East Grand Rapids Public Schools

SECONDARY SCIENCE CURRICULUM

Grades 6-12

EGRPS
EAST GRAND RAPIDS PUBLIC SCHOOLS

March 2019

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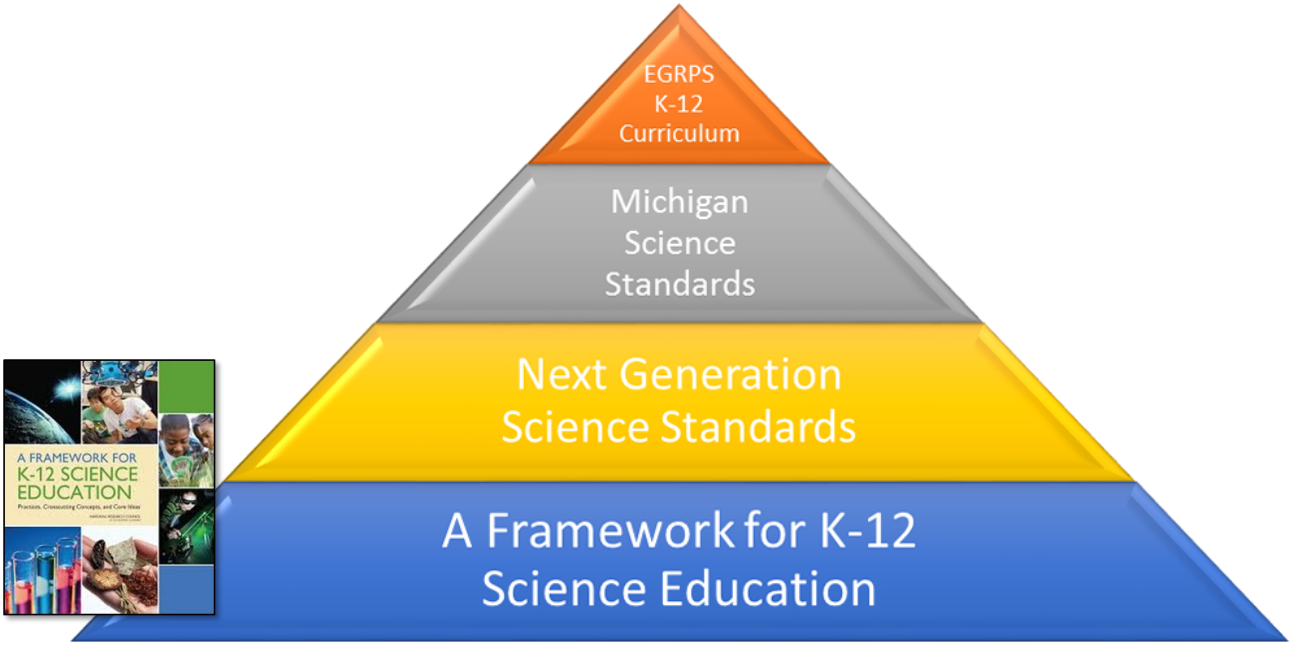
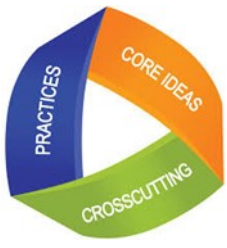
BACKGROUND

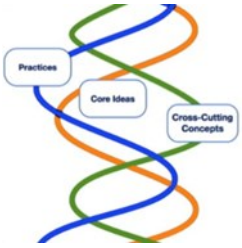
The new Michigan Science Standards (MSS) are the performance expectations (PE) outlined in the Next Generation Science Standards, which in turn are based on guidance set forth by the National Research Council in their 2011 publication, *A Framework for K-12 Science Education* ("*Framework*").



The Michigan Science Standards, which replace the Grade Level Content Expectations and the High School Content Expectations in Science, identify the student performance outcomes in topics of science and engineering outlined in the "*Framework.*" These are the standards on which the proposed East Grand Rapids Public Schools K-12 science curriculum was developed.



CURRICULAR APPROACH



The curriculum embraces the three-dimensions of science learning (3D learning) outlined in *A Framework for K-12 Science Education.* 3D learning refers to the thoughtful and deliberate integration of science and engineering practices, core ideas, and cross-disciplinary concepts. Through 3D learning, the Michigan Science Standards and the aligned EGRPS K-12 Science Curriculum emphasize that science is not just a series of isolated facts, but an interrelated world of inquiry and phenomena.

3D SCIENCE LEARNING

DIMENSION ONE:

Science and Engineering Practices

"What students do"

Students need to be engaged in doing science by applying the same practices used by scientists and engineers.

- Asking questions and defining problems
- Developing and using models
- Planning and carrying out investigations
- Analyzing and interpreting data
- Using mathematics and computational thinking
- Constructing explanations and designing solutions
- Engaging in argument from evidence

DIMENSION TWO:

Crosscutting Concepts (CCCs)

"How students think"

Students need to see and think about the connections of core ideas to the bigger science concepts that cross disciplinary lines. Students use these overarching and enduring understandings as a means to connect the core ideas from various disciplines into a "cumulative, coherent, and usable understanding of science and engineering" (*Framework*, page. 83).

- Patterns
- Cause and Effect
- Scale, Proportion, and Quantity
- Systems and System Models
- Energy and Matter in Systems
- Structure and Function
- Stability and Change of Systems

DIMENSION THREE:

Disciplinary Core Ideas (DCIs)

"What students know"

Students should engage in science and engineering practices in the context of core ideas that become ever more sophisticated as students move through school. The curriculum is organized across four disciplines: Physical Science, Earth Science, Life Science, and Engineering, Technology, and Applications of Science.

- Physical Science
- Earth and Space Science
- Life Science
- Engineering, Technology, & Applications of Science

SCIENCE INSTRUCTION

3D learning sees science as an interrelated world of inquiry and phenomena. With this fact in mind, the curriculum presents coherent investigations or engineering problems, where questions and phenomena motivate building and using the disciplinary and crosscutting ideas. By basing the curriculum on questions and phenomena, the learning becomes inquiry-based and integrates the three-dimensions of learning: Science and Engineering Practices (What students do), Crosscutting Concepts (How students think), and Disciplinary Core Ideas (What students know).

This calls for a different approach to teaching science; an approach that engages students in the practices of science and engineering by doing science. Within the context of this curriculum, science instruction will look different.

Science instruction will involve **less**:	Science instruction will involve **more**:
Rote memorization of facts and terminology	Facts and terminology learned as needed while developing explanations and designing solutions supported by evidence-based arguments and reasoning
Learning of ideas disconnected from questions about phenomena	Systems thinking to explain phenomena, giving context for the ideas to be learned and modeled
Teachers providing information to the whole class	Students conducting investigations, solving problems, and engaging in discussions with teachers' facilitation
Teachers posing questions with only one right answer	Students discussing open-ended questions that focus on the strength of the evidence used to generate claims
Students reading textbooks and answering questions at the end of each chapter	Students reading multiple sources and developing summaries of information
Worksheets	Student learning reflected through journals, reports, posters, and media presentations that explain and argue

Source: national Research Council. (2015). Guide to Implementing the Next Generation Science Standards (pp. 8-9). Washington, DC: National Academies Press. http://www.nap.edu/cataog/18802/guide-to-implementin-th-next-generation-science-standards

NEXT GENERATION SCIENCE STANDARDS

DIMENSION 1: Science and Engineering Practices	DIMENSION 2: Crosscutting Concepts (CCC)
• Asking questions and defining problems • Developing and using models • Planning and carrying out investigations • Analyzing and interpreting data • Using mathematics and computational thinking • Constructing explanations and designing solutions • Engaging in argument from evidence • Obtaining, evaluating, and communicating information	• Patterns • Cause and effect: Mechanism and explanation • Scale, proportion, and quantity • Systems and system models • Energy and matter: Flows, cycles, and conservation • Structure and function • Stability and change

DIMENSION 3: Disciplines

Physical Science	Life Science	Earth and Space Science	Engineering, Technology, and Applications of Science
CORE IDEAS	**CORE IDEAS**	**CORE IDEAS**	**CORE IDEAS**
PS1: Matter and its interactions PS2: Motion and stability: Forces and interactions PS3: Energy PS4: Waves and their applications in technologies for information transfer	LS1: From molecules to organisms: Structures and processes LS2: Ecosystems: Interactions, energy, and dynamics LS3: Heredity: Inheritance and variation of traits LS4: Biological evolution: Unity and diversity	ESS1: Earth's place in the universe ESS2: Earth's systems ESS3: Earth and human activity	ETS1: Engineering design ETS2: Links among engineering, technology, science, and society
SUB IDEAS	**SUB IDEAS**	**SUB IDEAS**	**SUB IDEAS**
PS1: Matter and its interactions PS1.A: Structures and Properties of Matter PS1.B: Chemical Reactions PS1.C: Nuclear Process **PS2: Motion and Stability: Forces and Interactions** PS2.A: Forces and Motions PS2.B: Types of Interactions PS2.C: Stability and Instability in Physical Systems **PS3: Energy** PS3.A: Definitions of Energy PS3.B: Conservation of Energy and Energy Transfer PS3.C: Relationship between Energy and Forces PS3.D: Energy in Chemical Processes and Everyday Life **PS4: Waves and Their Applications in Technologies for Information Transfer** PS4.A: Wave Properties PS4.B: Electromagnetic Radiation PS4.C: Information Technologies and Instrumentation	**LS1: From Molecules to Organisms: Structures/Processes** LS1.A: Structure and Function LS1.B: Growth and Development of Organisms LS1.C: Organization for Matter and Energy Flow in Organisms LS1.D: Information Processing **LS2: Ecosystems: Interactions, Energy, and Dynamics** LS2.A: Interdependent Relationships in Ecosystems LS2.B: Cycles of Matter & Energy Transfer in Ecosystems LS2.C: Ecosystem Dynamics, Functioning, and Resilience LS2.D: Social interactions and Group Behavior **LS 3: Heredity: Inheritance and Variation of Traits** LS3.A: Inheritance of Traits LS3.B: Variation of Traits **LS 4: Biological Evolution: Unity and Diversity** LS4.A: Evidence of Common Ancestry and Diversity LS4.B: Natural Selection LS4.C: Adaptation LS4.D: Biodiversity and Humans	**ESS1: Earth's Place in the Universe** ESS1.A: The Universe and Its Stars ESS1.B: Earth and the Solar System ESS1.C: The History of Planet Earth **ESS2: Earth's Systems** ESS2.A: Earth Materials and Systems ESS2.B: Plate Tectonics and Large-Scale System Interactions ESS2.C: The Roles of Water in Earth's Surface Processes ESS2.D: Weather and Climate ESS2.E: Biogeology **ESS3: Earth and Human Activity** ESS3.A: Natural Resources ESS3.B: Natural Hazards ESS3.C: Human Impacts on Earth Systems ESS3.D: Global Climate Change	**ETS1: Engineering Design** ETS1.A: Defining and Delimiting an Engineering Problem ETS1.B: Developing Possible Solutions ETS1.C: Optimizing the Design Solution **ETS2: Links Among Engineering, Technology, Science, and Society** ETS2.A: Interdependence of Science, Engineering, and Technology ETS2.B: Influence of Engineering, Technology, and Science on Society and the Natural World

DISCIPLINARY CORE IDEAS (DCI): A list of what students should understand about EACH sub-idea at the end of grades 2, 5, 8, and 12.

PERFORMANCE EXPECTATIONS (PE): Statements of what students at each grade level should be able to do after instruction; Incorporate the three dimensions into its wording.

TOPICS/BUNDLES: A group of PEs clustered together.

MICHIGAN / NGSX SCIENCE STANDARDS

SCOPE AND SEQUENCE OF MICHIGAN K-12 SCIENCE TOPICS

	TOPICS	K	1	2	3	4	5	6-8	9-12
PHYSICAL SCIENCE	Energy					√		√	√
	Structures & Properties of Matter			√			√	√	√
	Waves		√			√		√	√
	Forces & Interactions	√			√			√	√
	Waves and Electromagnetic Radiation							√	√
	Chemical Reactions							√	√
EARTH SCIENCE	Earth's Systems			√		√	√	√	√
	Weather & Climate	√		√	√			√	√
	Space Systems		√				√	√	√
	History of the Earth							√	√
	Human Impacts							√	
	Human Sustainability								√
LIFE SCIENCE	Inheritance and Variation of Traits				√				√
	Interdependent Relationships in Ecosystems	√		√	√			√	√
	Matter and Energy in Organisms and Ecosystems						√	√	√
	Structure, Function, and Information Processing		√			√		√	√
	Growth, Development, and Reproduction of Organisms							√	
	Natural Selection and Adaptations							√	
	Natural Selection and Evolution								√
ETSA	Engineering & Design	√	√	√	√	√	√	√	√

ETSA: *Engineering, Technology and Applications of Science*

MICHIGAN MIDDLE SCHOOL (6-8) SCIENCE STANDARDS: TOPICS AND PERFORMANCE EXPECTATIONS

PHYSICAL SCIENCE

STRUCTURE AND PROPERTIES OF MATTER

MS-PS1-1
Develop models to describe the atomic composition of simple molecules and extended structures.
MS-PS1-3
Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.
MS-PS1-4
Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.

CHEMICAL REACTIONS

MS-PS1-2
Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.
MS-PS1-5
Develop and use a model to describe how the total number of atoms does not change in a chemical reaction and thus mass is conserved.
MS-PS1-6
Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes.*

FORCES AND INTERACTIONS

MS-PS2-1
Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects.*
MS-PS2-2
Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.
MS-PS2-3
Ask questions about data to determine the factors that affect the strength of electric and magnetic forces.
MS-PS2-4
Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects.
MS-PS2-5
Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact.

ENERGY

MS-PS3-1
Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object.
MS-PS3-2
Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system.
MS-PS3-3
Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer. *
MS-PS3-4
Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample.
MS-PS3-5
Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.

MICHIGAN MIDDLE SCHOOL (6-8) SCIENCE STANDARDS: TOPICS AND PERFORMANCE EXPECTATIONS

PHYSICAL SCIENCE

WAVES AND ELECTROMAGNETIC RADIATION

MS-PS4-1
Use mathematical representations to describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave.

MS-PS4-2
Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.

MS-PS4-3
Integrate qualitative scientific and technical information to support the claim that digitized signals are a more reliable way to encode and transmit information than analog signals.

KEY

* *Integrates traditional science content with engineering.*

\+ *Allow for local, regional, or Michigan specific contexts or examples in teaching and assessment.*

Includes a Michigan specific performance expectation.

MICHIGAN MIDDLE SCHOOL (6-8) SCIENCE STANDARDS: TOPICS AND PERFORMANCE EXPECTATIONS

LIFE SCIENCE

STRUCTURE, FUNCTION, AND INFORMATION PROCESSING

MS-LS1-1
Conduct an investigation to provide evidence that living things are made of cells; either one cell or many different numbers and types of cells.
MS-LS1-2
Develop and use a model to describe the function of a cell as a whole and ways parts of cells contribute to the function.
MS-LS1-3
Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.
MS-LS1-8
Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories.

MATTER AND ENERGY IN ORGANISMS AND ECOSYSTEMS

MS-LS1-6
Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms.
MS-LS1-7
Develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as this matter moves through an organism.
MS-LS2-1
Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem. +
MS-LS2-3
Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem. +
MS-LS2-4
Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.

INTERDEPENDENT RELATIONSHIPS IN ECOSYSTEMS

MS-LS2-2
Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems. +
MS-LS2-5
Evaluate competing design solutions for maintaining biodiversity and ecosystem services. * +

GROWTH, DEVELOPMENT, AND REPRODUCTION OF ORGANISMS

MS-LS1-4
Use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively.
MS-LS1-5
Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms. +
MS-LS3-1
Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of the organism.
MS-LS3-2
Develop and use a model to describe why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation.
MS-LS4-5
Gather and synthesize information about the technologies that have changed the way humans influence the inheritance of desired traits in organisms.

MICHIGAN MIDDLE SCHOOL (6-8) SCIENCE STANDARDS: TOPICS AND PERFORMANCE EXPECTATIONS

LIFE SCIENCE

NATURAL SELECTION AND ADAPTATION

MS-LS4-1
Analyze and interpret data for patterns in the fossil record that document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth under the assumption that natural laws operate today as in the past. +

MS-LS4-2
Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships.

MS-LS4-3
Analyze displays of pictorial data to compare patterns of similarities in the embryological development across multiple species to identify relationships not evident in the fully formed anatomy.

MS-LS4-4
Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment.

MS-LS4-6
Use mathematical representations to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time.

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MICHIGAN MIDDLE SCHOOL (6-8) SCIENCE STANDARDS: TOPICS AND PERFORMANCE EXPECTATIONS

EARTH SCIENCE

SPACE SYSTEMS

MS-ESS1-1
Develop and use a model of the Earth-sun-moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons.
MS-ESS1-2
Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system.
MS-ESS1-3
Analyze and interpret data to determine scale properties of objects in the solar system.

HISTORY OF EARTH

MS-ESS1-4
Construct a scientific explanation based on evidence from rock strata for how the geologic time scale is used to organize Earth's 4.6-billion-year-old history.
MS-ESS2-2
Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.
MS-ESS2-3
Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of the past plate motions.

EARTH'S SYSTEMS

MS-ESS2-1
Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process. +
MS-ESS2-4
Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity. +
MS-ESS3-1
Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes. +

WEATHER AND CLIMATE

MS-ESS2-5
Collect data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions.
MS-ESS2-5 MI
Collect data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions in Michigan due to the Great Lakes and regional geography.
MS-ESS2-6
Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates.
MS-ESS3-5
Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.

MICHIGAN MIDDLE SCHOOL (6-8) SCIENCE STANDARDS: TOPICS AND PERFORMANCE EXPECTATIONS

EARTH SCIENCE

HUMAN IMPACTS

MS-ESS3-2
Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.

MS-ESS3-3
Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment. * +

MS-ESS3-4
Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.

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ENGINEERING DESIGN

MS-ETS1-1
Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

MS-ETS1-2
Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

MS-ETS1-3
Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

MS-ETS1-4
Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

MICHIGAN HIGH SCHOOL (9-12) SCIENCE STANDARDS: TOPICS AND PERFORMANCE EXPECTATIONS

PHYSICAL SCIENCE

STRUCTURE AND PROPERTIES OF MATTER

HS-PS1-1
Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.

HS-PS1-3
Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.

HS-PS1-8
Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay.

HS-PS2-6
Communicate scientific and technical information about why the molecular level structure is important in the functioning of designed materials. *

CHEMICAL REACTIONS

HS-PS1-2
Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.

HS-PS1-4
Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.

HS-PS1-5
Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.

HS-PS1-6
Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.*

HS-PS1-7
Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.

FORCES AND INTERACTIONS

HS-PS2-1
Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.

HS-PS2-2
Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system.

HS-PS2-3
Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.*

HS-PS2-4
Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.

HS-PS2-5
Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current.

MICHIGAN HIGH SCHOOL (9-12) SCIENCE STANDARDS: TOPICS AND PERFORMANCE EXPECTATIONS

PHYSICAL SCIENCE

ENERGY

HS-PS3-1
Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.

HS-PS3-2
Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative position of particles (objects).

HS-PS3-3
Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.*

HS-PS3-4
Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).

HS-PS3-5
Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.

WAVES AND ELECTROMAGNETIC RADIATION

HS-PS4-1
Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.

HS-PS4-2
Evaluate questions about the advantages of using a digital transmission and storage of information.

HS-PS4-3
Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other.

HS-PS4-4
Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.

HS-PS4-5
Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy. *

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MICHIGAN HIGH SCHOOL (9-12) SCIENCE STANDARDS: TOPICS AND PERFORMANCE EXPECTATIONS

LIFE SCIENCE

STRUCTURE AND FUNCTION

HS-LS1-1
Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells.
HS-LS1-2
Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.
HS-LS1-3
Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.

MATTER AND ENERGY IN ORGANISMS AND ECOSYSTEMS

HS-LS1-5
Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.
HS-LS1-6
Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules.
HS-LS1-7
Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy.
HS-LS2-3
Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions.
HS-LS2-4
Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem. +
HS-LS2-5
Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere. +

INTERDEPENDENT RELATIONSHIPS IN ECOSYSTEMS

HS-LS2-1
Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.
HS-LS2-2
Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.
HS-LS2-6
Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem. +
HS-LS2-7
Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.* +
HS-LS2-8
Evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce.
HS-LS4-6
Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity. +

MICHIGAN HIGH SCHOOL (9-12) SCIENCE STANDARDS: TOPICS AND PERFORMANCE EXPECTATIONS

LIFE SCIENCE

INHERITANCE AND VARIATION OF TRAITS

HS-LS1-4
Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms.

HS-LS3-1
Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.

HS-LS3-2
Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors.

HS-LS3-3
Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.

NATURAL SELECTION AND EVOLUTION

HS-LS4-1
Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence.

HS-LS4-2
Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment.

HS-LS4-3
Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait.

HS-LS4-4
Construct an explanation based on evidence for how natural selection leads to adaptation of populations.

HS-LS4-5
Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.

KEY

* *Integrates traditional science content with engineering.*

\+ *Allow for local, regional, or Michigan specific contexts or examples in teaching and assessment.*

 *Includes a Michigan specific performance expectation.*

MICHIGAN HIGH SCHOOL (9-12) SCIENCE STANDARDS: TOPICS AND PERFORMANCE EXPECTATIONS

EARTH SCIENCE

SPACE SYSTEMS

HS-ESS1-1
Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun's core to release energy that eventually reaches Earth in the form of radiation.
HS-ESS1-2
Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe.
HS-ESS1-3
Communicate scientific ideas about the way stars, over their life cycle, produce elements.
HS-ESS1-4
Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.

HISTORY OF EARTH

HS-ESS1-5
Evaluate evidence of the past and current movements of continental and oceanic crust and the theory of plate tectonics to explain the ages of crustal rocks.
HS-ESS1-6
Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of Earth's formation and early history.
HS-ESS2-1
Develop a model to illustrate how Earth's internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features.

EARTH'S SYSTEMS

HS-ESS2-2
Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems.
HS-ESS2-3
Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection.
HS-ESS2-5
Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes. +
HS-ESS2-6
Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.
HS-ESS2-7
Construct an argument based on evidence about the simultaneous coevolution of Earth's systems and life on Earth.

WEATHER AND CLIMATE

HS-ESS2-4
Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.
HS-ESS3-5
Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems. +

MICHIGAN HIGH SCHOOL (9-12) SCIENCE STANDARDS: TOPICS AND PERFORMANCE EXPECTATIONS

EARTH SCIENCE

HUMAN SUSTAINABILITY

HS-ESS3-1
Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.

HS-ESS3-2
Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios. * +

HS-ESS3-3
Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity. +

HS-ESS3-4
Evaluate or refine a technological solution that reduces impacts of human activities on natural systems. *

HS-ESS3-6
Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.

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ENGINEERING DESIGN

HS-ETS1-1
Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

HS-ETS1-2
Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

HS-ETS1-3
Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.

HS-ETS1-4
Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.

MICHIGAN / NGSX SCIENCE STANDARDS:

NEXT GENERATION K-12 LEARNING PROGRESSIONS

Earth Science Progression

Increasing Sophistication of Student Thinking

	K-2	3-5	6-8	9-12
ESS1.A The universe and its stars	Patterns of movement of the sun, moon, and stars as seen from Earth can be observed, described, and predicted.	Stars range greatly in size and distance from Earth and this can explain their relative brightness.		Light spectra from stars are used to determine their characteristics, processes, and lifecycles. Solar activity creates the elements through nuclear fusion. The development of technologies has provided the astronomical data that provide the empirical evidence for the Big Bang theory.
ESS1.A The universe and its stars			The solar system is part of the Milky Way, which is one of many billions of galaxies.	
ESS1.A The universe and its stars		The Earth's orbit and rotation, and the orbit of the moon around the Earth cause observable patterns.	The solar system contains many varied objects held together by gravity. Solar system models explain and predict eclipses, lunar phases, and seasons.	Kepler's laws describe common features of the motions of orbiting objects. Observations from astronomy and space probes provide evidence for explanations of solar system formation. Changes in Earth's tilt and orbit cause climate changes such as Ice Ages.
ESS1.C The history of planet Earth	Some events on Earth occur very quickly; others can occur very slowly.	Certain features on Earth can be used to order events that have occurred in a landscape.	Rock strata and the fossil record can be used as evidence to organize the relative occurrence of major historical events in Earth's history.	The rock record resulting from tectonic and other geoscience processes as well as objects from the solar system can provide evidence of Earth's early history and the relative ages of major geologic formations.
ESS2.A Earth materials and systems	Wind and water change the shape of the land.	Four major Earth systems interact. Rainfall helps to shape the land and affects the types of living things found in a region. Water, ice, wind, organisms, and gravity break rocks, soils, and sediments into smaller pieces and move them around.	Energy flows and matter cycles within and among Earth's systems, including the sun and Earth's interior as primary energy sources. Plate tectonics is one result of these processes.	Feedback effects exist within and among Earth systems.
ESS2.B Plate tectonics and large-scale system interactions	Maps show where things are located. One can map the shapes and kinds of land and water in any area.	Earth's physical features occur in patterns, as do earthquakes and volcanoes. Maps can be used to locate features and determine patterns in those events.	Plate tectonics is the unifying theory that explains movements of rocks at Earth's surface and geological history. Maps are used to display evidence of plate movement.	Radioactive decay within Earth's interior contributes to thermal convection in the mantle.

	K-2	3-5	6-8	9-12
ESS2.C The roles of water in Earth's surface processes	Water is found in many types of places and in different forms on Earth.	Most of Earth's water is in the ocean and much of the Earth's fresh water is in glaciers or underground.	Water cycles among land, ocean, and atmosphere, and is propelled by sunlight and gravity. Density variations of sea water drive interconnected ocean currents. Water movement causes weathering and erosion, changing land-scape features. ---------- Complex interactions determine local weather patterns and influence climate, including the role of the ocean.	The planet's dynamics are greatly influenced by water's unique chemical and physical properties.
ESS2.D Weather and climate	Weather is the combination of sunlight, wind, snow or rain, and temperature in a particu-lar region and time. People record weather patterns over time.	Climate describes patterns of typical weather conditions over different scales and variations. Historical weather patterns can be analyzed.		The role of radiation from the sun and its interactions with the atmosphere, ocean, and land are the foundation for the global climate system. Global climate models are used to predict future changes, including changes influenced by human behavior and natural factors.
ESS2.E Biogeology	Plants and animals can change their local environment. ---------- Living things need water, air, and resources from the land, and they live in places that have the things they need. Humans use natural resources for everything they do.	Living things can affect the physical characteristics of their environment.	[Content found in LS4.A and LS4.D]	The biosphere and Earth's other systems have many interconnections that cause a continual co-evolution of Earth's surface and life on it
ESS3.A Natural resources		Energy and fuels humans use are derived from natural sources and their use affects the environment. Some resources are renewable over time, others are not.	Humans depend on Earth's land, ocean, atmosphere, and biosphere for different resources, many of which are limited or not renewable. Resources are distributed unevenly around the planet as a result of past geologic processes.	Resource availability has guided the develop-ment of human society and use of natural resources has associated costs, risks, and benefits.
ESS3.B Natural hazards	In a region, some kinds of severe weather are more likely than others. Forecasts allow communities to prepare for severe weather.	A variety of hazards result from natural processes; humans cannot eliminate hazards but can reduce their impacts.	Mapping the history of natural hazards in a region and understanding related geological forces.	Natural hazards and other geological events have shaped the course of human history at local, regional, and global scales.
ESS3.C Human impacts on Earth systems	Things people do can affect the environment but they can make choices to reduce their impacts.	Societal activities have had major effects on the land, ocean, atmosphere, and even outer space. Societal activities can also help protect Earth's resources and environments.	Human activities have altered the biosphere, sometimes damaging it, although changes to environments can have different impacts for different living things. Activities and technologies can be engineered to reduce people's impacts on Earth.	Sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources, including the development of technologies.
ESS3.D Global climate change	N/A	N/A	Human activities affect global warming. Decisions to reduce the impact of global warming depend on understanding climate science, engineering capabilities, and social dynamics.	Global climate models used to predict changes continue to be improved, although discoveries about the global climate system are ongoing and continually needed.

Life Science Progression

Increasing Sophistication of Student Thinking

	K-2	3-5	6-8	9-12
LS1.A Structure and function	All organisms have external parts that they use to perform daily functions.	Organisms have both internal and external macroscopic structures that allow for growth, survival, behavior, and reproduction.	All living things are made up of cells. In organisms, cells work together to form tissues and organs that are specialized for particular body functions.	Systems of specialized cells within organisms help perform essential functions of life. Any one system in an organism is made up of numerous parts. Feedback mechanisms maintain an organism's internal conditions within certain limits and mediate behaviors.
LS1.B Growth and development of organisms	Parents and offspring often engage in behaviors that help the offspring sur-vive.	Reproduction is essential to every kind of organism. Organisms have unique and diverse life cycles.	Animals engage in behaviors that increase the odds of reproduction. An organism's growth is affected by both genetic and environmental factors.	Growth and division of cells in organisms occurs by mitosis and differentiation for specific cell types.
LS1.C Organization for matter and energy flow in organisms	Animals obtain food they need from plants or other ani-mals. Plants need water and light.	Food provides animals with the materials and energy they need for body repair, growth, warmth, and motion. Plants acquire material for growth chiefly from air, water, and process matter and obtain energy from sunlight, which is used to maintain conditions necessary for survival.	Plants use the energy from light to make sugars through photosynthesis. Within individual organisms, food is broken down through a series of chemical reactions that rearrange molecules and release energy.	The hydrocarbon backbones of sugars produced through photosynthesis are used to make amino acids and other molecules that can be assembled into proteins or DNA. Through cellular respiration, matter and energy flow through different organizational levels of an organism as elements are recombined to form different products and transfer energy.
LS1.D Information Processing	Animals sense and communicate information and respond to inputs with behaviors that help them grow and survive	Different sense receptors are specialized for particular kinds of information; Animals use their perceptions and memories to guide their actions.	Each sense receptor responds to different inputs, transmitting them as signals that travel along nerve cells to the brain; The signals are then processed in the brain, resulting in immediate behavior or memories.	N/A

	K-2	3-5	6-8	9-12
LS2.A Interdependent relationships in ecosystems	Plants depend on water and light to grow, and also depend on animals for pollination or to move their seeds around.	The food of almost any animal can be traced back to plants. Organisms are related in food webs in which some animals eat plants for food and other animals eat the animals that eat plants, while decomposers restore some materials back to the soil.	Organisms and populations are dependent on their environmental interactions both with other living things and with nonliving factors, any of which can limit their growth. Competitive, predatory, and mutually beneficial interactions vary across ecosystems but the patterns are shared.	Ecosystems have carrying capacities resulting from biotic and abiotic factors. The fundamental tension between resource availability and organism populations affects the abundance of species in any given ecosystem.
LS2.B Cycles of matter and energy transfer in ecosystems	[Content found in LS1.C and ESS3.A]	Matter cycles between the air and soil and among organisms as they live and die.	The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem. Food webs model how matter and energy are transferred among producers, consumers, and decomposers as the three groups interact within an ecosystem.	Photosynthesis and cellular respiration provide most of the energy for life processes. Only a fraction of matter consumed at the lower level of a food web is transferred up, resulting in fewer organisms at higher levels. At each link in an ecosystem elements are combined in different ways and matter and energy are conserved. Photosynthesis and cellular respiration are key components of the global carbon cycle.
LS2.C Ecosystem dynamics, functioning, and resilience	N/A	When the environment changes some organisms survive and reproduce, some move to new locations, some move into the transformed environment, and some die.	Ecosystem characteristics vary over time. Disruptions to any part of an ecosystem can lead to shifts in all of its populations. The completeness or integrity of an ecosystem's biodiversity is often used as a measure of its health.	If a biological or physical disturbance to an ecosystem occurs, including one induced by human activity, the ecosystem may return to its more or less original state or become a very different ecosystem, depending on the complex set of interactions within the ecosystem.
LS2.D Social interactions and group behavior	N/A	Being part of a group helps animals obtain food, defend themselves, and cope with changes.	N/A	Group behavior has evolved because membership can increase the chances of survival for individuals and their genetic relatives.

	K-2	3-5	6-8	9-12
LS3.A Inheritance of traits	Young organisms are very much, but not exactly, like their parents and also resemble other organisms of the same kind.	Different organisms vary in how they look and function because they have different inherited information; the environment also affects the traits that an organism develops.	Genes chiefly regulate a specific protein, which affect an individual's traits.	DNA carries instructions for forming species' characteristics. Each cell in an organism has the same genetic content, but genes expressed by cells can differ
LS3.B Variation of traits			In sexual reproduction, each parent contributes half of the genes acquired by the offspring resulting in variation between parent and offspring. Genetic information can be altered because of mutations, which may result in beneficial, negative, or no change to proteins in or traits of an organism.	The variation and distribution of traits in a population depend on genetic and environmental factors. Genetic variation can result from mutations caused by environmental factors or errors in DNA replication, or from chromosomes swapping sections during meiosis.
LS4.A Evidence of common ancestry and diversity	N/A	Some living organisms resemble organisms that once lived on Earth. Fossils provide evidence about the types of organisms and environments that existed long ago.	The fossil record documents the existence, diversity, extinction, and change of many life forms and their environments through Earth's history. The fossil record and comparisons of anatomical similarities between organisms enables the inference of lines of evolutionary descent.	The ongoing branching that produces multiple lines of descent can be inferred by comparing DNA sequences, amino acid sequences, and anatomical and embryological evidence of different organisms.
LS4.B Natural selection	N/A	Differences in characteristics between individuals of the same species provide advantages in surviving and reproducing.	Both natural and artificial selection result from certain traits giving some individuals an advantage in surviving and reproducing, leading to predominance of certain traits in a population.	Natural selection occurs only if there is variation in the genes and traits between organisms in a population. Traits that positively affect survival can become more common in a population.
LS4.C Adaptation	N/A	Particular organisms can only survive in particular environments --- Populations of organisms live in a variety of habitats. Change in those habitats affects the organisms living there.	Species can change over time in response to changes in environmental conditions through adaptation by natural selection acting over generations. Traits that support successful survival and reproduction in the new environment become more common.	Evolution results primarily from genetic variation of individuals in a species, competition for resources, and proliferation of organisms better able to survive and reproduce. Adaptation means that the distribution of traits in a population, as well as species expansion, emergence or extinction, can change when conditions change.
LS4.D Biodiversity and humans	A range of different organisms lives in different places.		Changes in biodiversity can influence humans' resources and ecosystem services they rely on.	Biodiversity is increased by formation of new species and reduced by extinction. Humans depend on biodiversity but also have adverse impacts on it. Sustaining biodiversity is essential to supporting life on Earth.

Physical Science Progression
Increasing Sophistication of Student Thinking

	K-2	3-5	6-8	9-12
PS1.A Structure of matter (includes PS1.C Nuclear processes)	Matter exists as different substances that have observable different properties. Different properties are suited to different purposes. Objects can be built up from smaller parts.	Matter exists as particles that are too small to see, and so matter is always conserved even if it seems to disappear. Measurements of a variety of observable properties can be used to identify particular materials.	The fact that matter is composed of atoms and molecules can be used to explain the properties of substances, diversity of materials, states of matter, phase changes, and conservation of matter.	The sub-atomic structural model and interactions between electric charges at the atomic scale can be used to explain the structure and interactions of matter, including chemical reactions and nuclear processes. Repeating patterns of the periodic table reflect patterns of outer electrons. A stable molecule has less energy than the same set of atoms separated; one must provide at least this energy to take the molecule apart.
PS1.B Chemical reactions	Heating and cooling substances cause changes that are sometimes reversible and sometimes not.	Chemical reactions that occur when substances are mixed can be identified by the emergence of substances with different properties; the total mass remains the same.	Reacting substances rearrange to form different molecules, but the number of atoms is conserved. Some reactions release energy and others absorb energy.	Chemical processes are understood in terms of collisions of molecules, rearrangement of atoms, and changes in energy as determined by properties of elements involved.
PS2.A Forces and motion	Pushes and pulls can have different strengths and directions, and can change the speed or direction of its motion or start or stop it.	The effect of unbalanced forces on an object results in a change of motion. Patterns of motion can be used to predict future motion. Some forces act through contact, some forces act even when the objects are not in contact. The gravitational force of Earth acting on an object near Earth's surface pulls that object toward the planet's center.	The role of the mass of an object must be qualitatively accounted for in any change of motion due to the application of a force.	Newton's 2nd law (F=ma) and the conservation of momentum can be used to predict changes in the motion of macroscopic objects.
PS2.B Types of interactions			Forces that act at a distance involve fields that can be mapped by their relative strength and effect on an object.	Forces at a distance are explained by fields that can transfer energy and can be described in terms of the arrangement and properties of the interacting objects and the distance between them. These forces can be used to describe the relationship between electrical and magnetic fields.
PS2.C Stability & instability in physical systems	N/A	N/A	N/A	N/A
PS3.A Definitions of energy	N/A	Moving objects contain energy. The faster the object moves, the more energy it has. Energy can be moved from place to place by moving objects, or through sound, light, or electrical currents. Energy can be converted from one form to another form.	Kinetic energy can be distinguished from the various forms of potential energy. Energy changes to and from each type can be tracked through physical or chemical interactions. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter.	The total energy within a system is conserved. Energy transfer within and between systems can be described and predicted in terms of energy associated with the motion or configuration of particles (objects). --- Systems move toward stable states.
PS3.B Conservation of energy and energy transfer	[Content found in PS3.D]			

	K-2	3-5	6-8	9-12
PS3.C Relationship between energy and forces	Bigger pushes and pulls cause bigger changes in an object's motion or shape.	When objects collide, contact forces transfer energy so as to change the objects' motions.	When two objects interact, each one exerts a force on the other, and these forces can transfer energy between them.	Fields contain energy that depends on the arrangement of the objects in the field.
PS3.D Energy in chemical processes and everyday life	Sunlight warms Earth's surface.	Energy can be "produced," "used," or "released" by converting stored energy. Plants capture energy from sunlight, which can later be used as fuel or food.	Sunlight is captured by plants and used in a reaction to produce sugar molecules, which can be reversed by burning those molecules to release energy.	Photosynthesis is the primary biological means of capturing radiation from the sun; energy cannot be destroyed, it can be converted to less useful forms.
PS4.A Wave properties	Sound can make matter vibrate, and vibrating matter can make sound.	Waves are regular patterns of motion, which can be made in water by disturbing the surface. Waves of the same type can differ in amplitude and wavelength. Waves can make objects move.	A simple wave model has a repeating pattern with a specific wavelength, frequency, and amplitude, and mechanical waves need a medium through which they are transmitted. This model can explain many phenomena including sound and light. Waves can transmit energy.	The wavelength and frequency of a wave are related to one another by the speed of the wave, which depends on the type of wave and the medium through which it is passing. Waves can be used to transmit information and energy.
PS4.B Electromagnetic radiation	Objects can be seen only when light is available to illuminate them.	Object can be seen when light reflected from their surface enters our eyes.	The construct of a wave is used to model how light interacts with objects.	Both an electromagnetic wave model and a photon model explain features of electromagnetic radiation broadly and describe common applications of electromagnetic radiation.
PS4.C Information technologies and instrumentation	People use devices to send and receive information.	---------- Patterns can encode, send, receive and decode information.	Waves can be used to transmit digital information. Digitized information is comprised of a pattern of 1s and 0s.	Large amounts of information can be stored and shipped around as a result of being digitized.

OVERVIEW

East Grand Rapids Public Schools

MIDDLE SCHOOL SCIENCE CURRICULUM by Topic

EGR MIDDLE SCHOOL SCIENCE CURRICULUM
ALIGNED TO MICHIGAN STATE SCIENCE STANDARDS

PHYSICAL SCIENCE

MICHIGAN STATE NGSS SCIENCE STANDARDS	GRADE LEVEL			CONTENT		
STRUCTURE AND PROPERTIES OF MATTER	**6th**	**7th**	**8th**	**Unit of Study - 6th**	**Unit of Study - 7th**	**Unit of Study - 8th**
MS-PS1-1 Develop models to describe the atomic composition of simple molecules and extended structures.	√			Chemistry		
MS-PS1-3 Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.	√	√		Chemistry	Pollution	
MS-PS1-4 Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.	√			Chemistry		
CHEMICAL REACTIONS	**6th**	**7th**	**8th**	**Unit of Study - 6th**	**Unit of Study - 7th**	**Unit of Study - 8th**
MS-PS1-2 Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred	√			Chemistry		
MS-PS1-5 Develop and use a model to describe how the total number of atoms does not change in a chemical reaction and thus mass is conserved.	√			Chemistry		
MS-PS1-6 Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes.	√			Chemistry		
FORCES AND INTERACTIONS	**6th**	**7th**	**8th**	**Unit of Study - 6th**	**Unit of Study - 7th**	**Unit of Study - 8th**
MS-PS2-1 Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects.*		√			Forces and Motion	
MS-PS2-2 Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object. ects is conserved when there is no net force on the system.		√			Forces and Motion	
MS-PS2-3 Ask questions about data to determine the factors that affect the strength of electric and magnetic forces.		√			Forces and Motion	
MS-PS2-4 Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects.		√			Forces and Motion	
MS-PS2-5 Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact.		√			Forces and Motion	

EGR MIDDLE SCHOOL SCIENCE CURRICULUM
ALIGNED TO MICHIGAN STATE SCIENCE STANDARDS

PHYSICAL SCIENCE

MICHIGAN STATE NGSS SCIENCE STANDARDS	GRADE LEVEL			CONTENT		
ENERGY	**6th**	**7th**	**8th**	**Unit of Study - 6th**	**Unit of Study - 7th**	**Unit of Study - 8th**
MS-PS3-1 Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object.	√	√		Chemistry	Forces and Motion	
MS-PS3-2 Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system.	√	√		Chemistry	Forces and Motion	
MS-PS3-3 Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.	√			Chemistry		
MS-PS3-4 Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample.	√			Chemistry		
MS-PS3-5 Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.	√	√		Chemistry	Forces and Motion	
WAVES AND ELECTROMAGNETIC RADIATION	**6th**	**7th**	**8th**	**Unit of Study - 6th**	**Unit of Study - 7th**	**Unit of Study - 8th**
MS-PS4-1 Use mathematical representations to describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave.			√			Waves and Energy
MS-PS4-2 Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.			√			Waves and Energy
MS-PS4-3 Integrate qualitative scientific and technical information to support the claim that digitized signals are a more reliable way to encode and transmit information than analog signals.			√			Waves and Energy

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EGR MIDDLE SCHOOL SCIENCE CURRICULUM
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LIFE SCIENCE

MICHIGAN STATE NGSS SCIENCE STANDARDS	GRADE LEVEL			CONTENT		
STRUCTURE, FUNCTION, AND INFORMATION PROCESSING	**6th**	**7th**	**8th**	**Unit of Study - 6th**	**Unit of Study - 7th**	**Unit of Study - 8th**
MS-LS1-1 Conduct an investigation to provide evidence that living things are made of cells; either one cell or many different numbers and types of cells.	√			Cells and Body Systems		
MS-LS1-2 Develop and use a model to describe the function of a cell as a whole and ways parts of cells contribute to the function.	√			Cells and Body Systems		
MS-LS1-3 Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.	√			Cells and Body Systems		
MS-LS1-8 Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories.	√			Cells and Body Systems		
MATTER AND ENERGY IN ORGANISMS AND ECOSYSTEMS	**6th**	**7th**	**8th**	**Unit of Study - 6th**	**Unit of Study - 7th**	**Unit of Study - 8th**
MS-LS1-6 Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms.		√			Plants and Ecology	
MS-LS1-7 Develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as this matter moves through an organism.		√			Plants and Ecology	
MS-LS2-1 Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem. +		√			Plants and Ecology	
MS-LS2-3 Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem. +		√			Plants and Ecology	
MS-LS2-4 Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.		√			Plants and Ecology	
INTERDEPENDENT RELATIONSHIPS IN ECOSYSTEMS	**6th**	**7th**	**8th**	**Unit of Study - 6th**	**Unit of Study - 7th**	**Unit of Study - 8th**
MS-LS2-2 Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems. +		√			Plants and Ecology	
MS-LS2-5 Evaluate competing design solutions for maintaining biodiversity and ecosystem services. * +		√			Plants and Ecology	

EGR MIDDLE SCHOOL SCIENCE CURRICULUM
ALIGNED TO MICHIGAN STATE SCIENCE STANDARDS

LIFE SCIENCE

MICHIGAN STATE NGSS SCIENCE STANDARDS	GRADE LEVEL			CONTENT		
GROWTH, DEVELOPMENT, AND REPRODUCTION OF ORGANISMS	**6th**	**7th**	**8th**	**Unit of Study - 6th**	**Unit of Study - 7th**	**Unit of Study - 8th**
MS-LS1-4 Use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively.		√			Natural Selection	
MS-LS1-5 Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms. +		√			Natural Selection	
MS-LS3-1 Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of the organism.			√			Heredity
MS-LS3-2 Develop and use a model to describe why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation.			√			Heredity
MS-LS4-5 Gather and synthesize information about the technologies that have changed the way humans influence the inheritance of desired traits in organisms.		√			Natural Selection	
NATURAL SELECTION AND ADAPTATION	**6th**	**7th**	**8th**	**Unit of Study - 6th**	**Unit of Study - 7th**	**Unit of Study - 8th**
MS-LS4-1 Analyze and interpret data for patterns in the fossil record that document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth under the assumption that natural laws operate today as in the past. +			√			Geology
MS-LS4-2 Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships.		√			Natural Selection	
MS-LS4-3 Analyze displays of pictorial data to compare patterns of similarities in the embryological development across multiple species to identify relationships not evident in the fully formed anatomy.		√			Natural Selection	
MS-LS4-4 Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment.		√			Natural Selection	
MS-LS4-6 Use mathematical representations to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time.		√			Natural Selection	

KEY

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EGR MIDDLE SCHOOL SCIENCE CURRICULUM
ALIGNED TO MICHIGAN STATE SCIENCE STANDARDS

EARTH SCIENCE

MICHIGAN STATE NGSS SCIENCE STANDARDS	GRADE LEVEL			CONTENT		
SPACE SYSTEMS	**6th**	**7th**	**8th**	**Unit of Study - 6th**	**Unit of Study - 7th**	**Unit of Study - 8th**
MS-ESS1-1 Develop and use a model of the Earth-sun-moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons.	√			Astronomy		
MS-ESS1-2 Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system.	√			Astronomy		
MS-ESS1-3 Analyze and interpret data to determine scale properties of objects in the solar system.	√		√	Astronomy		Geology
HISTORY OF EARTH	**6th**	**7th**	**8th**	**Unit of Study - 6th**	**Unit of Study - 7th**	**Unit of Study - 8th**
MS-ESS1-4 Construct a scientific explanation based on evidence from rock strata for how the geologic time scale is used to organize Earth's 4.6-billion-year-old history.			√			Geology
MS-ESS2-2 Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.			√			Geology
MS-ESS2-3 Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of the past plate motions.			√			Geology
EARTH'S SYSTEMS	**6th**	**7th**	**8th**	**Unit of Study - 6th**	**Unit of Study - 7th**	**Unit of Study - 8th**
MS-ESS2-1 Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process. +			√			Geology
MS-ESS2-4 Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity. +		√			Pollution	
MS-ESS3-1 Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes. +		√	√		Pollution	Geology

EGR MIDDLE SCHOOL SCIENCE CURRICULUM
ALIGNED TO MICHIGAN STATE SCIENCE STANDARDS

EARTH SCIENCE

MICHIGAN STATE NGSS SCIENCE STANDARDS	GRADE LEVEL			CONTENT		
WEATHER AND CLIMATE	**6th**	**7th**	**8th**	**Unit of Study - 6th**	**Unit of Study - 7th**	**Unit of Study - 8th**
MS-ESS2-5 Collect data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions.			√			Weather and Climate
MS-ESS2-5 MI Collect data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions in Michigan due to the Great Lakes and regional geography.			√			Weather and Climate
MS-ESS2-6 Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates.			√			Weather and Climate
MS-ESS3-5 Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.			√			Weather and Climate
HUMAN IMPACTS	**6th**	**7th**	**8th**	**Unit of Study - 6th**	**Unit of Study - 7th**	**Unit of Study - 8th**
MS-ESS3-2 Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.			√			Geology
MS-ESS3-3 Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment. * +		√			Pollution	Geology
S-ESS3-4 Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.		√			Pollution	Geology

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EGR MIDDLE SCHOOL SCIENCE CURRICULUM
ALIGNED TO MICHIGAN STATE SCIENCE STANDARDS

ENGINEERING DESIGN
Integrated Across the Units of Study at Each Grade Level

MICHIGAN STATE NGSS SCIENCE STANDARDS	GRADE LEVEL			CONTENT		
	6th	7th	8th	Unit of Study - 6th	Unit of Study - 7th	Unit of Study - 8th
MS-ETS1-1 Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.	√	√	√	Engineering, Technology, and Applications of Science	Engineering, Technology, and Applications of Science	Engineering, Technology, and Applications of Science
MS-ETS1-2 Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.	√	√	√	Engineering, Technology, and Applications of Science	Engineering, Technology, and Applications of Science	Engineering, Technology, and Applications of Science
MS-ETS1-3 Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.	√	√	√	Engineering, Technology, and Applications of Science	Engineering, Technology, and Applications of Science	Engineering, Technology, and Applications of Science
MS-ETS1-4 Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.	√	√	√	Engineering, Technology, and Applications of Science	Engineering, Technology, and Applications of Science	Engineering, Technology, and Applications of Science

East Grand Rapids Public Schools

MIDDLE SCHOOL SCIENCE CURRICULUM by Grade Level

SCIENCE STANDARDS
6th Grade

UNITS OF STUDY

Chemistry
Cells and Body Systems
Astronomy
Engineering, Technology, and Applications of Science

PHYSICAL SCIENCE - CHEMISTRY

STRUCTURE AND PROPERTIES OF MATTER

MS-PS1-1
Develop models to describe the atomic composition of simple molecules and extended structures.
MS-PS1-3
Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.
MS-PS1-4
Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.

CHEMICAL REACTIONS

MS-PS1-2
Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.
MS-PS1-5
Develop and use a model to describe how the total number of atoms does not change in a chemical reaction and thus mass is conserved.
MS-PS1-6
Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes. *

ENERGY

MS-PS3-1
Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object.
MS-PS3-2
Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system.
MS-PS3-3
Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer. *
MS-PS3-4
Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample.
MS-PS3-5
Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.

SCIENCE STANDARDS
6th Grade

LIFE SCIENCE - CELLS AND BODY SYSTEMS

STRUCTURE, FUNCTION, AND INFORMATION PROCESSING

MS-LS1-1
Conduct an investigation to provide evidence that living things are made of cells; either one cell or many different numbers and types of cells.
MS-LS1-2
Develop and use a model to describe the function of a cell as a whole and ways parts of cells contribute to the function.
MS-LS1-3
Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.
MS-LS1-8
Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories.

EARTH SCIENCE - ASTRONOMY

SPACE SYSTEMS - SOLAR SYSTEMS

MS-ESS1-1
Develop and use a model of the Earth-sun-moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons.
MS-ESS1-2
Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system.
MS-ESS1-3
Analyze and interpret data to determine scale properties of objects in the solar system.

ENGINEERING DESIGN: ENGINEERING, TECHNOLOGY, AND APPLICATIONS OF SCIENCE

MS-ETS1-1
Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
MS-ETS1-2
Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
MS-ETS1-3
Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
MS-ETS1-4
Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

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SCIENCE STANDARDS
7th Grade

UNITS OF STUDY

Forces and Motion
Plants and Ecology
Natural Selection
Pollution
Engineering, Technology, and Applications of Science

PHYSICAL SCIENCE - FORCES AND MOTION

FORCES AND INTERACTIONS

MS-PS2-1
Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects. *
MS-PS2-2
Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.
MS-PS2-3
Ask questions about data to determine the factors that affect the strength of electric and magnetic forces.
MS-PS2-4
Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects.
MS-PS2-5
Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact.

ENERGY

MS-PS3-1
Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object.
MS-PS3-2
Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system.
MS-PS3-5
Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.

SCIENCE STANDARDS
7th Grade

LIFE SCIENCE - PLANTS AND ECOLOGY

MATTER AND ENERGY IN ORGANISMS AND ECOSYSTEMS

MS-LS1-6
Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms.
MS-LS1-7
Develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as this matter moves through an organism.
MS-LS2-1
Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem. +
MS-LS2-3
Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem. +
MS-LS2-4
Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.

INTERDEPENDENT RELATIONSHIPS IN ECOSYSTEMS

MS-LS2-2
Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems. +
MS-LS2-5
Evaluate competing design solutions for maintaining biodiversity and ecosystem services. * +

LIFE SCIENCE - NATURAL SELECTION

GROWTH, DEVELOPMENT, AND REPRODUCTION OF ORGANISMS

MS-LS1-4
Use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively.
MS-LS1-5
Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms. +
MS-LS4-5
Gather and synthesize information about the technologies that have changed the way humans influence the inheritance of desired traits in organisms.

NATURAL SELECTION AND ADAPTATION

MS-LS4-2
Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships.
MS-LS4-3
Analyze displays of pictorial data to compare patterns of similarities in the embryological development across multiple species to identify relationships not evident in the fully formed anatomy.
MS-LS4-4
Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment.
MS-LS4-6
Use mathematical representations to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time.

SCIENCE STANDARDS
7th Grade

EARTH SCIENCE - POLLUTION

EARTH'S SYSTEMS

MS-ESS2-4
Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity. +

MS-ESS3-1
Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes. +

STRUCTURES AND PROPERTIES OF MATTER

MS-PS1-3
Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.

HUMAN IMPACTS

MS-ESS3-3
Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment. * +

MS-ESS3-4
Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.

ENGINEERING DESIGN: ENGINEERING, TECHNOLOGY, AND APPLICATIONS OF SCIENCE

MS-ETS1-1
Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

MS-ETS1-2
Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

MS-ETS1-3
Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

MS-ETS1-4
Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

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SCIENCE STANDARDS
8th Grade

UNITS OF STUDY

Waves and Energy
Heredity
Geology
Weather and Climate
Engineering, Technology, and Applications of Science

PHYSICAL SCIENCE - WAVES AND ENERGY

WAVES AND ELECTROMAGNETIC RADIATION

MS-PS4-1
Use mathematical representations to describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave.
MS-PS4-2
Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.
MS-PS4-3
Integrate qualitative scientific and technical information to support the claim that digitized signals are a more reliable way to encode and transmit information than analog signals.

LIFE SCIENCE - HEREDITY

GROWTH, DEVELOPMENT, AND REPRODUCTION OF ORGANISMS

MS-LS3-1
Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of the organism.
MS-LS3-2
Develop and use a model to describe why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation.

EARTH SCIENCE - GEOLOGY

SPACE SYSTEMS

MS-ESS1-3
Analyze and interpret data to determine scale properties of objects in the solar system.

HISTORY OF EARTH

MS-ESS1-4
Construct a scientific explanation based on evidence from rock strata for how the geologic time scale is used to organize Earth's 4.6-billion-year-old history.
MS-ESS2-2
Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.
MS-ESS2-3
Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of the past plate motions.
MS-LS4-1
Analyze and interpret data for patterns in the fossil record that document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth under the assumption that natural laws operate today as in the past. + (Natural Selection and Adaptations)

SCIENCE STANDARDS
8th Grade

EARTH SCIENCE - GEOLOGY (cont.)

EARTH'S SYSTEMS

MS-ESS2-1
Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process. +
MS-ESS3-1
Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes. +

HUMAN IMPACTS

MS-ESS3-2
Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.

EARTH SCIENCE - WEATHER AND CLIMATE

WEATHER AND CLIMATE

MS-ESS2-5
Collect data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions.
MS-ESS2-5 MI
Collect data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions in Michigan due to the Great Lakes and regional geography.
MS-ESS2-6
Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates.
MS-ESS3-5
Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.

ENGINEERING DESIGN: ENGINEERING, TECHNOLOGY, AND APPLICATIONS OF SCIENCE

MS-ETS1-1
Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
MS-ETS1-2
Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
MS-ETS1-3
Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
MS-ETS1-4
Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

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OVERVIEW

East Grand Rapids Public Schools

HIGH SCHOOL SCIENCE CURRICULUM by Topic

EGR HIGH SCHOOL SCIENCE CURRICULUM
ALIGNED TO MICHIGAN STATE SCIENCE STANDARDS

PHYSICAL SCIENCE

MICHIGAN STATE NGSS SCIENCE STANDARDS	EGRHS COURSE				UNIT OF STUDY			
STRUCTURE AND PROPERTIES OF MATTER	**IPC**	**PH**	**CH**	**BI**	**Integrated Physics & Chemistry**	**Physics**	**Chemistry**	**Biology**
HS-PS1-1 Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.	√	√	√		• Atomic Theory and Periodic Table of Elements • Electron Behavior • Bonding, Formulae, Nomenclature and Chemical Reactions	• Atomic Theory	• Atomic Theory and Periodic Table of Elements • Nuclear Chemistry and Electron Behavior • Bonding, Formulae, Nomenclature and Chemical Reactions	
HS-PS1-3 Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.	√		√		• Bonding, Formulae, Nomenclature and Chemical Reactions		• Bonding, Formulae, Nomenclature and Chemical Reactions • Intermolecular Forces and Gas Laws	
HS-PS1-8 Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay.	√	√	√		• Electron Behavior • Nuclear Chemistry	• Nuclear Chemistry	• Nuclear Chemistry and Electron Behavior	
HS-PS2-6 Communicate scientific and technical information about why the molecular level structure is important in the functioning of designed materials. *	√		√		• Bonding, Formulae, Nomenclature and Chemical Reactions		• Bonding, Formulae, Nomenclature and Chemical Reactions	
CHEMICAL REACTIONS	**IPC**	**PH**	**CH**	**BI**	**Integrated Physics & Chemistry**	**Physics**	**Chemistry**	**Biology**
HS-PS1-2 Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.	√		√		• Bonding, Formulae, Nomenclature and Chemical Reactions		• Bonding, Formulae, Nomenclature and Chemical Reactions • Mole and Stoichiometry	
HS-PS1-4 Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.	√		√		• Bonding, Formulae, Nomenclature and Chemical Reactions		• Energies	
HS-PS1-5 Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.			√				• Chemical Equilibrium and Aqueous Chemistry	
HS-PS1-6 Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.*			√				• Chemical Equilibrium and Aqueous Chemistry	
HS-PS1-7 Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.	√		√		• Bonding, Formulae, Nomenclature and Chemical Reactions		• Bonding, Formulae, Nomenclature and Chemical Reactions • Mole and Stoichiometry • Chemical Equilibrium and Aqueous Chemistry	

EGR HIGH SCHOOL SCIENCE CURRICULUM
ALIGNED TO MICHIGAN STATE SCIENCE STANDARDS

PHYSICAL SCIENCE

MICHIGAN STATE NGSS SCIENCE STANDARDS	EGRHS COURSE				UNIT OF STUDY			
FORCES AND INTERACTIONS	**IPC**	**PH**	**CH**	**BI**	**Integrated Physics & Chemistry**	**Physics**	**Chemistry**	**Biology**
HS-PS2-1 Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.	√	√			•Forces	•Forces		
HS-PS2-2 Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system.	√	√			•Energy and Momentum	•Momentum		
HS-PS2-3 Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.*			√		•Energy and Momentum	•Momentum		
HS-PS2-4 Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.	√	√			•Measurement and Motion •Electricity and Magnetism •Astrophysics	•Circular Motion •Electricity and Magnetism •Astrophysics		
HS-PS2-5 Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current.	√	√			•Electricity and Magnetism	•Electricity and Magnetism		
ENERGY	**IPC**	**PH**	**CH**	**BI**	**Integrated Physics & Chemistry**	**Physics**	**Chemistry**	**Biology**
HS-PS3-1 Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.	√	√	√		•Energy and Momentum	•Energy	•Energetics	
HS-PS3-2 Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative position of particles (objects).	√	√	√		•Energy and Momentum	•Energy	•Intermolecular Forces and Gas Laws •Energetics	
HS-PS3-3 Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.*	√	√			•Energy and Momentum	•Energy		
HS-PS3-4 Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).	√		√		•Geophysics	•Meteorology and Thermal Physics	•Energetics	
HS-PS3-5 Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.	√	√	√		•Electricity and Magnetism •Atomic Theory and Periodic Table of Elements	•Atomic Theory •Electricity and Magnetism	•Atomic Theory and Periodic Table of Elements	

EGR HIGH SCHOOL SCIENCE CURRICULUM
ALIGNED TO MICHIGAN STATE SCIENCE STANDARDS

PHYSICAL SCIENCE

MICHIGAN STATE NGSS SCIENCE STANDARDS	EGRHS COURSE				UNIT OF STUDY			
WAVES AND ELECTROMAGNETIC RADIATION	**IPC**	**PH**	**CH**	**BI**	**Integrated Physics & Chemistry**	**Physics**	**Chemistry**	**Biology**
HS-PS4-1 Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.	√	√			•Waves	•Waves		
HS-PS4-2 Evaluate questions about the advantages of using a digital transmission and storage of information.	√	√			•Waves	•Waves		
HS-PS4-3 Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other.	√	√			•Waves	•Waves		
HS-PS4-4 Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.	√	√			•Waves	•Waves		
HS-PS4-5 Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy. *	√	√			•Waves	•Waves		

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EGR HIGH SCHOOL SCIENCE CURRICULUM
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LIFE SCIENCE

MICHIGAN STATE NGSS SCIENCE STANDARDS	EGRHS COURSE				UNIT OF STUDY			
STRUCTURE AND FUNCTION	**IPC**	**PH**	**CH**	**BI**	**Integrated Physics & Chemistry**	**Physics**	**Chemistry**	**Biology**
HS-LS1-1 Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells.				√				• DNA/RNA
HS-LS1-2 Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organ-isms.				√				• Characteristics of Life • Cells
HS-LS1-3 Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.				√				• Photosynthesis/Cell Respiration
MATTER AND ENERGY IN ECOSYSTEMS	**IPC**	**PH**	**CH**	**BI**	**Integrated Physics & Chemistry**	**Physics**	**Chemistry**	**Biology**
HS-LS1-5 Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.				√				• Photosynthesis/Cell Respiration
HS-LS1-6 Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules.				√				• Chemistry of Life/ Biochemistry
HS-LS1-7 Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy.				√				• Photosynthesis/Cell Respiration
HS-LS2-3 Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions.				√				• Photosynthesis/Cell Respiration
HS-LS2-4 Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem. **				√				• Ecology
HS-LS2-5 Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere. **				√				• Chemistry of Life/ Biochemistry

EGR HIGH SCHOOL SCIENCE CURRICULUM
ALIGNED TO MICHIGAN STATE SCIENCE STANDARDS

LIFE SCIENCE

MICHIGAN STATE NGSS SCIENCE STANDARDS	EGRHS COURSE				UNIT OF STUDY			
INTERDEPENDENT RELATIONSHIPS IN ECOSYSTEMS	**IPC**	**PH**	**CH**	**BI**	**Integrated Physics & Chemistry**	**Physics**	**Chemistry**	**Biology**
HS-LS2-1 Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.				√				•Ecology
HS-LS2-2 Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.				√				•Ecology
HS-LS2-6 Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem. +				√				•Ecology
HS-LS2-7 Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity. * +				√				•Ecology
HS-LS2-8 Evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce.				√				•Evolution
HS-LS4-6 Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity. +				√				•Ecology
INHERITANCE AND VARIATION OF TRAITS	**IPC**	**PH**	**CH**	**BI**	**Integrated Physics & Chemistry**	**Physics**	**Chemistry**	**Biology**
HS-LS1-4 Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms.				√				•Cell Cycle
HS-LS3-1 Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.				√				•Evolution
HS-LS3-2 Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors.				√				•Genetics
HS-LS3-3 Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.				√				•Genetics

EGR HIGH SCHOOL SCIENCE CURRICULUM
ALIGNED TO MICHIGAN STATE SCIENCE STANDARDS

LIFE SCIENCE

MICHIGAN STATE NGSS SCIENCE STANDARDS	EGRHS COURSE				UNIT OF STUDY			
NATURAL SELECTION AND EVOLUTION	**IPC**	**PH**	**CH**	**BI**	**Integrated Physics & Chemistry**	**Physics**	**Chemistry**	**Biology**
HS-LS4-1 Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence.				√				• Evolution
HS-LS4-2 Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment.				√				• Evolution
HS-LS4-3 Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait.				√				• Evolution
HS-LS4-4 Construct an explanation based on evidence for how natural selection leads to adaptation of populations.				√				• Evolution
HS-LS4-5 Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.				√				• Evolution

KEY

* *Integrates traditional science content with engineering.*

\+ *Allow for local, regional, or Michigan specific contexts or examples in teaching and assessment.*


Includes a Michigan specific performance expectation.

EGR HIGH SCHOOL SCIENCE CURRICULUM
ALIGNED TO MICHIGAN STATE SCIENCE STANDARDS

EARTH SCIENCE

MICHIGAN STATE NGSS SCIENCE STANDARDS	EGRHS COURSE				UNIT OF STUDY			
SPACE SYSTEMS	**IPC**	**PH**	**CH**	**BI**	**Integrated Physics & Chemistry**	**Physics**	**Chemistry**	**Biology**
HS-ESS1-1 Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun's core to release energy that eventually reaches Earth in the form of radiation.	√	√	√		•Astrophysics	•Astrophysics	•Nuclear Chemistry and Electron Behavior	
HS-ESS1-2 Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe.	√	√			•Astrophysics	•Astrophysics		
HS-ESS1-3 Communicate scientific ideas about the way stars, over their life cycle, produce elements.	√	√	√		•Atomic Theory and Periodic Table of Elements •Astrophysics	•Astrophysics	•Atomic Theory and Periodic Table of Elements •Nuclear Chemistry and Electron Behavior	
HS-ESS1-4 Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.	√	√			•Astrophysics	•Circular Motion •Astrophysics		
HISTORY OF EARTH	**IPC**	**PH**	**CH**	**BI**	**Integrated Physics & Chemistry**	**Physics**	**Chemistry**	**Biology**
HS-ESS1-5 Evaluate evidence of the past and current movements of continental and oceanic crust and the theory of plate tectonics to explain the ages of crustal rocks.	√	√			•Geophysics	•Geophysics		
HS-ESS1-6 Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of Earth's formation and early history.	√	√			•Astrophysics •Geophysics	•Astrophysics •Geophysics		
HS-ESS2-1 Develop a model to illustrate how Earth's internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features.	√	√			•Geophysics	•Geophysics		
EARTH'S SYSTEMS	**IPC**	**PH**	**CH**	**BI**	**Integrated Physics & Chemistry**	**Physics**	**Chemistry**	**Biology**
HS-ESS2-2 Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems.			√				•Environmental Chemistry	
HS-ESS2-3 Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection. HS-ESS2-5 Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes. +	√	√			•Geophysics	•Geophysics		
HS-ESS2-5 Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes. +			√				•Environmental Chemistry	
HS-ESS2-6 Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.				√				•Ecology
HS-ESS2-7 Construct an argument based on evidence about the simultaneous coevolution of Earth's systems and life on Earth.				√				•Evolution

EGR HIGH SCHOOL SCIENCE CURRICULUM
ALIGNED TO MICHIGAN STATE SCIENCE STANDARDS

EARTH SCIENCE

MICHIGAN STATE NGSS SCIENCE STANDARDS	EGRHS COURSE				UNIT OF STUDY			
WEATHER AND CLIMATE	**IPC**	**PH**	**CH**	**BI**	**Integrated Physics & Chemistry**	**Physics**	**Chemistry**	**Biology**
HS-ESS2-4 Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.	√	√	√		•Geophysics	•Meteorology and Thermal Physics	•Energetics	
HS-ESS3-5 Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems. +	√	√	√		•Geophysics	•Meteorology and Thermal Physics	•Environmental Chemistry	
HUMAN SUSTAINABILITY	**IPC**	**PH**	**CH**	**BI**	**Integrated Physics & Chemistry**	**Physics**	**Chemistry**	**Biology**
HS-ESS3-1 Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.	√	√			•Geophysics	•Geophysics		
HS-ESS3-2 Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios. * +	√	√	√		•Nuclear Chemistry	•Nuclear Chemistry	•Energetics	
HS-ESS3-3 Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity. +				√				•Ecology
HS-ESS3-4 Evaluate or refine a technological solution that reduces impacts of human activities on natural systems. *	√				•Nuclear Chemistry	•Nuclear Chemistry		
HS-ESS3-6 Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.			√				•Environmental Chemistry	

KEY

* *Integrates traditional science content with engineering.*

\+ *Allow for local, regional, or Michigan specific contexts or examples in teaching and assessment.*

Includes a Michigan specific performance expectation.

EGR HIGH SCHOOL SCIENCE CURRICULUM
ALIGNED TO MICHIGAN STATE SCIENCE STANDARDS

ENGINEERING DESIGN
Integrated Across the Units of Study at Each Grade Level

MICHIGAN STATE NGSS SCIENCE STANDARDS	EGRHS COURSE				UNIT OF STUDY			
	IPC	PH	CH	BI	Integrated Physics & Chemistry	Physics	Chemistry	Biology
HS-ETS1-1 Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.	√	√	√	√	•Engineering, Technology, and Applications of Science	•Engineering, Technology, and Application of Science	•Engineering, Technology, and Applications of Science	•Engineering, Technology, and Applications of Science
HS-ETS1-2 Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.	√	√	√	√	•Engineering, Technology, and Applications of Science	•Engineering, Technology, and Application of Science	•Engineering, Technology, and Applications of Science	•Engineering, Technology, and Applications of Science
HS-ETS1-3 Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.	√	√	√	√	•Engineering, Technology, and Applications of Science	•Engineering, Technology, and Application of Science	•Engineering, Technology, and Applications of Science	•Engineering, Technology, and Applications of Science
HS-ETS1-4 Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.	√	√	√	√	•Engineering, Technology, and Applications of Science	•Engineering, Technology, and Application of Science	•Engineering, Technology, and Applications of Science	•Engineering, Technology, and Applications of Science

East Grand Rapids Public Schools

HIGH SCHOOL SCIENCE CURRICULUM by COURSE

EGR HIGH SCHOOL SCIENCE CURRICULUM ALIGNED TO MICHIGAN STATE SCIENCE STANDARDS

INTEGRATED PHYSICS AND CHEMISTRY		PHYSICS		CHEMISTRY AND PRE AP/ IB CHEMISTRY		BIOLOGY AND BIOLOGY HONORS	
NGSS Standards	**Unit Topic**	**NGSS Standards**	**Unit Topic**	**NGSS Standards**	**Unit Topic**	**NGSS Standards**	**Unit Topic**
HS-PS2-4	Measurement and All Motion		Measurement	**HS-PS1-1** **HS-PS3-5** **HS-ESS1-3**	Atomic Theory & Periodic Table of Elements	**HS-LS1-2**	Introduction-Characteristics of Life
HS-PS2-1	Forces		Linear Motion	**HS-ESS1-1** **HS-ESS1-3** **HS-PS1-1** **HS-PS1-8**	Nuclear Chemistry and Electron Behavior	**HS-LS2-4** **HS-LS2-1** **HS-LS2-2** **HS-LS2-6** **HS-LS2-7** **HS-LS4-6** **HS-ESS2-6** **HS-ESS3-3**	Ecology
HS-PS2-2 **HS-PS2-3** **HS-PS3-1** **HS-PS3-2** **HS-PS3-3**	Energy and Momentum	**HS-PS2-1**	Forces	**HS-PS1-1** **HS-PS1-2** **HS-PS1-3** **HS-PS2-6** **HS-PS1-7**	Bonding, Formulae, Nomenclature and Chemical Reactions	**HS-LS1-6** **HS-LS2-5**	Chemistry of Life/ Biochemistry
HS-PS2-4 **HS-PS2-5** **HS-PS3-5**	Electricity and Magnetism	**HS-PS2-2** **HS-PS2-3**	Momentum	**HS-PS1-2** **HS-PS1-7**	Moles and Stoichiometry	**HS-LS1-2**	Cells
HS-PS4-1 **HS-PS4-2** **HS-PS4-3** **HS-PS4-4** **HS-PS4-5**	Waves	**HS-PS3-1** **HS-PS3-2** **HS-PS3-3**	Energy	**HS-PS1-3** **HS-PS3-2**	Intermolecular Forces and Gas Laws	**HS-LS1-4**	Cell Cycle
HS-PS1-1 **HS-PS3-5** **HS-ESS1-3**	Atomic Theory & Periodic Table of Elements	**HS-ESS1-4** **HS-PS2-4**	Circular Motion	**HS-PS1-5** **HS-PS1-6** **HS-PS1-7**	Chemical Equilibrium and Aqueous Chemistry	**HS-LS1-3** **HS-LS1-5** **HS-LS1-7** **HS-LS2-3**	Photosynthesis/ Cell Respiration
HS-PS1-1 **HS-PS1-8**	Electron Behavior	**HS-PS1-1** **HS-PS3-5** **HS-ESS1-3**	Atomic Theory	**HS-PS3-1** **HS-PS3-2** **HS-PS3-4** **HS-PS1-4** **HS-ESS2-4** **HS-ESS3-2**	Energetics	**HS-LS3-2** **HS-LS3-3**	Genetics
HS-PS1-1 **HS-PS1-2** **HS-PS1-3** **HS-PS2-6** **HS-PS1-7**	Bonding, Formulae, Nomenclature and Chemical Reactions	**HS-PS2-4** **HS-PS2-5** **HS-PS3-5**	Electricity and Magnetism	**HS-ESS2-2** **HS-ESS2-5** **HS-ESS3-5** **HS-ESS3-6**	Environmental Chemistry	**HS-LS1-1** **HS-LS3-1**	DNA/RNA
HS-PS2-4 **HS-ESS1-1** **HS-ESS1-2** **HS-ESS1-3** **HS-ESS1-4** **HS-ESS1-6**	Astrophysics	**HS-PS4-1** **HS-PS4-2** **HS-PS4-3** **HS-PS4-4** **HS-PS4-5**	Waves				Virus-Bacteria
HS-ESS1-5 **HS-ESS1-6** **HS-ESS2-1** **HS-ESS2-3** **HS-ESS2-4** **HS-ESS3-1** **HS-ESS3-5** **HS-PS3-4**	Geophysics	**HS-PS2-4** **HS-ESS1-1** **HS-ESS1-2** **HS-ESS1-3** **HS-ESS1-4** **HS-ESS1-6**	Astrophysics			**HS-LS2-8** **HS-LS4-1** **HS-LS4-2** **HS-LS4-3** **HS-LS4-4** **HS-LS-4-5** **HS-ESS2-7**	Evolution
HS-PS1-8 **HS-ESS3-2** **HS-ESS3-4**	Nuclear Chemistry	**HS-ESS1-5** **HS-ESS1-6** **HS-ESS2-1** **HS-ESS2-3** **HS-ESS3-1**	Geophysics				
		HS-ESS2-4 **HS-ESS3-5** **HS-PS3-4**	Meteorology & Thermal Physics				
		HS-PS1-8 **HS-ESS3-2** **HS-ESS3-4**	Nuclear Chemistry				

EGR HIGH SCHOOL SCIENCE COURSES

COURSE TITLE	DESCRIPTION	TEXTBOOK/SUPPORT MATERIALS
Integrated Physics and Chemistry	Integrated Physics and Chemistry is an introductory course to investigate the basic principles of physics and chemistry. This course is designed for students who need a less mathematical and more hands-on approach to the physical sciences.	Physics, Pearson/Prentice Hall and open source and online reading materials
Physics	Physics is an introductory course to the basic principles of Newtonian and modern physics in using Algebra.	Physics, Pearson/Prentice Hall
Physics Honors	This course covers the same principles and concepts as presented in Physics, but the pace and depth of mathematical analysis is much greater.	Physics: Principles and Problems, Glencoe
AP Physics	AP Physics C is a college level course that covers Newtonian physics including the use of Calculus.	Halliday and Resnick: Fundamentals of Physics 10th Edition
Biology	This beginning course uses a conceptual approach to explain key concepts in biology. There is an emphasis on cell biology, genetics, and the biochemistry of living things.	Glencoe Science Biology, National Geographic, Glencoe CK-12 Flexbook
Biology Honors	This course covers the same principles and concepts as presented in Biology, but the pace and depth of inquiry is much greater.	Glencoe Science Biology, National Geographic, Glencoe CK-12 Flexbook
AP Biology	AP Biology is an advanced level biology course. It is designed to be equivalent to a first year college biology course.	Open Stax AP Biology (online) Campbell and Reece 8th ed.
IB Biology HL (2 year)	IB (HL) Biology is a two-year course designed to provide students an in-depth study of the relationship of structure, function and interaction within and between all biological systems.	Pearson HL IB Biology Inthinking.net
Chemistry	This is an introductory course in theories and concepts of modern chemistry.	Open source and online reading materials only
Pre-AP/IB Chemistry	The Pre-AP/IB Chemistry class is faster paced and more rigorous compared to the previous honors class in order to better prepare students for college level courses such as AP Chemistry and IB Chemistry SL	Open source and online reading materials only
IB Chemistry SL	The IB chemistry (SL) course combines academic study with the acquisition of practical and investigational skills through the experimental approach. Students examine the chemical principles that form the basis of physical and biological systems through the core content and develop their skills designing experiments, analyzing data, and drawing conclusions from experimental data.	IB In Thinking, IB Questionbank, Specific Probeware, IB Chemistry SL Textbook
AP Chemistry	AP Chemistry is the equivalent to a college course usually taken by chemistry majors during their first year of college.	Chemistry by Raymond Chang, McGraw-Hill, 11th edition, 2014
Adv. Projects in Physics and Engineering	Basic physics concepts looked at from an advanced engineering level.	Open source and online reading materials only
Environmental Science	This course explores the many aspects of the environment and our influence on our environment through multiple scientific disciplines and perspectives.	Open source and online reading materials only
Anatomy and Physiology	This course focuses on the structures of the human body, what/where they are, how they function, came to be, and compare to other organisms	Essentials of Anatomy & Physiology, Pearson/ Prentice Hall; Open Source & Online Reading Materials
Forensics and Genetics	In this course students will investigate aspects of forensic science involving the inspection of physical, chemical, and biological items of evidence.	Forensic Science for High School (Kendall/ Hunt); Open Source & Online Reading Materials

EGR HIGH SCHOOL SCIENCE PATHWAYS

	9th	10th	11th	12th
Path for students enrolled in Algebra in 9th grade	Integrated Physics and Chemistry (IPC)	Chemistry	Biology	Science Elective
Path for students enrolled in a math course beyond Algebra in the 9th grade	Physics Physics Honors	Chemistry Pre-AP/IB Chemistry Honors	Biology Biology Honors AP Biology	Science Elective
Path for students who enroll in the IB Diploma Programme	Physics Physics Honors	Chemistry Pre-AP/IB Chemistry Honors	IB Chemistry SL	Biology Biology Honors AP Biology
	Physics Physics Honors	Chemistry Pre-AP/IB Chemistry Honors	IB Biology HL A	IB Biology HL B

GRADUATION REQUIREMENTS FOR SCIENCE
1.0 credit in Biology 1.0 credits in Physics or Chemistry 1.0 credit in any Science **3.0 Total Science Credits Required**

SCIENCE ELECTIVES
Advance Projects in Engineering Anatomy and Physiology Forensics and Genetics Environmental Science AP Biology AP Chemistry AP Physics IB Chemistry SL

INTEGRATED PHYSICS AND CHEMISTRY

UNIT TOPIC	UNIT DESCRIPTION	ENGINEERING AND LABS	MSS/NGSS STANDARDS
Measurement and All Motion	This unit discusses basic issues in measurement, including the metric system and uncertainty. It introduces and refines types of motion including linear and circular motions. It refines concepts of velocity and acceleration.	Length measurement methods and associated tools (paces, tape measure, meter stick, ruler, caliper, micrometer, laser/sonic devices) Motion Sensor Lab Centripetal Force Lab	HS-PS2-4
Forces	Basic introduction to Newton's laws and applications. Includes calculations of weight and discussion of inertial reference frames.	3rd Law balloon rockets	HS-PS2-1
Energy and Momentum	This unit introduces the conservation of linear momentum and the impulse momentum theorem. Applications include collisions.	Car Crash Project HS-PS-2-3 (could do egg drop challenge i.e. build an egg catcher… Windmill/Rubber band Car/ Machine Project)	HS-PS2-2 HS-PS2-3 HS-PS3-1 HS-PS3-2 HS-PS3-3
Electricity and Magnetism	Introduction to topics in electricity and magnetism including; static electricity, electrical magnetic force, electric current, voltage, and resistance. Analysis of electric circuits and devices will include Ohm's Law calculations. This study will include analysis of electrical technology that utilize electrify and magnetic forces.	Electronic Circuits Design Kits End of Unit Project Build a Simple Motor Lab	HS-PS2-4 HS-PS2-5 HS-PS3-5
Waves	Mathematical representations of frequency, wavelength and wave speed. Transfer and storage of information. Interactions between waves and matter. EM radiation and wave particle duality.	Dangers of Radiation Project	HS-PS4-1 HS-PS4-2 HS-PS4-3 HS-PS4-4 HS-PS4-5
Atomic Theory & Periodic Table of Elements	In this unit, students investigate the atom, beginning with the development of atomic theory. They learn about charges, the effects of these charges, and properties of elements. These properties are related to the Periodic Table of Elements and students use the Periodic Table to make predictions about the properties of elements based on location on the periodic table.	Modeling matter lab box prediction, Bean bag isotope lab, Matter lab	HS-PS1-1 HS-PS3-5 HS-ESS1-3
Electron Behavior	Students will predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms. Students will explore periodic trends.	Flame test lab, periodic trends lab, Colorimetry lab	HS-PS1-1 HS-PS1-8
Bonding, Formulae, Nomenclature and Chemical Reactions	In this unit, students investigate the different ways atoms bond with other atoms. This includes the study of ionic and molecular compounds along with metallic and covalent network structures. Students will mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.	Types of Reaction Lab	HS-PS1-1 HS-PS1-2 HS-PS1-3 HS-PS2-6 HS-PS1-7
Astrophysics	Topics include cosmology and the life cycle of stars. Examples include the big bang, light spectra, distant galaxies, composition of objects in the universe.	Space research project exoplanets	HS-PS2-4 HS-ESS1-1 HS-ESS1-2 HS-ESS1-3 HS-ESS1-4 HS-ESS1-6
Geophysics	Introduction to topics in physical geology. Internal and surface processes, thermal convection of matter, carbon cycling and effects, water and its geological effects. Climate and weather, convection, heat transfer, 2nd law of thermodynamics, greenhouse effect.	Thermal Lab/Solar Earth Cooker Newton's Law of Cooling	HS-ESS1-5 HS-ESS1-6 HS-ESS2-1 HS-ESS2-3 HS-ESS2-4 HS-ES3-1 HS-ESS3-5 HS-PS3-4
Nuclear Chemistry	In this unit, students look closely at the nucleus, the different ways it can change, and the results of those changes. This understanding is then applied to natural phenomena like radioactive dating and the composition of stars.	Skittle half-life simulation lab Energy Project	HS-PS1-8 HS-ESS3-2 HS-ESS3-4

PHYSICS AND PHYSICS HONORS

UNIT TOPIC	UNIT DESCRIPTION	ENGINEERING AND LABS	MSS/NGSS STANDARDS
Measurement	This unit discusses basic issues in measurement, including the metric system and uncertainty.	Length measurement methods and associated tools (paces, tape measure, meter stick, ruler, caliper, micrometer, laser/sonic devices)	
Linear Motion	Introduction to kinematics. Measuring, computing and interpreting accelerations, velocity and displacement. Emphasis on problem solving and introducing the skills to apply mathematical descriptions to real world situations.	Motion Sensor Lab	
Forces	Basic introduction to Newton's laws and applications. Includes calculations of weight and discussion of inertial reference frames. Vector applications for Honors Physics.	Second Law with Air track 3rd Law balloon rockets	HS-PS2-1
Momentum	This unit introduces the conservation of linear momentum and the impulse momentum theorem. Applications include collisions.	Car Crash Project HS-PS-2-3 (Could do egg drop challenge i.e. build an egg catcher)	HS-PS2-2 HS-PS2-3
Energy	Conservation of Energy, power and work energy theorems.	Windmill/Rubber band Car/ Machine Project HS-PS3-3	HS-PS3-1 HS-PS3-2 HS-PS3-3
Circular Motion	This unit introduces centripetal acceleration and forces, universal gravitation and Kepler's laws and satellite motion.	Centripetal Force Lab Kepler's 3 Laws Modeling Lab	HS-ESS1-4 HS-PS2-4
Atomic Theory	In this unit, students investigate the atom, beginning with the development of atomic theory. They learn about charges, the effects of these charges, and properties of elements. These properties are related to the Periodic Table of Elements and students use the Periodic Table to make predictions about the properties of elements based on location on the periodic table.	Modeling matter lab box prediction, Bean bag isotope lab, Matter lab	HS-PS1-1 HS-PS3-5 HS-ESS1-3
Electricity and Magnetism	Introduction to topics in electricity and magnetism including; static electricity, electrical magnetic force, electric current, voltage, and resistance. Analysis of electric circuits and devices will include Ohm's Law calculations. This study will include analysis of electrical technology that utilize electrify and magnetic forces.	End of unit project Build a Simple Motor Lab	HS-PS2-4 HS-PS2-5 HS-PS3-5
Waves	Mathematical representations of frequency, wavelength and wave speed. Transfer and storage of information. Interactions between waves and matter. EM radiation and wave particle duality.	Dangers of Radiation Project	HS-PS4-1 HS-PS4-2 HS-PS4-3 HS-PS4-4 HS-PS4-5
Astrophysics	Topics include cosmology and the life cycle of stars. Examples include the big bang, light spectra, distant galaxies, composition of objects in the universe.	Space research project exoplanets	HS-PS2-4 HS-ESS1-1 HS-ESS1-2 HS-ESS1-3 HS-ESS1-4 HS-ESS1-6
Geophysics	Introduction to topics in physical geology. Internal and surface processes, thermal convection of matter, carbon cycling and effects, water and its geological effects.	Thermal Lab/Solar Earth Cooker	HS-ESS1-5 HS-ESS1-6 HS-ESS2-1 HS-ESS2-3 HS-ESS3-1
Meteorology & Thermal Physics	Climate and weather, convection, heat transfer, 2nd law of thermodynamics, greenhouse effect.	Newton's Law of Cooling HS-PS3-4	HS-ES2-4 HS-ESS3-5 HS-PS3-4
Nuclear Chemistry	In this unit, students look closely at the nucleus, the different ways it can change, and the results of those changes. This understanding is then applied to natural phenomena like radioactive dating and the composition of stars.	Skittle half-life simulation lab Energy Project	HS-PS1-8 HS-ESS3-2 HS-ESS3-4

AP® PHYSICS C: MECHANICS

About the Advanced Placement Program® (AP®)

The Advanced Placement Program® has enabled millions of students to take college-level courses and earn college credit, advanced placement, or both, while still in high school. AP® Exams are given each year in May. Students who earn a qualifying score on an AP Exam are typically eligible to receive college credit and/or placement into advanced courses in college. Every aspect of AP course and exam development is the result of collaboration between AP teachers and college faculty. They work together to develop AP courses and exams, set scoring standards, and score the exams. College faculty review every AP teacher's course syllabus.

AP Physics Program

The AP Program offers four physics courses.

AP Physics 1 is a full-year course that is the equivalent of a first-semester introduction college course in algebra-based physics.

AP Physics 2 is a full-year course, equivalent to a second-semester introductory college course in physics. The course covers fluid mechanics; thermodynamics; electricity and magnetism; optics; and quantum, atomics, and nuclear physics.

AP Physics C: Mechanics is a half-year course equivalent to a semester-long, introductory calculus-based college course. It covers kinematics; Newton's laws of motion; work, energy, and power; systems of particles and linear momentum; circular motion and rotation; and oscillations and gravitation.

AP Physics C: Electricity and Magnetism, a half-year course following Physics C: Mechanics, is equivalent to a semester-long, introductory calculus-based college course and covers electrostatics; conductors, capacitors, and dielectrics; electric circuits; magnetic fields; and electromagnetism.

AP Physics C: Mechanics Course Overview

AP Physics C: Mechanics is equivalent to a one-semester, calculus-based, college-level physics course, especially appropriate for students planning to specialize or major in physical science or engineering. The course explores topics such as kinematics; Newton's laws of motion; work, energy and power; systems of particles and linear momentum; circular motion and rotation; and oscillations and gravitation. Introductory differential and integral calculus is used throughout the course.

LABORATORY REQUIREMENT

AP Physics C: Mechanics should include a hands-on laboratory component comparable to a semester-long introductory college-level physics laboratory. Students should spend a minimum of 20 percent of instructional time engaged in hands-on laboratory work. Students ask questions, make observations and predictions, design experiments, analyze data, and construct arguments in a collaborative setting, where they direct and monitor their progress. Each student should complete a lab notebook or portfolio of lab reports.

PREREQUISITE

Students should have taken or be concurrently taking calculus.

AP Physics C: Mechanics Course Content

The AP Physics C: Mechanics course applies both differential and integral calculus and provides instruction in each of the following six content areas:

- Kinematics
- Newton's laws of motion
- Work, energy and power
- Systems of particles and linear momentum
- Circular motion and rotation
- Oscillations and gravitation

Learning Objectives for Laboratory and Experimental Situations

Students establish lines of evidence and use them to develop and refine testable explanations and predictions of natural phenomena. Focusing on these disciplinary practices and experimental skills enables teachers to use the principles of scientific inquiry to promote a more engaging and rigorous experience for AP Physics C: Mechanics students. Such practices or skills require students to

- Design experiments
- Observe and measure real phenomena
- Organize, display, and critically analyze data
- Analyze sources of error and determine uncertainties in measurement
- Draw inferences from observations and data
- Communicate results, including suggested ways to improve experiments and proposed questions for further study

A minimum of 20 percent of instructional time is devoted to hands-on and inquiry-based laboratory investigations.

AP® PHYSICS C: MECHANICS

AP Physics C: Mechanics Exam Structure

AP PHYSICS C: MECHANICS EXAM: 1 HOUR, 30 MINUTES

Assessment Overview

The AP Physics C: Mechanics Exam includes questions posed in a laboratory or experimental setting. Questions assess understanding of content as well as experimental skills. The exam may also include questions that overlap several major topical areas or questions on miscellaneous topics such as identification of vectors and scalars, vector mathematics, or graphs of functions.

Students will be allowed to use a four-function, scientific, or graphing calculator on the entire AP Physics C: Mechanics and AP Physics C: Electricity and Magnetism Exams. Scientific or graphing calculators (including the approved graphing calculators listed at www.collegeboard.org/ap/calculators) cannot have any unapproved features or capabilities.

Format of Assessment

Section I: Multiple Choice | 35 Questions | 45 Minutes | 50% of Exam Score

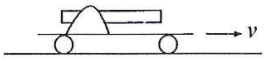
- Individual Questions
- Questions in Sets

Section II: Free Response | 3 Questions | 45 Minutes | 50% of Exam Score

- Laboratory Based
- Discrete Questions

AP PHYSICS C : MECHANICS SAMPLE EXAM QUESTIONS

Sample Multiple-Choice Question



(a) $\frac{Mv}{m}$

(b) $\frac{(M+m)v}{m}$

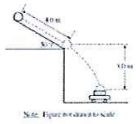
(c) $\frac{(M-m)v}{m}$

(d) $\frac{mv}{M}$

(e) $\frac{mv}{(M-m)}$

Correct Answer: B

Sample Free-Response Question



(a) On the figure below, draw and label the forces (not components) acting on the ball at their points of application as it rolls along the roof.

(b) Calculate the force due to friction acting on the ball as it rolls along the roof. If you need to draw anything other than what you have shown in part (a) to assist in your solution, use the space below. Do NOT add anything to the figure in part (a).

(c) Calculate the linear speed of the center of mass of the ball when it reaches the bottom edge of the roof.

(d) A wagon containing a box is at rest on the ground below the roof so that the ball falls a vertical distance of 3.0 m and lands and sticks in the center of the box. The total mass of the wagon and the box is 12 kg. Calculate the horizontal speed of the wagon immediately after the ball lands in it.

Educators: apcentral.collegeboard.org/apphysicscmechanics

Students: apstudent.collegeboard.org/apphysicscmechanics

CollegeBoard

00558-044 (Updated December 2016)

CHEMISTRY

UNIT TOPIC	UNIT DESCRIPTION	ENGINEERING AND LABS	MSS/NGSS STANDARDS
Atomic Theory & Periodic Table of Element	In this unit, students investigate the atom, beginning with the development of atomic theory. They learn about charges, the effects of these charges, and properties of elements. These properties are related to the Periodic Table of Elements and students use the Periodic Table to make predictions about the properties of elements based on location on the periodic table.	Modeling matter lab activities, Bean bag isotope lab, Matter lab	HS-PS1-1 HS-PS3-5 HS-ESS1-3
Nuclear Chemistry and Electron Behavior	In this unit, students look closely at the nucleus, the different ways it can change, and the results of those changes. This understanding is then applied to natural phenomena like radioactive dating and the composition of stars. Students will also predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms. Students will explore periodic trends.	Flame test lab, periodic trends lab, Colorimetry lab, Van Andel Stars Project	HS-ESS1-1 HS-ESS1-3 HS,PS1-1 HS-PS1-8
Bonding, Formulae, Nomenclature and Chemical Reactions	In this unit, students investigate the different ways atoms bond with other atoms. This includes the study of ionic and molecular compounds along with metallic and covalent network structures. Students will mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.	Design a rocket fuel delivery system to launch a pipet rocket, types of chemical reactions, Conservation of matter lab, Ionic vs. covalent substance property lab	HS-PS1-1 HS-PS1-2 HS-PS1-3 HS-PS2-6 HS-PS1-7
Moles and Stoichiometry	In this unit, students investigate the mathematical relationship between reactants and products in chemical reactions. This investigation includes using patterns in familiar reactions to predict other reactions as well as using mathematical modeling to make predictions about quantities.	Design an airbag engineering project, Empirical formula lab, Nail lab, Limiting Reactants Lab	HS-PS1-2 HS-PS1-7
Intermolecular Forces and Gas Laws	In this unit, students will investigate and model the different intermolecular forces as well as the properties that can be attributed to these forces. They will relate molecular geometry to properties. Students will investigate the kinetic theory, particularly with the behavior of gases. When studying gases, they investigate the relationship between the pressure, temperature, and volume of a gas and the consequences when any of those factors are changed.	IMF Lab, Stem IMF lab, Gas laws inquiry lab, Collection of butane over water	HS-PS1-3 HS-PS3-2
Chemical Equilibrium and Aqueous Chemistry	In this unit, students continue their investigation of chemical reactions, beginning with a study of factors affecting the rate of reaction. They are introduced to the idea of reversible reactions, the concept of equilibrium, and work with Le Chatelier's principle. Finally, students investigate acids and bases in society.	Rate of reaction lab, Acids and bases, Titration, Le Chatelier's Lab	HS-PS1-5 HS-PS1-6 HS-PS1-7
Energetics	In this unit, students investigate the energy in chemical reactions. They learn about endo and exothermic reactions, calorimetry, and the effects of energy changes on Earth's systems	Candle lab, Burning of a nut, Unknown metal lab	HS-PS3-1 HS-PS3-2 HS-PS3-4 HS-PS1-4 HS-ESS2-4 HS-ESS3-2
Environmental Chemistry	In this unit, students apply their understanding of chemistry to Earth systems. Particularly, they investigate the role of chemistry in climate change. Included in their study is an investigation into possible solutions for human impacts on the environment.		HS-ESS2-2 HS-ESS2-5 HS-ESS3-5 HS-ESS3-6

PRE AP/IB CHEMISTRY

UNIT TOPIC	UNIT DESCRIPTION	ENGINEERING AND LABS	MSS/NGSS STANDARDS
Atomic Theory & Periodic Table of Element	In this unit, students investigate the atom, beginning with the development of atomic theory. They learn about charges, the effects of these charges, and properties of elements. These properties are related to the Periodic Table of Elements and students use the Periodic Table to make predictions about the properties of elements based on location on the periodic table.	Modeling matter lab activities, Bean bag isotope lab, Matter lab	HS-PS1-1 HS-PS3-5 HS-ESS1-3
Nuclear Chemistry and Electron Behavior	In this unit, students look closely at the nucleus, the different ways it can change, and the results of those changes. This understanding is then applied to natural phenomena like radioactive dating and the composition of stars. Students will also predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms. Students will explore periodic trends.	Flame test lab, periodic trends lab, colorimetry lab, Van Andel stars project, Nuclear Project	HS-ESS1-1 HS-ESS1-3 HS,PS1-1 HS-PS1-8
Bonding, Formulae, Nomenclature and Chemical Reactions	In this unit, students investigate the different ways atoms bond with other atoms. This includes the study of ionic and molecular compounds along with metallic and covalent network structures. Students will mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.	Design a rocket fuel delivery system to launch a pipet rocket, types of chemical reactions, Conservation of matter lab, Ionic vs covalent substance property lab	HS-PS1-1 HS-PS1-2 HS-PS1-3 HS-PS2-6 HS-PS1-7
Moles and Stoichiometry	In this unit, students investigate the mathematical relationship between reactants and products in chemical reactions. This investigation includes using patterns in familiar reactions to predict other reactions as well as using mathematical modeling to make predictions about quantities.	Design an airbag engineering project, Empirical formula lab, Nail lab, Limiting Reactants Lab	HS-PS1-2 HS-PS1-7
Intermolecular Forces and Gas Laws	In this unit, students will investigate and model the different intermolecular forces as well as the properties that can be attributed to these forces. They will relate molecular geometry to properties. Students will investigate the kinetic theory, particularly with the behavior of gases. When studying gases, they investigate the relationship between the pressure, temperature, and volume of a gas and the consequences when any of those factors are changed.	IMF Lab, Stem IMF lab, Gas laws inquiry lab, Collection of butane over water	HS-PS1-3 HS-PS3-2
Chemical Equilibrium and Aqueous Chemistry	In this unit, students continue their investigation of chemical reactions, beginning with a study of factors affecting the rate of reaction. They are introduced to the idea of reversible reactions, the concept of equilibrium, and work with Le Chatelier's principle. Finally, students investigate acids and bases in society.	Rate of reaction lab, Acids and bases, Titration, Le Chatelier's Lab	HS-PS1-5 HS-PS1-6 HS-PS1-7
Energetics	In this unit, students investigate the energy in chemical reactions. They learn about endo and exothermic reactions, calorimetry, and the effects of energy changes on Earth's systems	Candle lab, Burning of a nut, Unknown metal lab	HS-PS3-1 HS-PS3-2 HS-PS3-4 HS-PS1-4 HS-ESS2-4 HS-ESS3-2
Environmental Chemistry	In this unit, students apply their understanding of chemistry to Earth systems. Particularly, they investigate the role of chemistry in climate change. Included in their study is an investigation into possible solutions for human impacts on the environment.		HS-ESS2-2 HS-ESS2-5 HS-ESS3-5 HS-ESS3-6

AP® CHEMISTRY

About the Advanced Placement Program® (AP®)

The Advanced Placement Program® has enabled millions of students to take college-level courses and earn college credit, advanced placement, or both, while still in high school. AP Exams are given each year in May. Students who earn a qualifying score on an AP Exam are typically eligible, in college, to receive credit, placement into advanced courses, or both. Every aspect of AP course and exam development is the result of collaboration between AP teachers and college faculty. They work together to develop AP courses and exams, set scoring standards, and score the exams. College faculty review every AP teacher's course syllabus.

AP Chemistry Course Overview

The AP Chemistry course provides students with a college-level foundation to support future advanced course work in chemistry. Students cultivate their understanding of chemistry through inquiry-based investigations, as they explore topics such as: atomic structure, intermolecular forces and bonding, chemical reactions, kinetics, thermodynamics, and equilibrium.

LABORATORY REQUIREMENT

This course requires that 25 percent of the instructional time engages students in lab investigations. This includes a minimum of 16 hands-on labs (at least six of which are inquiry based), and it is recommended that students keep a lab notebook throughout.

RECOMMENDED PREREQUISITES

Students should have successfully completed a general high school chemistry course and Algebra II.

AP Chemistry Course Content

The key concepts and related content that define the AP Chemistry course and exam are organized around underlying principles called the Big Ideas. They encompass core scientific principles, theories, and processes that cut across traditional boundaries and provide a broad way of thinking about the particulate nature of matter underlying the observations students make about the physical world. The following are Big Ideas:

- The chemical elements are the building blocks of matter, which can be understood in terms of the arrangements of atoms.
- Chemical and physical properties of materials can be explained by the structure and the arrangement of atoms, ions, or molecules and the forces between them.
- Changes in matter involve the rearrangement and/or reorganization of atoms and/or the transfer of electrons.
- Rates of chemical reactions are determined by details of the molecular collisions.
- The laws of thermodynamics describe the essential role of energy and explain and predict the direction of changes in matter.
- Bonds or attractions that can be formed can be broken. These two processes are in constant competition, sensitive to initial conditions and external forces or changes.

Science Practices

Students establish lines of evidence and use them to develop and refine testable explanations and predictions of natural phenomena. Focusing on these disciplinary practices enables teachers to use the principles of scientific inquiry to promote a more engaging and rigorous experience for AP Chemistry students. Such practices require that students:

- Use representations and models to communicate scientific phenomena and solve scientific problems;
- Use mathematics appropriately;
- Engage in scientific questioning to extend thinking or to guide investigations within the context of the AP course;
- Plan and implement data collection strategies in relation to a particular scientific question;
- Perform data analysis and evaluation of evidence;
- Work with scientific explanations and theories; and
- Connect and relate knowledge across various scales, concepts, and representations in and across domains.

Inquiry-Based Investigations

Twenty-five percent of instructional time is devoted to inquiry-based laboratory investigations. Students ask questions, make observations and predictions, design experiments, analyze data, and construct arguments in a collaborative setting, where they direct and monitor their progress.

AP® CHEMISTRY

AP Chemistry Exam Structure

AP CHEMISTRY EXAM: 3 HOURS 15 MINUTES

Assessment Overview

Exam questions are based on learning objectives, which combine science practices with specific content. Students learn to

- Solve problems mathematically — including symbolically;
- Design and describe experiments;
- Perform data and error analysis
- Explain, reason, or justify answers; and
- Interpret and develop conceptual models.

Students have a periodic table of the elements and a formula and constants chart to use on the entire exam. In addition, students may use a scientific or graphing calculator on the free-response section.

Format of Assessment

Section I: Multiple Choice: 60 Questions | 1 Hour, 30 Minutes | 50% of Exam Score

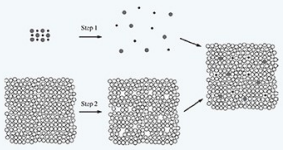
- Discrete items
- Items in sets
- A calculator is not permitted on Section I

Section II: Free Response: 7 Questions | 1 Hour, 45 Minutes | 50% of Exam Score

Three long- and four short-answer questions. The seven questions ensure the assessment of the following skills: experimental design, quantitative/qualitative translation, analysis of authentic lab data and observations to identify patterns or explain phenomena, creating or analyzing atomic and molecular views to explain observations, and following a logical/analytical pathway to solve a problem.

AP CHEMISTRY SAMPLE EXAM QUESTIONS

Sample Multiple-Choice Question



The dissolution of an ionic solute in a polar solvent can be imagined as occurring in three steps, as shown in the figure at left. In step 1, the separation between ions in the solute is greatly increased, just as will occur when the solute dissolves in the polar solvent. In step 2, the polar solvent is expanded to make spaces that the ions will occupy. In the last step, the ions are inserted into the spaces in the polar solvent. Which of the following best describes the enthalpy change, ΔH, for each step?

(A) All three steps are exothermic.

(B) All three steps are endothermic.

(C) Steps 1 and 2 are exothermic, and the final step is endothermic.

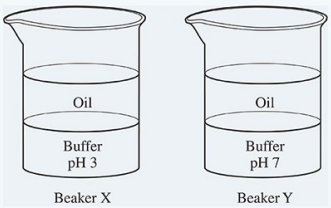
(D) Steps 1 and 2 are endothermic, and the final step is exothermic.

Correct Answer: D

Sample Free-Response Question: Analyzing Lab Data and Observations

$$\underset{yellow}{HIn(aq)} + H_2O(l) \rightleftarrows \underset{blue}{In^-(aq)} + H_3O^+(aq)$$

The indicator HIn is a weak acid with a pK_a value of 5.0. It reacts with water as represented in the equation above. Consider the two beakers below. Each beaker has a layer of colorless oil (a nonpolar solvent) on top of a layer of aqueous buffer solution. In beaker X, the pH of the buffer solution is 3, and in beaker Y, the pH of the buffer solution is 7. A small smount of HIn is placed in both beakers. The mixtures are stirred well, and the oil and water layers are allowed to separate.



(A) What is the predominant form of HIn in the aqueous buffer in beaker Y, the acid form or the conjugate base form? Explain your reasoning.

(B) In beaker X, the oil layer is yellow, whereas in beaker Y, the oil layer is colorless. Explain these observations in terms of both acid-base equilibria and interparticle forces.

Educators: apcentral.collegeboard.org/apchemistry

Students: apstudent.collegeboard.org/apchemistry

CollegeBoard

00558-023 (Updated January 2017)

IB DP SUBJECT BRIEF: CHEMISTRY - STANDARD LEVEL

International Baccalaureate Diploma Programme Subject Brief

Sciences:

Chemistry—Standard level

First assessments 2016 – Last assessments 2022

The IB Diploma Programme (DP) is a rigorous, academically challenging and balanced programme of education designed to prepare students aged 16 to 19 for success at university and life beyond. The DP aims to encourage students to be knowledgeable, inquiring, caring and compassionate, and to develop intercultural understanding, open-mindedness and the attitudes necessary to respect and evaluate a range of viewpoints. Approaches to teaching and learning (ATL) within the DP are deliberate strategies, skills and attitudes that permeate the teaching and learning environment. In the DP students develop skills from five ATL categories: thinking, research, social, self-management and communication.

To ensure both breadth and depth of knowledge and understanding, students must choose at least one subject from five groups: 1) their best language, 2) additional language(s), 3) social sciences, 4) experimental sciences, and 5) mathematics. Students may choose either an arts subject from group 6, or a second subject from groups 1 to 5. At least three and not more than four subjects are taken at higher level (240 recommended teaching hours), while the remaining are taken at standard level (150 recommended teaching hours). In addition, three core elements—the extended essay, theory of knowledge and creativity, action, service—are compulsory and central to the philosophy of the programme.

These IB DP subject briefs illustrate four key course components.
I. Course description and aims
II. Curriculum model overview
III. Assessment model
IV. Sample questions

I. Course description and aims

Chemistry is an experimental science that combines academic study with the acquisition of practical and investigational skills. Chemical principles underpin both the physical environment in which we live and all biological systems. Chemistry is often a prerequisite for many other courses in higher education, such as medicine, biological science and environmental science.

Both theory and practical work should be undertaken by all students as they complement one another naturally, both in school and in the wider scientific community. The DP chemistry course allows students to develop a wide range of practical skills and to increase facility in the use of mathematics. It also allows students to develop interpersonal and information technology skills, which are essential to life in the 21st century.

By studying chemistry students should become aware of how scientists work and communicate with each other. While the scientific method may take on a wide variety of forms, it is the emphasis on a practical approach through experimental work that characterizes the subject. Teachers provide students with opportunities to develop manipulative skills, design investigations, collect data, analyse results and evaluate and communicate their findings.

Through the overarching theme of the nature of science, the aims of the DP chemistry course are to enable students to:

1. appreciate scientific study and creativity within a global context through stimulating and challenging opportunities
2. acquire a body of knowledge, methods and techniques that characterize science and technology
3. apply and use a body of knowledge, methods and techniques that characterize science and technology
4. develop an ability to analyse, evaluate and synthesize scientific information
5. develop a critical awareness of the need for, and the value of, effective collaboration and communication during scientific activities
6. develop experimental and investigative scientific skills including the use of current technologies
7. develop and apply 21st century communication skills in the study of science
8. become critically aware, as global citizens, of the ethical implications of using science and technology
9. develop an appreciation of the possibilities and limitations of science and technology
10. develop an understanding of the relationships between scientific disciplines and their influence on other areas of knowledge.

II. Curriculum model overview

Component	Recommended teaching hours
Core	**95**
1. Stoichiometric relationships	13.5
2. Atomic structure	6
3. Periodicity	6
4. Chemical bonding and structure	13.5
5. Energetics/thermochemistry	9
6. Chemical kinetics	7
7. Equilibrium	4.5
8. Acids and bases	6.5
9. Redox processes	8
10. Organic chemistry	11
11. Measurement and data processing	10

IB DP SUBJECT BRIEF: CHEMISTRY - STANDARD LEVEL

Option (choice of one out of four)	**15**
A. Materials	15
B. Biochemistry	15
C. Energy	15
D. Medicinal chemistry	15
Practical scheme of work	**40**
Prescribed and other practical activities	20
Individual investigation (internally assessed)	10
Group 4 project	10

The group 4 project

The group 4 project is a collaborative activity where students from different group 4 subjects, within or between schools, work together. It allows for concepts and perceptions from across disciplines to be shared while appreciating the environmental, social and ethical implications of science and technology. It can be practically or theoretically based and aims to develop an understanding of the relationships between scientific disciplines and their influence on other areas of knowledge. The emphasis is on interdisciplinary cooperation and the scientific processes.

III. Assessment model

It is the intention of this course that students are able to fulfill the following assessment objectives:

1. Demonstrate knowledge and understanding of:
   - facts, concepts, and terminology
   - methodologies and techniques
   - communicating scientific information.
2. Apply:
   - facts, concepts, and terminology
   - methodologies and techniques
   - methods of communicating scientific information.
3. Formulate, analyse and evaluate:
   - hypotheses, research questions and predictions
   - methodologies and techniques
   - primary and secondary data
   - scientific explanations.
4. Demonstrate the appropriate research, experimental, and personal skills necessary to carry out insightful and ethical investigations.

Assessment at a glance

Type of assessment	Format of assessment	Time (hours)	Weighting of final grade (%)
External		3	80
Paper 1	30 multiple-choice questions (Core)	0.75	20
Paper 2	Short answer and extended response questions (Core)	1.25	40
Paper 3	Data- and practical-based questions, plus short answer and extended response questions on the option	1	20
Internal		10	20
Individual investigation	Investigation and write-up of 6 to 12 pages	10	20

IV. Sample questions

- What is the total number of atoms in 0.50 mol of 1,4-diaminobenzene, $H_2NC_6H_4NH_2$?
  A. 16.0×10^{23}
  B. 48.0×10^{23}
  C. 96.0×10^{23}
  D. 192.0×10^{23}

  (Avogadro's constant (L or N_A) = 6.0×10^{23} mol^{-1}.) (Paper 1)
- Many automobile manufacturers are developing vehicles that use hydrogen as a fuel.
  1. Suggest why such vehicles are considered to cause less harm to the environment than those with internal combustion engines.
  2. Hydrogen can be produced from the reaction of coke with steam: $C(s)+2H_2O(g) \rightarrow 2H_2(g)+CO_2(g)$

  Using information from section 12 of the data booklet, calculate the change in enthalpy, ΔH, in kJ mol^{-1}, for this reaction. (Paper 2)

About the IB: For over 40 years the IB has built a reputation for high-quality, challenging programmes of education that develop internationally minded young people who are well prepared for the challenges of life in the 21st century and able to contribute to creating a better, more peaceful world.

For further information on the IB Diploma Programme, and a complete list of DP subject briefs, visit: ***http://www.ibo.org/diploma/****.*

Complete subject guides can be accessed through the IB online curriculum centre (OCC) or purchased through the IB store: ***http://store.ibo.org****.*

For more on how the DP prepares students for success at university, visit: ***www.ibo.org/recognition*** *or email:* ***recognition@ibo.org****.*

BIOLOGY AND BIOLOGY HONORS

UNIT TOPIC	UNIT DESCRIPTION	ENGINEERING AND LABS	MSS/NGSS STANDARDS
Introduction--Characteristics of Life	Students will investigate the characteristics of life, measurement in biology, and microscopy.	Daphnia HR & drugs,	HS-LS1-2
Ecology	In this unit, students will investigate the ecological principles of conservation biology, population ecology, community ecology, and biodiversity. This will include populations, carrying capacity, and the flow of matter and energy.	Travelling Nitrogen Lessons of the Kaibab EcoJar	HS-LS2-4 HS-LS2-1 HS-LS2-2 HS-LS2-6 HS-LS2-7 HS-LS4-6 HS-ESS2-6 HS-ESS3-3
Chemistry of Life/ Biochemistry	In this unit students create a model to cycling of carbon in the environment, investigate the chemistry of water, the role of enzymes, and discuss the roles of different biological macromolecules.	Identification of Biomolecules in Food, Water?, Catalase Testing Organics--Biochemistry (Crime Lab)	HS-LS1-6 HS-LS2-5
Cells	In this unit students investigate cell membrane structure and function with a focus on transport of molecules across a semipermeable membrane. Students explore organelle function as it relates to the overall function of cellular and overall system function.	Construct a plasma membrane Gummy Bear Osmosis	HS-LS1-2
Cell Cycle	In this unit students investigate mitotic division of cells to create models of cell division as it explain to issue of tissue growth, repair and organisms asexual reproduction Students will explore surface area to volume ratio.	Observe prepared slides of allium roots Nutrient agar cell size lab Osmosis diffusion of an artificial cell (dialysis tube)	HS-LS1-4
Photosynthesis Cell Respiration	In this unit students will focus on the transfer of energy occurring in cells - both the capture of it from the environment and the release of in internally. Students will explore factors that influence both processes and how they are related to each other.	Leaf disk lab BTB/Exercise Lab	HS-LS1-3 HS-LS1-5 HS-LS1-7HS-LS2-3
Genetics	Students will investigate the principles of genetics including monohybrid and dihybrid crosses, codominance, incomplete dominance, genetic disorders, pedigree analysis, and karyotyping.	Dragon genetics Pedigree Analysis	HS-LS3-2 HS-LS3-3
DNA/RNA	In this unit, students will investigate the structure and function of DNA and RNA including discovery of, replication, transcription, translation, and connections to heredity.	CHONPS (Transcript/Translate) lab	HS-LS1-1 HS-LS3-1
Virus-Bacteria	In this unit, students will explore the structure, function, and applications/connections to humans for bacteria and viruses.	Tracking the Plague Antimicrobial resistance lab S. marcescens Lab	
Evolution	In this unit students will explore evolutionary biology through investigations focusing on coevolution, speciation, natural selection, cladistics, evidence for evolution, and mechanisms of evolution.		HS-LS2-8 HS-LS4-1 HS-LS4-2 HS-LS4-3 HS-LS4-4 HS-LS-4-5 HS-ESS2-7

AP® BIOLOGY

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AP Biology Course Overview

AP Biology is an introductory college-level biology course. Students cultivate their understanding of biology through inquiry-based investigations as they explore the following topics: evolution, cellular processes — energy and communication, genetics, information transfer, ecology, and interactions.

LABORATORY REQUIREMENT

This course requires that 25 percent of the instructional time will be spent in hands-on laboratory work, with an emphasis on inquiry-based investigations that provide students with opportunities to apply the science practices.

PREREQUISITE

Students should have successfully completed high school courses in biology and chemistry.

AP Biology Course Content

The course is based on four Big Ideas, which encompass core scientific principles, theories, and processes that cut across traditional boundaries and provide a broad way of thinking about living organisms and biological systems. The following are Big Ideas:

- The process of evolution explains the diversity and unity of life.
- Biological systems utilize free energy and molecular building blocks to grow, to reproduce, and to maintain dynamic homeostasis.
- Living systems store, retrieve, transmit, and respond to information essential to life processes.
- Biological systems interact, and these systems and their interactions possess complex properties.

Science Practices

Students establish lines of evidence and use them to develop and refine testable explanations and predictions of natural phenomena. Focusing on these disciplinary practices enables teachers to use the principles of scientific inquiry to promote a more engaging and rigorous experience for AP Biology students. Such practices require that students:

- Use representations and models to communicate scientific phenomena and solve scientific problems;
- Use mathematics appropriately;
- Engage in scientific questioning to extend thinking or to guide investigations within the context of the AP course;
- Plan and implement data collection strategies in relation to a particular scientific question;
- Perform data analysis and evaluation of evidence;
- Work with scientific explanations and theories; and
- Connect and relate knowledge across various scales, concepts, and representations in and across domains.

Inquiry-Based Investigations

Twenty-five percent of instructional time is devoted to hands-on laboratory work with an emphasis on inquiry-based investigations. Investigations require students to ask questions, make observations and predictions, design experiments, analyze data, and construct arguments in a collaborative setting, where they direct and monitor their progress.

AP® BIOLOGY

AP Biology Exam Structure

AP BIOLOGY EXAM: 3 HOURS

Assessment Overview

Exam questions are based on learning objectives, which combine science practices with specific content. Students learn to

- Solve problems mathematically — including symbolically
- Design and describe experiments and analyze data and sources of error
- Explain, reason, or justify answers with emphasis on deeper, conceptual understanding
- Interpret and develop conceptual models

Due to the increased emphasis on quantitative skills and application of mathematical methods in the questions, students are allowed to use simple four-function calculators (with square root) on the entire exam. Students also receive a formula list as part of their testing materials.

Format of Assessment

Section I: Multiple Choice | 69 Questions | 1 Hour, 30 Minutes | 50% of Exam Score

Multiple-Choice: 63 Questions

- Discrete Questions
- Questions in sets

Grid-In: 6 Questions

- Discrete Questions
- Questions integrate biology and mathematical skills

Section II: Free Response | 8 Questions | 1 Hour, 30 Minutes (includes 10-minute reading period) | 50% of Exam Score

- Long Free Response (2 questions, one of which is lab or data-based)
- Short Free Response (6 questions, each requiring a paragraph-length argument/response)

AP BIOLOGY SAMPLE EXAM QUESTIONS

Sample Multiple-Choice Question

Two flasks with identical medium containing nutrients and glucose are inoculated with yeast cells that are capable of both anaerobic and aerobic respiration. Culture 1 is then sealed to prevent fresh air from reaching the culture; culture 2 is loosely capped to permit air to reach the culture. Both flasks are periodically shaken.

*Which of the following best **predicts** which culture will contain more yeast cells after one week, and most accurately **justifies** that prediction?*

A. Culture 1, because fresh air is toxic to yeast cells and will inhibit their growth

B. Culture 1, because fermentation is a more efficient metabolic process than cellular respiration

C. Culture 2, because fresh air provides essential nitrogen nutrients to the culture

D. Culture 2, because oxidative cellular respiration is a more efficient metabolic process than fermentation.

Correct Answer: D

Sample Grid-In Question

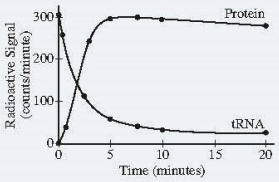
The data below demonstrate the frequency of tasters and non-tasters in an isolated population at Hardy-Weinberg equilibrium. The allele for non-tasters is recessive.

How many of the tasters in the population are heterozygous for tasting?

Tasters	Non-Tasters
8235	4328

Sample Short Free-Response Question

The role of tRNA in the process of translation was investigated by the addition of tRNA with attached radioactive leucine to an in vitro translation system that included mRNA and ribosomes. The results are shown by the graph.



*In a **short paragraph**, describe how this figure justifies the claim that the role of tRNA is to carry amino acids that are then transferred from the tRNA to growing polypeptide chains.*

Educators: apcentral.collegeboard.org/apbiology

Students: apstudent.collegeboard.org/apbiology

CollegeBoard

00558-020 (Updated January 2017)

IB DP SUBJECT BRIEF: BIOLOGY - HIGHER LEVEL

International Baccalaureate Diploma Programme Subject Brief

Sciences:

Biology—Higher level

First assessments 2016 – Last assessments 2022

The IB Diploma Programme (DP) is a rigorous, academically challenging and balanced programme of education designed to prepare students aged 16 to 19 for success at university and life beyond. The DP aims to encourage students to be knowledgeable, inquiring, caring and compassionate, and to develop intercultural understanding, open-mindedness and the attitudes necessary to respect and evaluate a range of viewpoints. Approaches to teaching and learning (ATL) within the DP are deliberate strategies, skills and attitudes that permeate the teaching and learning environment. In the DP students develop skills from five ATL categories: thinking, research, social, self-management and communication.

To ensure both breadth and depth of knowledge and understanding, students must choose at least one subject from five groups: 1) their best language, 2) additional language(s), 3) social sciences, 4) experimental sciences, and 5) mathematics. Students may choose either an arts subject from group 6, or a second subject from groups 1 to 5. At least three and not more than four subjects are taken at higher level (240 recommended teaching hours), while the remaining are taken at standard level (150 recommended teaching hours). In addition, three core elements—the extended essay, theory of knowledge and creativity, action, service—are compulsory and central to the philosophy of the programme.

These IB DP subject briefs illustrate four key course components.

I. Course description and aims
II. Curriculum model overview
III. Assessment model
IV. Sample questions

I. Course description and aims

Biology is the study of life. The vast diversity of species makes biology both an endless source of fascination and a considerable challenge. Biologists attempt to understand the living world at all levels from the micro to the macro using many different approaches and techniques. Biology is still a young science and great progress is expected in the 21st century. This progress is important at a time of growing pressure on the human population and the environment.

By studying biology in the DP students should become aware of how scientists work and communicate with each other. While the scientific method may take on a wide variety of forms, it is the emphasis on a practical approach through experimental work that characterizes the sciences. Teachers provide students with opportunities to design investigations, collect data, develop manipulative skills, analyse results, collaborate with peers and evaluate and communicate their findings.

Through the overarching theme of the nature of science, the aims of the DP biology course are to enable students to:

1. appreciate scientific study and creativity within a global context through stimulating and challenging opportunities
2. acquire a body of knowledge, methods and techniques that characterize science and technology
3. apply and use a body of knowledge, methods and techniques that characterize science and technology
4. develop an ability to analyse, evaluate and synthesize scientific information
5. develop a critical awareness of the need for, and the value of, effective collaboration and communication during scientific activities
6. develop experimental and investigative scientific skills including the use of current technologies
7. develop and apply 21st century communication skills in the study of science
8. become critically aware, as global citizens, of the ethical implications of using science and technology
9. develop an appreciation of the possibilities and limitations of science and technology
10. develop an understanding of the relationships between scientific disciplines and their influence on other areas of knowledge.

II. Curriculum model overview

Component	Recommended teaching hours
Core	**95**
1. Cell biology	15
2. Molecular biology	21
3. Genetics	15
4. Ecology	12
5. Evolution and biodiversity	12
6. Human physiology	20
Additional higher level	**60**
7. Nucleic acids	9
8. Metabolism, cell respiration and photosynthesis	14
9. Plant biology	13
10. Genetics and evolution	8
11. Animal physiology	16

IB DP SUBJECT BRIEF: BIOLOGY - HIGHER LEVEL

Option (Choice of one out of four)	**25**
A. Neurobiology and behaviour	25
B. Biotechnology and bioinformatics	25
C. Ecology and conservation	25
D. Human physiology	25
Practical scheme of work	**60**
Prescribed and other practical activities	40
Individual investigation	10
Group 4 project	10

The group 4 project

The group 4 project is a collaborative activity where students from different group 4 subjects, within or between schools, work together. It allows for concepts and perceptions from across disciplines to be shared while appreciating the environmental, social and ethical implications of science and technology. It can be practically or theoretically based and aims to develop an understanding of the relationships between scientific disciplines and their influence on other areas. The emphasis is on interdisciplinary cooperation and the scientific processes

III. Assessment model

It is the intention of this course that students are able to fulfill the following assessment objectives:

1. Demonstrate knowledge and understanding of:
   - facts, concepts, and terminology
   - methodologies and techniques
   - communicating scientific information.
2. Apply:
   - facts, concepts, and terminology
   - methodologies and techniques
   - methods of communicating scientific information.
3. Formulate, analyse and evaluate:
   - hypotheses, research questions and predictions
   - methodologies and techniques
   - primary and secondary data
   - scientific explanations.
4. Demonstrate the appropriate research, experimental, and personal skills necessary to carry out insightful and ethical investigations.

Assessment at a glance

Type of assessment	Format of assessment	Time (hours)	Weighting of final grade (%)
External		4.5	80
Paper 1	40 multiple-choice questions	1	20
Paper 2	Data-based, short answer and extended response questions	2.25	36
Paper 3	Data-based, short answer and extended response questions	1.25	24
Internal		10	20
Individual investigation	Investigation and write-up of 6 to 12 pages	10	20

IV. Sample questions

- Membrane proteins of mice cells were marked with green and membrane proteins of human cells were marked with red. The cells were fused together. What would be seen after two hours? (Paper 1)

- The species is the basis for naming and classifying organism.
  - Explain how new species can emerge by
    - directional selection
    - disruptive selection
    - polyploidy.
  - Outline the advantages to scientists of the binomial system for naming species.
  - Describe the use of dichotomous keys for the identification of specimens. (Paper 2)

- Brain death is a clinical diagnosis based on the absence of neurological function, with a known irreversible cause of coma.
  - Explain a named method to assess brain damage.
  - Distinguish between a reflex arc and other responses by the nervous system.
  - Describe the events that occur in the nervous system when something very hot is touched. (Paper 3)

About the IB: For over 40 years the IB has built a reputation for high-quality, challenging programmes of education that develop internationally minded young people who are well prepared for the challenges of life in the 21st century and able to contribute to creating a better, more peaceful world.

For further information on the IB Diploma Programme, and a complete list of DP subject briefs, visit: ***http://www.ibo.org/diploma/****.*

Complete subject guides can be accessed through the IB online curriculum centre (OCC) or purchased through the IB store: ***http://store.ibo.org****.*

For more on how the DP prepares students for success at university, visit: ***www.ibo.org/recognition*** *or email:* ***recognition@ibo.org****.*

ADVANCED PROJECTS IN PHYSICS AND ENGINEERING

UNIT TOPIC	UNIT DESCRIPTION	ENGINEERING AND LABS	MSS/NGSS STANDARDS
Engineering Tools and Measurements	Students will learn to use various building and measurement tools used by engineers. This unit will also include engineering measurement methods and standards.	Survey Lab	
Linear Motion	Introduction to kinematics. Measuring, computing and interpreting accelerations, velocity and displacement. Emphasis on problem solving and introducing the skills to apply mathematical descriptions to real world situations.	Car Ramp Project	HS-ESS1-4 HS-PS2-4
Forces	Basic introduction to Newton's laws and applications. Includes extensive use of free-body vector diagrams to solve real world problems.	Parachute Project	HS-PS2-1
Projectiles	Introduction to 2-d kinematics. Measuring, computing and interpreting object acceleration, velocity and displacements in the both vertical and horizontal which are under the influence of gravity and air resistance . Emphasis on problem solving and introducing the skills to apply mathematical descriptions to real world situations.	Launcher Project	HS-ESS1-4 HS-PS2-4
Energy	Students will learn conservation of energy, power and work energy theorems. Students will design and build working mechanical devices and measure efficiency. Students will design and build working mechanical devices and measure efficiency.	Roller Coaster/Self Propelled Cars	HS-PS3-1 HS-PS3-2 HS-PS3-3
Torque and Rotation	This unit introduces centripetal acceleration and forces, rotational motion and torque. Students will design and build working rotational devices and measure torque and efficiency.	Torque and Spinning Toys	HS-ESS1-4 HS-PS2-4
Fluid Power and Hydraulics	Students will learn basic fluid physics including Pascal's laws and hydraulic power applications.	Fluid Power Project	HS-PS2-1 HS-PS2-6
Mechanical Waves and Sound	Mathematical representations of frequency, wavelength and wave speed. Interactions between waves and matter.	Musical Instrument Project	HS-PS4-1
Optics/Light	Mathematical representations of frequency, wavelength and wave speed. Transfer and storage of information. Interactions between waves and matter. EM radiation and wave particle duality.	Build Optical Device	HS-PS4-3 HS-PS4-4.
Electricity and Magnetism Final Project	Introduction to topics in electricity and magnetism including; static electricity, electrical magnetic force, electric current, voltage, and resistance. Analysis of electric circuits and devices will include Ohm's Law calculations. This study will include analysis of electrical technology that utilize electrify and magnetic forces.	Build Electromagnetic device	HS-PS2-5 HS-PS3-1

ANATOMY AND PHYSIOLOGY

UNIT TOPIC	UNIT DESCRIPTION	ENGINEERING AND LABS	MSS/NGSS STANDARDS
Characteristics of Life & Feedback	Students will learn: processes/characteristics of life; In particular students learn and investigate homeostasis	Feedback/Homeostasis Lab	HS-LS1-3 HS-LS3-3
Organization of Body	Students will learn: anatomical terms related to directions and organization, the levels of organization within the body, and a general overview of the systems present	Produce Person	HS-PS2-6 HS-LS1-2 HS-LS1-1
Histology	Students will learn: the various types of tissues present in the body and how their structure relates to function	Tissue Engineering, Microscopy	HS-LS1-2 HS-ETS1-2.
Integumentary System	Students will learn: components of system (skin and accessory structures), functions of the layers, how/why skin is colored, and how the system is interdependent with other systems		HS-LS2-8 HS-LS1-4 HS-LS3-3 HS-LS4-4
Skeletal System	Students will learn: microscopic to macroscopic structure of bones, how bones grow/adapt, various classifications of joints, and the types of movements produced.	Design a bone/join Joint dissection	HS-LS1-4 HS-LS3-3 HS-PS2-6
Muscular System	Students will learn: how muscles are organized/ structured at various levels, the process of and what influences contraction, and how muscles are fueled.	Fatigue	HS-LS1-6 HS-LS1-7 HS-LS2-3 HS-LS4-4
Nervous System	Students will learn: types of tissue present in the system; how nerves send conduct impulses	Brain dissection	HS-LS1-4
Senses	Students will learn: the types of sensory receptors in the body, the difference between special and general senses, options to look more into eyes, nose, ears, mouth	Eye dissection	
Circulatory System	Students will learn: Differences between veins and arteries, the structure of the heart, cardiac cycle and output	Cardiac Output Heart dissection	HS-LS4-4

ENVIRONMENTAL SCIENCE

UNIT TOPIC	UNIT DESCRIPTION	ENGINEERING AND LABS	MSS/NGSS STANDARDS	
Introduction & Sustainability	This unit explores the fundamental properties of environmental science including sustainability. The unit will include some aspects of the history of environmental science, explorations into different aspects of the environment, sustainable decision making, and stakeholders involved in environmental issues.	Hetch Hetchy Debate...Sustainable Island	HS-ESS3-1 HS-ESS3-2 HS-ESS3-3 HS-ESS3-6	
Biodiversity, Biomes, & Conservation Ecology	Principles of conservation ecology are explored including biomes, keystone species, population & community ecology along with management strategies for ecosystem management such as edge effects and changing environments	Park or Zoo Design & Enrichment Project	HS-ESS2-6 HS-ESS3-1 HS-ESS3-3 HS-LS2-1 HS-LS2-2	HS-LS2-4 HS-LS2-6 HS-LS4-5 HS-LS4-6
Resource Management--Forestry/Ag/ Fisheries	Exploring various resources that have a biological connection such as agriculture, forestry, and fisheries to apply concepts of the Tragedy of the Commons, wise use of resources, and limitations and impacts of resource management decisions.	Various Projects and Focus may include forestry projects, paper industry, recycling, prairie restoration, soils labs, or fisheries	HS-ESS3-1 HS-ESS3-2 HS-ESS3-3 HSESS3-6	
Earth Resources--Mining & Fossil Fuels	Mining exploration and fossil fuels will be explored through activities and lessons that highlight the processes of exploration, extraction, processing, and products. This unit continues to highlight sustainable methods, economic factors and understandings, market influences, and conservation.	Cookie Mining...Oil Exploration...	HS-ESS2-2 HS-ESS2-4 HS-ESS3-1 HS-ESS3-2	HS-ESS3-3 HS-ESS3-4 HS-ESS3-6
Earth Resources--Air & Water	Water resources are investigated for drinking water, surface water, and groundwater. The unit also connects to water quality and pollution. Geological principles such as river dynamics, water supply infrastructure, clean water, and wastewater treatment are integrated into this unit. Further connections to air quality and air pollutants will be discussed.	Water quality lab, River systems [stream dynamics]	HS-ESS2-2 HS-ESS2-4 HS-ESS2-5 HS-ESS3-1	HS-ESS3-3 HS-ESS3-4 HS-ESS3-6
Pollution	This is an extension unit to connect water, air, mineral, and fossil fuel resources for different types of pollutants, contaminant transport, remediation strategies, and engineering solutions	Oil Spill Activity...Contaminant Transport Environmental Chemistry Activity	HS-ESS2-2 HS-ESS2-4 HS-ESS3-1 HS-ESS3-3	HS-ESS3-4 HS-ESS3-5 HS-ESS3-6
Energy Resources--Alt Energy	Energy resources and different alternatives to fossil fuels are explored in this unit. Unit activities will include investigating different energy technologies and energy transfer. Deeper studies will be done through wind turbines including building and testing a small wind turbine to investigate efficiency.	Windmill Project	HS-PS3-1 HS-PS3-3 HS-ESS3-1 HS-ESS3-2 HS-ESS3-3	
Resource Management--Land Use, Urbanization, & Urban Planning	In this unit, aspects of land use and land use planning are explored including SMART growth principles, green transportation, and integrating different green strategies into an urban setting.	City Planning Project	HS-ESS3-1 HS-ESS3-2 HS-ESS3-3 HS-ESS3-4 HS-ESS3-6	
Geologic Hazards & Geophysics	Different geologic hazards impact their surroundings. In this unit various geologic hazards are explored including plate tectonics, volcanoes, tsunamis, mass movement, and other earth processes that influence the environment.	Earthquake labs, volcano labs, mass movement activity	HS-ESS1-5 HS-ESS2-1 HS-ESS2-2	HS-ESS2-3 HS-ESS2-5 HS-ESS3-1
Geological & Ecological Process & Applications Coastal/Dunes-Deserts/Glaciers-Mountains	As a unit, this is a choice section that allows students to investigate various geologic settings and investigate the physical properties of the areas, environmental issues that are specific to those settings, and look at the ecology of that particular region.	Sand Study or Other Projects investigating processes and applications	HS-ESS1-5 HS-ESS2-1 HS-ESS2-2 HS-ESS2-3 HS-ESS2-5	HS-ESS3-1 HS-ESS3-3 HS-ESS3-4 HS-ESS3-5

ENVIRONMENTAL SCIENCE

UNIT TOPIC	UNIT DESCRIPTION	ENGINEERING AND LABS	MSS/NGSS STANDARDS	
Marine Science & Oceanography	Investigations into the processes of the ocean and investigate how humans impact ocean ecosystems		HS-ESS2-1 HS-ESS2-2 HS-ESS2-5 HS-ESS3-1 HS-ESS3-3 HS-ESS3-4	HS-ESS3-5 HS-LS2-1 HS-LS2-2 HS-LS2-4 HS-LS2-6 HS-LS4-6
Meteorology & Climate	This unit includes investigations into basic meteorology terms and concepts, meteorological measurements, interpretations of meteorological data, severe weather and its effect on the environment. The unit also focuses on climatology and studying what impacts local and global climate, interpreting climatological data, and investigating models involving the greenhouse effect.	Weather observations, modeling, and Model UN Debate	HS-ESS2-2 HS-ESS3-1 HS-ESS3-4 HS-ESS3-5 HS-ESS3-6	
Sustainable Design	Students will investigate elements of sustainable design including materials, heating and cooling, energy supply, water use, and other elements that impact the impact of a home on its environment and environmental factors that impact design.	Design a Sustainable Park Visitor Center or Home	HS-ESS3-2 HS-ESS3-2 HS-ESS3-2 HS-ESS3-4 HS-ESS3-6	
Space & Planetary Geology--Environmental Systems	Students will investigate different aspects of astronomy as it connects to Earth's environment, the environment of other planets, planetary geology, exoplanets, and connections to elements that have influenced Earth's history and understanding our place in the universe.	Investigations in planetary geology, mapping, and habitat system design	HS-ESS1-1 HS-ESS1-2 HS-ESS1-3 HS-ESS1-4 HS-ESS1-6	
Geographic Information Systems (GIS)	Using remote sensing data, Google earth, and other aerial techniques to investigate aspects of topography, land use, ecological change, and other environmental connections and applications.	Topographic maps lab...3D topographic features activity...GIS and Landsat image lab	HS-ESS3-3 HS-ESS3-4	
Environmental Engineering	Environmental engineering as a unit allows for specialized investigations into areas of environmental engineering to support the engineering process as it applies to a specific environmental question.	Various investigations into engineering solutions for different environmental problems [such as constructing a dam to control flow rates, solar heating systems, or bridges	HS-ESS3-2 HS-ESS3-3 HS-ESS3-4	
Power of One--Sustainability [Senior Project]	The capstone unit of this project-based course is to create an opportunity for students to investigate an area of personal engagement within the topic of environmental science. The project requires research-based support as well as experimental/engineering process data in support of a student generated claim.	Various environmental science & engineering based research projects--student driven [examples: Solar Cookers, aquaponics, road salt impacts on plants, etc.		

FORENSICS AND GENETICS

UNIT TOPIC	UNIT DESCRIPTION	ENGINEERING AND LABS	MSS/NGSS STANDARDS
Forensic Law	The students will learn the basic differences between criminology and criminalistics.		
Crime Scene	Students will learn to document crime scenes with measurement and photos.		
Evidence	Students will learn the differences between class and individual evidence.		HS-LS3-1 HS-LS3-2
Fingerprinting	Students will learn the techniques of finger-printing, tire tracks, shoe size vs. height, and biometrics.	Fingerprint-Lifted, Dusted and Superglue Fumed Shoe prints Biometrics Tire Tracks and Numbers on Tires	HS-PS1-2 HS-LS3-2
Hair	Students will differentiate between types of human and animal hair.	Animal and Human Hair Scale Testing with nail polish	HS-LS1-4
Fiber	Students will identify the different characteristics of fibers.	Burn Lab for Fibers and Chemical Testing	HS-PS2-6
Drug Analysis	Students will determine the different types of drugs based on lab experiences and the effects of the job.		HS-PS1-2 HS-PS1-5
Glass	Students will analyze different types of glass and look at their fracture patterns.		
Document Forgery	Students will analyze different types of glass and look at their fracture patterns to determine the entry/exit points of bullets in glass.		
Blood Spatter Analysis	Students will look at blood spatter and determine what type of impact, where the shot came from and direction of blood flow based on the cast away patterns.		HS-PS2-3
Genetics	Students will learn the probability of different types of crosses and structure of chromosomes. They will learn about genetic disorders, karyotypes and pedigrees. Students will learn about the newest discoveries in the genetics world. They will also talk about the bioethics that are involved.		HS-LS1-1 HS-LS3-1 HS-LS4-1