Text of Adopted Amendments to 19 TAC

Chapter 112. Texas Essential Knowledge and Skills for Science

Subchapter C. High School

§112.31. Implementation of Texas Essential Knowledge and Skills for Science, High School [~~, Beginning with School Year 2010-2011~~] .

(a) The provisions of [~~§§112.32-112.39 of~~] this subchapter shall be implemented by school districts [~~beginning with the 2010-2011 school year~~] .

(b) The provisions of §§112.34, 112.35, 112.38, and 112.39 of this subchapter adopted in 2017 shall be implemented by school districts beginning with the **2018-2019** [~~**2017-2018**~~] school year.

§112.34. Biology [~~, Beginning with School Year 2010-2011~~] (One Credit) , Adopted 2017 .

(a) General requirements. Students shall be awarded one credit for successful completion of this course. Prerequisites: none. This course is recommended for students in Grade 9, 10, or 11.

(b) Introduction.

(1) Biology. In Biology, students conduct laboratory and field investigations, use scientific **practices** [~~**methods**~~] during investigations, and make informed decisions using critical thinking and scientific problem solving. Students in Biology study a variety of topics that include: structures and functions of cells and viruses; growth and development of organisms; cells, tissues, and organs; nucleic acids and genetics; biological evolution; taxonomy; metabolism and energy transfers in living organisms; living systems; homeostasis; and ecosystems and the environment.

(2) Nature of science. Science, as defined by the National Academy of Sciences, is the "use of evidence to construct testable explanations and predictions of natural phenomena, as well as the knowledge generated through this process." This vast body of changing and increasing knowledge is described by physical, mathematical, and conceptual models. Students should know that some questions are outside the realm of science because they deal with phenomena that are not currently scientifically testable.

(3) Scientific inquiry. Scientific inquiry is the planned and deliberate investigation of the natural world. Scientific methods of investigation are experimental, descriptive, or comparative. The method chosen should be appropriate to the question being asked.

(4) Science and social ethics. Scientific decision making is a way of answering questions about the natural world. Students should be able to distinguish between scientific decision-making methods (scientific methods) and ethical and social decisions that involve science (the application of scientific information).

(5) Science, systems, and models. A system is a collection of cycles, structures, and processes that interact. All systems have basic properties that can be described in space, time, energy, and matter. Change and constancy occur in systems as patterns and can be observed, measured, and modeled. These patterns help to make predictions that can be scientifically tested. Students should analyze a system in terms of its components and how these components relate to each other, to the whole, and to the external environment.

(6) Statements containing the word "including" reference content that must be mastered, while those containing the phrase "such as" are intended as possible illustrative examples.

(c) Knowledge and skills.

(1) Scientific processes. The student, for at least 40% of instructional time, conducts laboratory and field investigations using safe, environmentally appropriate, and ethical practices. The student is expected to:

(A) demonstrate safe practices during laboratory and field investigations; and

(B) demonstrate an understanding of the use and conservation of resources and the proper disposal or recycling of materials.

(2) Scientific processes. The student uses scientific **practices** [~~**methods**~~] and equipment during laboratory and field investigations. The student is expected to:

(A) know the definition of science and understand that it has limitations, as specified in subsection (b)(2) of this section;

(B) know that hypotheses are tentative and testable statements that must be capable of being supported or not supported by observational evidence. Hypotheses of durable explanatory power that [~~which~~] have been tested over a wide variety of conditions are incorporated into theories;

(C) know scientific theories are based on natural and physical phenomena and are capable of being tested by multiple independent researchers. Unlike hypotheses, scientific theories are well established [~~well-established~~] and highly reliable [~~highly-reliable~~] explanations, but they may be subject to change as new areas of science and new technologies are developed;

(D) distinguish between scientific hypotheses and scientific theories;

(E) plan and implement descriptive, comparative, and experimental investigations, including asking questions, formulating testable hypotheses, and selecting equipment and technology;

(F) collect and organize qualitative and quantitative data and make measurements with accuracy and precision using tools such as [~~calculators, spreadsheet software,~~] data-collecting probes, [~~computers,~~] standard laboratory glassware, microscopes, various prepared slides, stereoscopes, metric rulers, [~~electronic~~] balances, gel electrophoresis apparatuses, micropipettes [~~micropipettors~~] , hand lenses, Celsius thermometers, hot plates, lab notebooks or journals, timing devices, [~~cameras,~~] Petri dishes, lab incubators, dissection equipment, meter sticks, and models, diagrams, or samples of biological specimens or structures;

(G) analyze, evaluate, make inferences, and predict trends from data; and

(H) communicate valid conclusions supported by the data through methods such as lab reports, labeled drawings, graphic organizers, journals, summaries, oral reports, and technology-based reports.

(3) Scientific processes. The student uses critical thinking, scientific reasoning, and problem solving to make informed decisions within and outside the classroom. The student is expected to:

(A) [~~in all fields of science,~~] analyze, evaluate, and critique scientific explanations by using empirical evidence, logical reasoning, and experimental and observational testing, [~~including examining all sides of scientific evidence of those scientific explanations,~~] so as to encourage critical thinking by the student;

(B) communicate and apply scientific information extracted from various sources such as current events, [~~news reports,~~] published journal articles, and marketing materials;

(C) draw inferences based on data related to promotional materials for products and services;

(D) evaluate the impact of scientific research on society and the environment;

(E) evaluate models according to their limitations in representing biological objects or events; and

(F) research and describe the history of biology and contributions of scientists.

(4) Science concepts. The student knows that cells are the basic structures of all living things with specialized parts that perform specific functions and that viruses are different from cells. The student is expected to:

(A) compare and contrast prokaryotic and eukaryotic cells **, including their complexity,** and **compare and contrast** [~~**evaluate**~~] scientific explanations for **cellular** [~~**their**~~] complexity ;

(B) investigate and explain cellular processes, including homeostasis and [~~, energy conversions,~~] transport of molecules [~~, and synthesis of new molecules~~] ; and

(C) compare the structures of viruses to cells, describe viral reproduction, and describe the role of viruses in causing diseases such as human immunodeficiency virus (HIV) and influenza.

(5) Science concepts. The student knows how an organism grows and the importance of cell differentiation. The student is expected to:

(A) describe the stages of the cell cycle, including deoxyribonucleic acid (DNA) replication and mitosis, and the importance of the cell cycle to the growth of organisms;

[~~(B) examine specialized cells, including roots, stems, and leaves of plants; and animal cells such as blood, muscle, and epithelium;~~]

(B) [~~(C)~~] describe the roles of DNA, ribonucleic acid (RNA), and environmental factors in cell differentiation; and

(C) [~~(D)~~] recognize that disruptions of the cell cycle lead to diseases such as cancer.

(6) Science concepts. The student knows the mechanisms of genetics such as [~~, including~~] the role of nucleic acids and the principles of Mendelian and non-Mendelian genetics [~~Genetics~~] . The student is expected to:

(A) identify components of DNA, **identify** [~~and~~] [~~**describe**~~] how information for specifying the traits of an organism is carried in the DNA , and **examine** [~~**evaluate**~~] scientific explanations for the origin of DNA ;

(B) recognize that components that make up the genetic code are common to all organisms;

(C) explain the purpose and process of transcription and translation using models of DNA and RNA;

(D) recognize that gene expression is a regulated process;

(E) identify and illustrate changes in DNA and evaluate the significance of these changes;

(F) predict possible outcomes of various genetic combinations such as monohybrid crosses, dihybrid crosses , and non-Mendelian inheritance; and

(G) recognize the significance of meiosis to sexual reproduction . [~~; and~~]

[~~(H) describe how techniques such as DNA fingerprinting, genetic modifications, and chromosomal analysis are used to study the genomes of organisms.~~]

(7) Science concepts. The student knows evolutionary theory is a scientific explanation for the unity and diversity of life. The student is expected to:

(A) analyze and evaluate how evidence of common ancestry among groups is provided by the fossil record, biogeography, and homologies, including anatomical, molecular, and developmental;

(B) examine [~~analyze and evaluate~~] scientific explanations [~~concerning any data~~] of abrupt [~~sudden~~] appearance and [~~,~~] stasis [~~, and sequential nature of groups~~] in the fossil record;

(C) analyze and evaluate how natural selection produces change in populations, not individuals;

(D) analyze and evaluate how the elements of natural selection, including inherited variation, the potential of a population to produce more offspring than can survive, and a finite supply of environmental resources, result in differential reproductive success;

(E) analyze and evaluate the relationship of natural selection to adaptation and to the development of diversity in and among species; and

(F) analyze [~~and evaluate the effects of~~] other evolutionary mechanisms, including genetic drift, gene flow, mutation, and recombination . [~~; and~~]

[~~(G) analyze and evaluate scientific explanations concerning the complexity of the cell.~~]

(8) Science concepts. The student knows that taxonomy is a branching classification based on the shared characteristics of organisms and can change as new discoveries are made. The student is expected to:

(A) define taxonomy and recognize the importance of a standardized taxonomic system to the scientific community;

(B) categorize organisms using a hierarchical classification system based on similarities and differences shared among groups; and

(C) compare characteristics of taxonomic groups, including archaea, bacteria, protists, fungi, plants, and animals.

(9) Science concepts. The student knows the significance of various molecules involved in metabolic processes and energy conversions that occur in living organisms. The student is expected to:

(A) compare the [~~structures and~~] functions of different types of biomolecules, including carbohydrates, lipids, proteins, and nucleic acids;

(B) compare the reactants and products of photosynthesis and cellular respiration in terms of energy , energy conversions, and matter; and

(C) identify and investigate the role of enzymes . [~~; and~~]

[~~(D) analyze and evaluate the evidence regarding formation of simple organic molecules and their organization into long complex molecules having information such as the DNA molecule for self-replicating life.~~]

(10) Science concepts. The student knows that biological systems are composed of multiple levels. The student is expected to:

(A) describe the interactions that occur among systems that perform the functions of regulation, nutrient absorption, reproduction, and defense from injury or illness in animals;

(B) describe the interactions that occur among systems that perform the functions of transport, reproduction, and response in plants; and

(C) analyze the levels of organization in biological systems and relate the levels to each other and to the whole system.

(11) Science concepts. The student knows that biological systems work to achieve and maintain balance. The student is expected to:

[~~(A) describe the role of internal feedback mechanisms in the maintenance of homeostasis;~~]

[~~(B) investigate and analyze how organisms, populations, and communities respond to external factors;~~]

(A) [~~(C)~~] summarize the role of microorganisms in both maintaining and disrupting the health of both organisms and ecosystems; and

(B) [~~(D)~~] describe how events and processes that occur during ecological succession can change populations and species diversity.

(12) Science concepts. The student knows that interdependence and interactions occur within an environmental system. The student is expected to:

(A) interpret relationships, including predation, parasitism, commensalism, mutualism, and competition , among organisms;

(B) compare variations and adaptations of organisms in different ecosystems;

(C) analyze the flow of matter and energy through trophic levels using various models, including food chains, food webs, and ecological pyramids;

[~~(D) recognize that long-term survival of species is dependent on changing resource bases that are limited;~~]

(D) [~~(E)~~] describe the flow of matter through the carbon and nitrogen cycles and explain the consequences of disrupting these cycles; and

(E) [~~(F)~~] describe how environmental change can impact ecosystem stability.

§112.35. Chemistry [~~, Beginning with School Year 2010-2011~~] (One Credit) , Adopted 2017 .

(a) General requirements. Students shall be awarded one credit for successful completion of this course. Required prerequisites: one unit of high school science and Algebra I. Suggested prerequisite: completion of or concurrent enrollment in a second year of mathematics [~~math~~] . This course is recommended for students in Grade 10, 11, or 12.

(b) Introduction.

(1) Chemistry. In Chemistry, students conduct laboratory and field investigations, use scientific **practices** [~~**methods**~~] during investigations, and make informed decisions using critical thinking and scientific problem solving. Students study a variety of topics that include characteristics of matter, use of the Periodic Table, development of atomic theory and chemical bonding, chemical stoichiometry, gas laws, solution chemistry, thermochemistry, and nuclear chemistry. Students will investigate how chemistry is an integral part of our daily lives.

(2) Nature of science [~~Science~~] . Science, as defined by the National Academy of Sciences, is the "use of evidence to construct testable explanations and predictions of natural phenomena, as well as the knowledge generated through this process." This vast body of changing and increasing knowledge is described by physical, mathematical, and conceptual models. Students should know that some questions are outside the realm of science because they deal with phenomena that are not currently scientifically testable.

(3) Scientific inquiry. Scientific inquiry is the planned and deliberate investigation of the natural world. Scientific **practices** [~~**methods**~~] of investigation can be experimental, descriptive, or comparative. The method chosen should be appropriate to the question being asked.

(4) Science and social ethics. Scientific decision making is a way of answering questions about the natural world. Students should be able to distinguish between scientific decision-making methods and ethical and social decisions that involve the application of scientific information.

(5) Scientific systems. A system is a collection of cycles, structures, and processes that interact. All systems have basic properties that can be described in terms of space, time, energy, and matter. Change and constancy occur in systems as patterns and can be observed, measured, and modeled. These patterns help to make predictions that can be scientifically tested. Students should analyze a system in terms of its components and how these components relate to each other, to the whole, and to the external environment.

(6) Statements containing the word "including" reference content that must be mastered, while those containing the phrase "such as" are intended as possible illustrative examples.

(c) Knowledge and skills.

(1) Scientific processes. The student, for at least 40% of instructional time, conducts laboratory and field investigations using safe, environmentally appropriate, and ethical practices. The student is expected to:

(A) demonstrate safe practices during laboratory and field investigations, including the appropriate use of safety showers, eyewash fountains, safety goggles or chemical splash goggles, as appropriate , and fire extinguishers;

(B) know specific hazards of chemical substances such as flammability, corrosiveness, and radioactivity as summarized on the [~~Material~~] Safety Data Sheets (SDS) [~~(MSDS)~~] ; and

(C) demonstrate an understanding of the use and conservation of resources and the proper disposal or recycling of materials.

(2) Scientific processes. The student uses scientific **practices** [~~**methods**~~] to solve investigative questions. The student is expected to:

(A) know the definition of science and understand that it has limitations, as specified in subsection (b)(2) of this section;

(B) know that scientific hypotheses are tentative and testable statements that must be capable of being supported or not supported by observational evidence. Hypotheses of durable explanatory power that [~~which~~] have been tested over a wide variety of conditions are incorporated into theories;

(C) know that scientific theories are based on natural and physical phenomena and are capable of being tested by multiple independent researchers. Unlike hypotheses, scientific theories are well established [~~well-established~~] and highly reliable [~~highly-reliable~~] explanations, but may be subject to change as new areas of science and new technologies are developed;

(D) distinguish between scientific hypotheses and scientific theories;

(E) plan and implement investigative procedures, including asking questions, formulating testable hypotheses, and selecting equipment and technology, including graphing calculators, computers and probes, electronic balances, an adequate supply of consumable chemicals, and sufficient scientific glassware such as beakers, Erlenmeyer flasks, pipettes, graduated cylinders, volumetric flasks, [~~safety goggles,~~] and burettes [~~, electronic balances, and an adequate supply of consumable chemicals~~] ;

(F) collect data and make measurements with accuracy and precision;

(G) express and manipulate chemical quantities using scientific conventions and mathematical procedures, including dimensional analysis, scientific notation, and significant figures;

(H) organize, analyze, evaluate, make inferences, and predict trends from data; and

(I) communicate valid conclusions supported by the data through methods such as lab reports, labeled drawings, graphs, journals, summaries, oral reports, and technology-based reports.

(3) Scientific processes. The student uses critical thinking, scientific reasoning, and problem solving to make informed decisions within and outside the classroom. The student is expected to:

(A) [~~in all fields of science,~~] analyze, evaluate, and critique scientific explanations by using empirical evidence, logical reasoning, and experimental and observational testing **, so as to encourage critical thinking by the student** [~~, including examining all sides of~~

~~scientific evidence of those scientific explanations, so as to encourage critical thinking by the student~~] ;

(B) communicate and apply scientific information extracted from various sources such as current events, [~~news reports,~~] published journal articles, and marketing materials;

(C) draw inferences based on data related to promotional materials for products and services;

(D) evaluate the impact of research on scientific thought, society, and the environment;

(E) describe the connection between chemistry and future careers; and

(F) [~~research and~~] describe the history of chemistry and contributions of scientists.

(4) Science concepts. The student knows the characteristics of matter and can analyze the relationships between chemical and physical changes and properties. The student is expected to:

(A) differentiate between physical and chemical changes and properties;

(B) identify extensive <u>properties such as mass and volume</u> and intensive properties <u>such as density and melting point</u> ;

(C) compare solids, liquids, and gases in terms of compressibility, structure, shape, and volume; and

(D) classify matter as pure substances or mixtures through investigation of their properties.

(5) Science concepts. The student understands the historical development of the Periodic Table and can apply its predictive power. The student is expected to:

(A) explain the use of chemical and physical properties in the historical development of the Periodic Table;

(B) [~~use the Periodic Table to~~] identify and explain the properties of chemical families, including alkali metals, alkaline earth metals, halogens, noble gases, and transition metals <u>, using the Periodic Table</u> ; and

(C) <u>interpret</u> [~~use the Periodic Table to identify and explain~~] periodic trends, including atomic <u>radius</u> [~~and ionic radii~~] , electronegativity, and ionization energy <u>, using the Periodic Table</u> .

(6) Science concepts. The student knows and understands the historical development of atomic theory. The student is expected to:

(A) <u>describe</u> [~~understand~~] the experimental design and conclusions used in the development of modern atomic theory, including Dalton's Postulates, Thomson's discovery of electron properties, Rutherford's nuclear atom, and Bohr's nuclear atom;

(B) <u>describe</u> [~~understand the electromagnetic spectrum and~~] the mathematical relationships between energy, frequency, and wavelength of light <u>using the electromagnetic spectrum</u> ;

[~~(C) calculate the wavelength, frequency, and energy of light using Planck's constant and the speed of light;~~]

<u>(C)</u> [~~(D)~~] [~~use isotopic composition to~~] calculate average atomic mass of an element <u>using isotopic composition</u> ; and

<u>(D)</u> [~~(E)~~] express the arrangement of electrons in atoms <u>of representative elements using</u> [~~through~~] electron configurations and Lewis valence electron dot structures.

(7) Science concepts. The student knows how atoms form ionic, <u>covalent, and</u> metallic [~~, and covalent~~] bonds. The student is expected to:

(A) name ionic compounds containing main group or transition metals, covalent compounds, acids, and bases [~~,~~] using International Union of Pure and Applied Chemistry (IUPAC) nomenclature rules;

(B) write the chemical formulas of [~~common polyatomic ions,~~] ionic compounds containing representative elements, [~~main group or~~] transition metals and common polyatomic ions , covalent compounds, and acids [~~,~~] and bases;

(C) construct electron dot formulas to illustrate ionic and covalent bonds;

(D) describe [~~the nature of~~] metallic bonding and [~~apply the theory to~~] explain metallic properties such as thermal and electrical conductivity, malleability, and ductility; and

(E) classify [~~predict~~] molecular structure for molecules with linear, trigonal planar, and [~~or~~] tetrahedral electron pair geometries as explained by [~~using~~] Valence Shell Electron Pair Repulsion (VSEPR) theory.

(8) Science concepts. The student can quantify the changes that occur during chemical reactions. The student is expected to:

(A) define and use the concept of a mole;

(B) [~~use the mole concept to~~] calculate the number of atoms [~~, ions,~~] or molecules in a sample of material using Avogadro's number ;

(C) calculate percent composition of compounds [~~and empirical and molecular formulas~~] ;

(D) differentiate between empirical and molecular formulas;

(E) [~~(D)~~] [~~use the law of conservation of mass to~~] write and balance chemical equations using the law of conservation of mass ; [~~and~~]

(F) differentiate among double replacement [~~**(ion swap)**~~] reactions, including acid-base reactions and precipitation reactions, and oxidation-reduction reactions such as synthesis, decomposition, single replacement, and combustion reactions;

(G) [~~(E)~~] perform stoichiometric calculations, including determination of mass and gas volume relationships between reactants and products [~~, calculation of limiting reagents,~~] and percent yield ; and [~~.~~]

(H) describe the concept of limiting reactants in a balanced chemical equation.

(9) Science concepts. The student understands the principles of ideal gas behavior, kinetic molecular theory, and the conditions that influence the behavior of gases. The student is expected to:

(A) describe and calculate the relations between volume, pressure, number of moles, and temperature for an ideal gas as described by Boyle's law, Charles' law, Avogadro's law, Dalton's law of partial pressure, and the ideal gas law; and

[~~(B) perform stoichiometric calculations, including determination of mass and volume relationships between reactants and products for reactions involving gases; and~~]

(B) [~~(C)~~] describe the postulates of kinetic molecular theory.

(10) Science concepts. The student understands and can apply the factors that influence the behavior of solutions. The student is expected to:

(A) describe the unique role of water in solutions in terms of polarity [~~chemical and biological systems~~] ;

(B) apply the [~~develop and use~~] general rules regarding solubility through investigations with aqueous solutions;

(C) calculate the concentration of solutions in units of molarity;

(D) [~~use molarity to~~] calculate the dilutions of solutions using molarity ;

(E) distinguish among [~~between~~] types of solutions such as electrolytes and nonelectrolytes ; [~~and~~] unsaturated, saturated, and supersaturated solutions ; and strong and weak acids and bases ;

(F) investigate factors that influence solid and gas solubilities and rates of dissolution such as temperature, agitation, and surface area;

(G) define acids and bases and distinguish between Arrhenius and Bronsted-Lowry definitions and predict products in acid-base [~~acid base~~] reactions that form water; and

[~~(H) understand and differentiate among acid-base reactions, precipitation reactions, and oxidation-reduction reactions;~~]

(H) [~~(I)~~] define pH and [~~use the hydrogen or hydroxide ion concentrations to~~] calculate the pH of a solution using the hydrogen ion concentration. [~~; and~~]

[~~(J) distinguish between degrees of dissociation for strong and weak acids and bases.~~]

(11) Science concepts. The student understands the energy changes that occur in chemical reactions. The student is expected to:

(A) describe [~~understand~~] energy and its forms, including kinetic, potential, chemical, and thermal energies;

(B) describe [~~understand~~] the law of conservation of energy and the processes of heat transfer in terms of calorimetry ;

(C) classify reactions as exothermic or endothermic and represent energy changes that occur in chemical reactions using [~~use~~] thermochemical equations or graphical analysis [~~to calculate energy changes that occur in chemical reactions and classify reactions as exothermic or endothermic~~] ; and

(D) perform calculations involving heat, mass, temperature change, and specific heat . [~~; and~~]

[~~(E) use calorimetry to calculate the heat of a chemical process.~~]

(12) Science concepts. The student understands the basic processes of nuclear chemistry. The student is expected to:

(A) describe the characteristics of alpha, beta, and gamma radioactive decay processes in terms of balanced nuclear equations [~~radiation~~]; and

[~~(B) describe radioactive decay process in terms of balanced nuclear equations; and~~]

(B) [~~(C)~~] compare fission and fusion reactions.

§112.38. Integrated Physics and Chemistry [~~, Beginning with School Year 2010-2011~~] (One Credit) , Adopted 2017 .

(a) General requirements. Students shall be awarded one credit for successful completion of this course. Prerequisites: none. This course is recommended for students in Grade 9 or 10.

(b) Introduction.

(1) Integrated Physics and Chemistry. In Integrated Physics and Chemistry, students conduct laboratory and field investigations, use scientific **practices** [~~**methods**~~] during investigation, and make informed decisions using critical thinking and scientific problem solving. This course integrates the disciplines of physics and chemistry in the following topics: force, motion, energy, and matter.

(2) Nature of science. Science, as defined by the National Academy of Sciences, is the "use of evidence to construct testable explanations and predictions of natural phenomena, as well as the

knowledge generated through this process." This vast body of changing and increasing knowledge is described by physical, mathematical, and conceptual models. Students should know that some questions are outside the realm of science because they deal with phenomena that are not currently scientifically testable.

(3) Scientific inquiry. Scientific inquiry is the planned and deliberate investigation of the natural world. Scientific methods of investigation are experimental, descriptive, or comparative. The method chosen should be appropriate to the question being asked.

(4) Science and social ethics. Scientific decision making is a way of answering questions about the natural world. Students should be able to distinguish between scientific decision-making methods (scientific practices) and ethical and social decisions that involve science (the application of scientific information).

(5) Science, systems, and models. A system is a collection of cycles, structures, and processes that interact. All systems have basic properties that can be described in space, time, energy, and matter. Change and constancy occur in systems as patterns and can be observed, measured, and modeled. These patterns help to make predictions that can be scientifically tested. Students should analyze a system in terms of its components and how these components relate to each other, to the whole, and to the external environment.

(6) Statements containing the word "including" reference content that must be mastered, while those containing the phrase "such as" are intended as possible illustrative examples.

(c) Knowledge and skills.

(1) Scientific processes. The student, for at least 40% of instructional time, conducts laboratory and field investigations using safe, environmentally appropriate, and ethical practices. The student is expected to:

(A) demonstrate safe practices during laboratory and field investigations , including the appropriate use of safety showers, eyewash fountains, safety goggles or chemical splash goggles, as appropriate, and fire extinguishers ; [~~and~~]

(B) know specific hazards of chemical substances such as flammability, corrosiveness, and radioactivity as summarized on the Safety Data Sheets (SDS); and

(C) [~~(B)~~] demonstrate an understanding of the use and conservation of resources and the proper disposal or recycling of materials.

(2) Scientific processes. The student uses scientific **practices** [~~**methods**~~] during laboratory and field investigations. The student is expected to:

(A) know the definition of science and understand that it has limitations, as specified in subsection (b)(2) of this section;

(B) plan and implement investigative procedures, including asking questions, formulating testable hypotheses, and selecting equipment and technology;

(C) collect data and make measurements with accuracy and precision;

(D) organize, analyze, evaluate, make inferences, and predict trends from data; and

(E) communicate valid conclusions supported by the data through methods such as lab reports, labeled drawings, graphs, journals, summaries, oral reports, and technology-based reports .

(3) Scientific processes. The student uses critical thinking, scientific reasoning, and problem solving to make informed decisions. The student is expected to:

(A) [~~in all fields of science,~~] analyze, evaluate, and critique scientific explanations by using empirical evidence, logical reasoning, and experimental and observational testing **, so as to encourage critical thinking by the student** [~~, including examining all sides of~~

~~scientific evidence of those scientific explanations, so as to encourage critical thinking by the student~~] ;

(B) communicate and apply scientific information extracted from various sources such as current events, [~~news reports,~~] published journal articles, and marketing materials;

(C) draw inferences based on data related to promotional materials for products and services;

(D) evaluate the impact of research on scientific thought, society, and the environment;

(E) describe connections between physics and chemistry and future careers; and

(F) research and describe the history of physics and chemistry and contributions of scientists.

(4) Science concepts. The student knows concepts of force and motion evident in everyday life. The student is expected to:

(A) describe and calculate an object's motion in terms of position, displacement, speed, and acceleration;

(B) measure and graph distance and speed as a function of time [~~using moving toys~~] ;

(C) investigate how an object's motion changes only when a net force is applied, including activities and equipment such as toy cars, vehicle restraints, sports activities, and classroom objects;

(D) describe and calculate [~~assess~~] the relationship between force, mass, and acceleration [~~, noting the relationship is independent of the nature of the force,~~] using equipment such as dynamic carts, moving toys, vehicles, and falling objects;

(E) explain [~~apply~~] the concept of conservation of momentum using action and reaction forces [~~such as students on skateboards~~] ;

(F) describe the gravitational attraction between objects of different masses at different distances [~~, including satellites~~] ; and

(G) examine electrical force as a universal force between any two charged objects [~~and compare the relative strength of the electrical force and gravitational force~~] .

(5) Science concepts. The student recognizes multiple forms of energy and knows the impact of energy transfer and energy conservation in everyday life. The student is expected to:

(A) recognize and demonstrate that objects and substances in motion have kinetic energy such as vibration of atoms, water flowing down a stream moving pebbles, and bowling balls knocking down pins;

(B) recognize and demonstrate common forms of potential energy, including gravitational, elastic, and chemical, such as a ball on an inclined plane, springs, and batteries;

(C) demonstrate that moving electric charges produce magnetic forces and moving magnets produce electric forces;

(D) investigate the law of conservation of energy;

(E) investigate and demonstrate the movement of thermal energy through solids, liquids, and gases by convection, conduction, and radiation such as in weather, living, and mechanical systems;

(F) evaluate the transfer of electrical energy in series and parallel circuits and conductive materials;

(G) explore the characteristics and behaviors of energy transferred by waves, including acoustic, seismic, light, and waves on water , as they reflect, refract, diffract, interfere with [~~superpose on~~] one another, and [~~bend around corners, reflect off surfaces,~~] are absorbed by materials [~~, and change direction when entering new materials~~] ;

(H) analyze energy transformations of renewable and nonrenewable resources [~~conversions such as those from radiant, nuclear, and geothermal sources; fossil fuels such as coal, gas, oil; and the movement of water or wind~~] ; and

(I) critique the advantages and disadvantages of various energy sources and their impact on society and the environment.

(6) Science concepts. The student knows that relationships exist between the structure and properties of matter. The student is expected to:

(A) examine differences in physical properties of solids, liquids, and gases as explained by the arrangement and motion of atoms [~~, ions,~~] or molecules [~~of the substances and the strength of the forces of attraction between those particles~~] ;

(B) relate chemical properties of substances to the arrangement of their atoms [~~or molecules~~] ;

(C) analyze physical and chemical properties of elements and compounds such as color, density, viscosity, buoyancy, boiling point, freezing point, conductivity, and reactivity;

(D) relate the placement of an element on the Periodic Table to its physical and chemical behavior [~~of an element~~] , including bonding and classification [~~, to its placement on the Periodic Table~~] ; [~~and~~]

(E) relate the structure of water to its function as a solvent ; and [~~and investigate the properties of solutions and factors affecting gas and solid solubility, including nature of solute, temperature, pressure, pH, and concentration.~~]

(F) investigate the properties of water solutions and factors affecting solid solubility, including nature of solute, temperature, and concentration.

(7) Science concepts. The student knows that changes in matter affect everyday life. The student is expected to:

(A) investigate changes of state as it relates to the arrangement of particles of matter and energy transfer;

(B) recognize that chemical changes can occur when substances react to form different substances and that these interactions are largely determined by the valence electrons;

(C) demonstrate that mass is conserved when substances undergo chemical change and that the number and kind of atoms are the same in the reactants and products;

(D) classify [~~analyze~~] energy changes that accompany chemical reactions such as those occurring in heat packs, cold packs, and glow sticks [~~and classify them~~] as exothermic or endothermic reactions;

(E) describe types of nuclear reactions such as fission and fusion and their roles in applications such as medicine and energy production; and

(F) research and describe the environmental and economic impact of the end-products of chemical reactions such as those that may result in acid rain, degradation of water and air quality, and ozone depletion.

§112.39. Physics [~~, Beginning with School Year 2010-2011~~] (One Credit) , Adopted 2017 .

(a) General requirements. Students shall be awarded one credit for successful completion of this course. Algebra I is suggested as a prerequisite or corequisite [~~co-requisite~~] . This course is recommended for students in Grade 9, 10, 11, or 12.

(b) Introduction.

(1) Physics. In Physics, students conduct laboratory and field investigations, use scientific **practices** [~~**methods**~~] during investigations, and make informed decisions using critical thinking and scientific

problem solving. Students study a variety of topics that include: laws of motion; changes within physical systems and conservation of energy and momentum; forces; thermodynamics; characteristics and behavior of waves; and atomic, nuclear, and quantum physics. Students who successfully complete Physics will acquire factual knowledge within a conceptual framework, practice experimental design and interpretation, work collaboratively with colleagues, and develop critical-thinking [~~critical thinking~~] skills.

(2) Nature of science. Science, as defined by the National Academy of Sciences, is the "use of evidence to construct testable explanations and predictions of natural phenomena, as well as the knowledge generated through this process." This vast body of changing and increasing knowledge is described by physical, mathematical, and conceptual models. Students should know that some questions are outside the realm of science because they deal with phenomena that are not currently scientifically testable by empirical science .

(3) Scientific inquiry. Scientific inquiry is the planned and deliberate investigation of the natural world. Scientific methods of investigation can be experimental, descriptive, or comparative. The method chosen should be appropriate to the question being asked.

(4) Science and social ethics. Scientific decision making is a way of answering questions about the natural world. Students should be able to distinguish between scientific decision-making methods and ethical and social decisions that involve the application of scientific information.

(5) Scientific systems. A system is a collection of cycles, structures, and processes that interact. All systems have basic properties that can be described in terms of space, time, energy, and matter. Change and constancy occur in systems as patterns and can be observed, measured, and modeled. These patterns help to make predictions that can be scientifically tested. Students should analyze a system in terms of its components and how these components relate to each other, to the whole, and to the external environment.

(6) Statements containing the word "including" reference content that must be mastered, while those containing the phrase "such as" are intended as possible illustrative examples.

(c) Knowledge and skills.

(1) Scientific processes. The student conducts investigations, for at least 40% of instructional time, using safe, environmentally appropriate, and ethical practices. These investigations must involve actively obtaining and analyzing data with physical equipment [~~,~~] but may also involve experimentation in a simulated environment as well as field observations that extend beyond the classroom. The student is expected to:

(A) demonstrate safe practices during laboratory and field investigations; and

(B) demonstrate an understanding of the use and conservation of resources and the proper disposal or recycling of materials.

(2) Scientific processes. The student uses a systematic approach to answer scientific laboratory and field investigative questions. The student is expected to:

(A) know the definition of science and understand that it has limitations, as specified in subsection (b)(2) of this section;

(B) know that scientific hypotheses are tentative and testable statements that must be capable of being supported or not supported by observational evidence [~~. Hypotheses of durable explanatory power which have been tested over a wide variety of conditions are incorporated into theories~~] ;

(C) know that scientific theories are based on natural and physical phenomena and are capable of being tested by multiple independent researchers. Unlike hypotheses, scientific theories are well established [~~well-established~~] and highly reliable [~~highly reliable~~] explanations, but may be subject to change [~~as new areas of science and new technologies are developed~~] ;

[(D) distinguish between scientific hypotheses and scientific theories;]

(D) [(E)] design and implement investigative procedures, including making observations, asking well defined [well-defined] questions, formulating testable **hypotheses** , identifying variables, selecting appropriate equipment and technology, [and] evaluating numerical answers for reasonableness , and identifying causes and effects of uncertainties in measured data ;

(E) [(F)] demonstrate the use of course apparatus, equipment, techniques, and procedures, including multimeters (current, voltage, resistance), [triple beam] balances, batteries, [clamps,] dynamics demonstration equipment, collision apparatus, [data acquisition probes, discharge tubes with power supply (H, He, Ne, Ar), hand-held visual spectroscopes, hot plates, slotted and hooked] lab masses, [bar] magnets, [horseshoe magnets,] plane mirrors, convex lenses, [pendulum support, power supply, ring clamps, ring stands,] stopwatches, trajectory apparatus, [tuning forks, carbon paper,] graph paper, magnetic compasses, [polarized film, prisms,] protractors, [resistors, friction blocks, mini lamps (bulbs) and sockets, electrostatics kits, 90-degree rod clamps,] metric rulers, spring scales, [knife blade switches, Celsius] thermometers, [meter sticks, scientific calculators, graphing technology, computers, cathode ray tubes with horseshoe magnets, ballistic carts or equivalent, resonance tubes, spools of nylon thread or string, containers of iron filings, rolls of white craft paper, copper wire, Periodic Table, electromagnetic spectrum charts,] slinky springs, and/or other equipment and materials that will produce the same results [wave motion ropes, and laser pointers] ;

(F) [(G)]use a wide variety of additional course apparatus, equipment, techniques, materials, and procedures as appropriate such as ripple tank with wave generator, wave motion rope, tuning forks, hand-held visual spectroscopes, discharge tubes with power supply (H, He, Ne, Ar), electromagnetic spectrum charts, laser pointers, micrometer, caliper, [radiation monitor,] computer, data acquisition probes, scientific calculators, graphing technology, electrostatic kits, [ballistic pendulum,] electroscope, inclined plane, optics bench, optics kit, polarized film, prisms, pulley with table clamp, motion detectors, photogates, friction blocks, ballistic carts or equivalent, resonance tube, [ring stand screen, four inch ring,] stroboscope, resistors, copper wire, switches, iron filings, and/or other equipment and materials that will produce the same results [graduated cylinders, and ticker timer] ;

(G) [(H)] make measurements with accuracy and precision and record data using scientific notation and International System (SI) units;

[(I) identify and quantify causes and effects of uncertainties in measured data;]

(H) [(J)] organize , [and] evaluate , [data] and make inferences from data, including the use of tables, charts, and graphs;

(I) [(K)] communicate valid conclusions supported by the data through various methods such as lab reports, labeled drawings, graphic organizers, journals, summaries, oral reports, and technology-based reports; and

(J) [(L)] express [and manipulate] relationships among physical variables quantitatively, including the use of graphs, charts, and equations.

(3) Scientific processes. The student uses critical thinking, scientific reasoning, and problem solving to make informed decisions within and outside the classroom. The student is expected to:

(A) [in all fields of science,] analyze, evaluate, and critique scientific explanations by using empirical evidence, logical reasoning, and experimental and observational testing **, so as to encourage critical thinking by the student** [, including examining all sides of scientific evidence of those scientific explanations, so as to encourage critical thinking by the student] ;

(B) communicate and apply scientific information extracted from various sources such as current events, news reports, published journal articles, and marketing materials;

[~~(C) draw inferences based on data related to promotional materials for products and services;~~]

<u>(C)</u> [~~(D)~~] explain the impacts of the scientific contributions of a variety of historical and contemporary scientists on scientific thought and society;

<u>(D)</u> [~~(E)~~] research and describe the connections between physics and future careers; and

<u>(E)</u> [~~(F)~~] express <u>, manipulate,</u> and interpret relationships symbolically in accordance with accepted theories to make predictions and solve problems mathematically [~~, including problems requiring proportional reasoning and graphical vector addition~~] .

(4) Science concepts. The student knows and applies the laws governing motion in a variety of situations. The student is expected to:

(A) generate and interpret graphs and charts describing different types of motion, including <u>investigations using</u> [~~the use of~~] real-time technology such as motion detectors or photogates;

(B) describe and analyze motion in one dimension using equations <u>and graphical vector addition</u> with the concepts of distance, displacement, speed, average velocity, instantaneous velocity, <u>frames of reference,</u> and acceleration;

(C) analyze and describe accelerated motion in two dimensions <u>, including</u> using equations, <u>graphical vector addition, and</u> [~~including~~] projectile and circular examples; <u>and</u>

(D) calculate the effect of forces on objects, including the law of inertia, the relationship between force and acceleration, and the nature of force pairs between objects <u>using methods, including free-body force diagrams.</u> [~~;~~]

[~~(E) develop and interpret free-body force diagrams; and~~]

[~~(F) identify and describe motion relative to different frames of reference.~~]

(5) Science concepts. The student knows the nature of forces in the physical world. The student is expected to:

(A) [~~research and~~] describe the [~~historical development of the~~] concepts of gravitational, electromagnetic, weak nuclear, and strong nuclear forces;

(B) describe and calculate how the magnitude of the gravitational force between two objects depends on their masses and the distance between their centers;

(C) describe and calculate how the magnitude of the <u>electric</u> [~~electrical~~] force between two objects depends on their charges and the distance between <u>their centers</u> [~~them~~] ;

(D) identify <u>and describe</u> examples of electric and magnetic forces <u>and fields</u> in everyday life <u>such as generators, motors, and transformers</u> ;

(E) characterize materials as conductors or insulators based on their <u>electric</u> [~~electrical~~] properties; <u>and</u>

(F) <u>investigate</u> [~~design, construct,~~] and calculate [~~in terms of~~] current through, potential difference across, resistance of, and power used by electric circuit elements connected in both series and parallel combinations <u>.</u> [~~;~~]

[~~(G) investigate and describe the relationship between electric and magnetic fields in applications such as generators, motors, and transformers; and~~]

[~~(H) describe evidence for and effects of the strong and weak nuclear forces in nature.~~]

(6) Science concepts. The student knows that changes occur within a physical system and applies the laws of conservation of energy and momentum. The student is expected to:

(A) investigate and calculate quantities using the work-energy theorem in various situations;

(B) investigate examples of kinetic and potential energy and their transformations;

(C) calculate the mechanical energy of, power generated within, impulse applied to, and momentum of a physical system;

(D) demonstrate and apply the laws of conservation of energy and conservation of momentum in one dimension; and

[~~(E) describe how the macroscopic properties of a thermodynamic system such as temperature, specific heat, and pressure are related to the molecular level of matter, including kinetic or potential energy of atoms;~~]

[~~(F) contrast and give examples of different processes of thermal energy transfer, including conduction, convection, and radiation; and~~]

(E) [~~(G)~~] [~~analyze and~~] explain everyday examples that illustrate the four laws of thermodynamics and the processes of thermal energy transfer [~~, including the law of conservation of energy and the law of entropy~~] .

(7) Science concepts. The student knows the characteristics and behavior of waves. The student is expected to:

(A) examine and describe oscillatory motion and wave propagation in various types of media;

(B) investigate and analyze characteristics of waves, including velocity, frequency, amplitude, and wavelength, and calculate using the relationship between wavespeed, frequency, and wavelength;

(C) compare characteristics and behaviors of transverse waves, including electromagnetic waves and the electromagnetic spectrum, and characteristics and behaviors of longitudinal waves, including sound waves;

(D) investigate behaviors of waves, including reflection, refraction, diffraction, interference, resonance, and the Doppler effect; and

(E) describe and predict image formation as a consequence of reflection from a plane mirror and refraction through a thin convex lens . [~~; and~~]

[~~(F) describe the role of wave characteristics and behaviors in medical and industrial applications.~~]

(8) Science concepts. The student knows simple examples of atomic, nuclear, and quantum phenomena. The student is expected to:

(A) describe the photoelectric effect and the dual nature of light;

(B) compare and explain the emission spectra produced by various atoms;

(C) calculate and describe the applications [~~significance~~] of mass-energy equivalence [~~and apply it in explanations of phenomena such as nuclear stability, fission, and fusion~~] ; and

(D) give examples of applications of atomic and nuclear phenomena using the standard model such as nuclear stability, fission and fusion, radiation therapy, diagnostic imaging, semiconductors, superconductors, solar cells, and nuclear power and examples of applications of quantum phenomena [~~such as digital cameras~~] .