function of that structure in genetic inheritance
- Some specific body parts: mouth, pharynx, esophagus, rectum, arteries, capillaries, red blood cells, nose, larynx, trachea, alveoli, sensory neurons, motor neurons, smooth and cardiac muscles, cartilage, ligaments, tendons, the role of bones in producing blood cells
- Some cells produce signals to communicate only with nearby cells

Ecosystems: Interactions, Energy, and Dynamics

- Nitrogen cycle
- Food web roles (moved to earlier grades)
- Impact of birth, death, immigration, and emigration on population size (moved to earlier grades)

Heredity: Inheritance and Variation of Traits

- Importance of maintaining chromosome number during asexual reproduction
- Haploid cells and diploid zygotes
- Several inheritance patterns caused by several types of genetic traits: codominant, sex-linked, polygenic, incomplete dominance, multiple alleles, dihybrid crosses
- Specifics of Mendel's Laws

Biological Evolution: Unity and Diversity

- Comparison of prokaryotes and eukaryotes
- Describing the six kingdoms
- Definition of species, classified into hierarchical taxonomic system

Molecules to Organisms: Structures and Processes

- Role of proteins in carrying out essential functions of life, including structural proteins, hormones, and antibodies
- Features of viruses and bacteria which explain their ability to survive in a wide variety of environments

Ecosystems: Interactions, Energy, and Dynamics

- Role of photosynthesis, respiration, decomposition, and combustion in the global cycling of carbon
- Biotic and abiotic factors that affect ecosystem carrying capacity and biodiversity (including species diversity)
- Need for constant input of energy to sustain energy transfer between trophic levels
- Dynamic interactions that constantly occur in ecosystems and how changes to those may result in a new ecosystem; greater biodiversity tends to have greater resistance to changes
- Impact of and methods to reduce the impact of human action on ecosystem health

Heredity: Inheritance and Variation of Traits

- Mutations during replication and mutations caused by environmental factors

Biological Evolution: Unity and Diversity

- Interaction of genetic and environmental factors to determine variation of traits in a population.
- Necessary conditions for evolution by natural selection

High School: Chemistry

Content in the 2001/6 chemistry standards that is **not included** in the revised 2015 chemistry standards

Matter and Its Interactions

- Identifying differences between physical and chemical changes (moved to earlier grades)
- Classification of metals, nonmetals, and metalloids
- Historical models of atoms
- Rutherford's Gold Foil Experiment
- Types of radioactive decay; half-life
- Nuclear equations
- Chemical formulas for ionic and molecular compounds
- Full electron configurations; Lewis dot structures
- Comparison of pure solvents and solutions
- Heterogeneous and homogeneous mixtures
- Specific physical properties and changes (moved to earlier grades)
- States of matter and their properties in terms of particle motion (moved to earlier grades)
- Effects of hydrogen bonding
- Buffers

Content in the 2001/6 chemistry standards that is **added** to the revised 2015 chemistry standards

Matter and Its Interactions

- Physical properties of substances are related to internal spatial arrangements, movement, and strength of electrostatic forces; two major types of crystal structures include atom/ionic networks and molecular crystals
- Differences in atomic composition and molecular geometry allow for identification, detection, and separation of substances in a mixture
- Difference in conductivity between a solution and its pure solvent

High School: Introductory Physics

Content in the 2001/6 introductory physics standards that is **not included** in the revised 2015 introductory physics standards

Motion and Stability: Forces and Interactions

- Compare and contrast vector and scale quantities
- Distinguishing static and kinetic friction
- Forces involved in circular motion
- Power as work done per unit time; work as change in mechanical energy
- Balanced and unbalanced forces in a system (Newton's First Law) (moved to earlier grades)
- Using a model to demonstrate Newton's Third Law of Motion of colliding objects (moved to earlier grades)

Energy

- When thermal energy is added or removed, there will be changes in particle motion, relative spatial arrangement, temperature and state (moved to earlier grades)
- Electric motors or generators
- Electric charge on, in, or through insulators and conductors
- Electric circuit diagrams and symbols

Waves and Their Applications in Technologies for Information Transfer

- Differentiate between transverse and longitudinal mechanical waves
- Doppler effect
- Electromagnetic spectrum in terms of frequency and wavelength and identifying location of different waves on the spectrum
- Harmonic motion
- Waves have repeating patterns with specific amplitude, frequency, and wavelength (moved to earlier grades)
- Waves are regular patterns of motion that energy can travel along and can differ in amplitude and wavelength (moved to earlier grades)
- Light and mechanical waves are reflected, absorbed and transmitted through materials (moved to earlier grades)

Motion and Stability: Forces and Interactions

- Relationship of electric currents and magnetic fields

Energy

- Energy in electrical and magnetic fields

Waves and Their Applications in Technologies for Information Transfer

- Electromagnetism can be described by a wave model or a particle model; each explains different phenomena
- Technological devices use principles of wave behavior and interactions with matter to transmit and capture energy and information

High School: Technology/Engineering

Content in the 2001/6 technology/engineering standards that is **not included** in the revised 2015 technology/engineering standards

Materials, Tools, and Manufacturing

- Choose and safely use appropriate tools to construct a prototype (moved to earlier grades)

Technological Systems

- Materials used in structures
- Effect of Bernoulli's principle on buildings and bridges
- Purpose of zoning laws and building codes
- Hydraulic and pneumatic systems related to manufacturing and transportation systems
- Velocity of liquid moving in a pipe
- Sources of resistance for water moving in a pipe

Energy and Power Technologies

- Alternatives to nonrenewable energies
- Components of a circuit including sources, conductors, breakers, fuses, controllers and loads
- Resistance is affected by external factors
- Alternating current and direct current
- Applications of laser and fiber optic technologies
- Application of electromagnetic signals in fiber optic technologies
- Criteria for selecting safe tools and procedures for manufacturing process

Content in the 2001/6 technology/engineering standards that is **added** to the revised 2015 technology/engineering standards

Engineering Design

- Apply scientific and engineering principles to a complex real-world problem to create smaller more manageable problems that can be solved
- Criteria and constraints can be defined qualitatively and quantitatively
- Criteria and trade-offs need to be prioritized
- Use of computer simulations to model solutions

Energy and Power Technologies

- Humans use energy and power systems that harness resources to accomplish tasks effectively and efficiently
- Costs and benefits of custom vs. mass production
- Materials can be transformed to meet a purpose or function