Ohio's Science Education

Science High School Syllabi

This section of the Science Education standards includes course syllabi for the most commonly taught high school science courses. There are expanded syllabi for Physical Science and Biology, as these are the two entry level courses mandated by the Ohio Core. The syllabi for the advanced courses are representative of some of courses that might be selected to fulfill the advance science requirement of the Ohio Core.

Biology Syllabus

Course Title:	Biology

Course/Unit Overview

Biology is a high school level course which satisfies the requirements of the Ohio Core Science Graduation Requirements, as required by section 3313.603 of the Ohio Revised Code (ORC). This course investigates the composition, diversity, complexity and interconnectedness of life on Earth. Fundamental concepts of heredity and evolution provide a framework through inquiry-based instruction to explore the living world and its impact on the environment. Students engage in investigations to understand and explain the behavior of living things in a variety of scenarios that incorporate scientific reasoning, analysis, communication skills and real-world applications.

Course Content

Heredity

Clarification for Instruction

DNA provides for both the continuity of traits from one generation to the next and the variation that in time can lead to differences within a species and to entirely new species. Understanding DNA makes possible an explanation of such phenomena as the similarities and differences between parents and offspring, hereditary diseases and the evolution of new species. This understanding also makes it possible for scientists to manipulate genes and thereby create new combinations of traits and new varieties of organisms.

Students should be able to illustrate and explain the structure and function of the DNA (deoxyribonucleic acid) molecule. DNA contains genetic information that is encoded into genes. This information provides instructions for the production of proteins, which are responsible for the characteristics and operation of all living things. Genes occur in different forms called alleles (e.g., gene for pea plant height has two alleles, tall and short). Sometimes there are spontaneous changes that occur in the DNA molecule that are mutations. Mutations may be a source of genetic variation or they may have no impact on the organism. If mutations occur in sex cells, they can be passed on to the next generation. If mutations occur in somatic cells, the functioning of that cell may be affected. If cells are exposed to certain chemicals or radiation, the rate of mutations can increase, possibly leading to cancer. Students understand the fundamentals of Mendelian genetics in order to springboard into the concepts of modern genetics. Concepts of segregation, independent assortment, dominant and recessive traits, sex-linked traits and jumping genes should be explored.

Cellular Genetics

- Mendelian and non-Mendelian genetic mechanisms and inheritance
  - Meiosis
  - Punnett Square
- Structure and function of DNA in cells
  - Relationship of the structure and function of DNA to protein synthesis and the characteristics of an organism
- Genes and their forms
- Mutations
  - Sex and body cells
- Biotechnology

Evolution

Clarification of Instruction

Know what evolutionary change is and how it played out over geological time, they can now turn to its mechanism.

They need to shift from thinking in terms of selection of individuals with a trait to changing proportions of a trait in populations. Knowledge of artificial selection, coming from studies of pedigrees and their own experiments can be applied to natural systems in which selection occurs because of environmental conditions. Students should be familiar with isotopic dating techniques used to determine the actual age of fossils and hence to appreciate that sufficient time may have elapsed for successive changes to have accumulated. Knowledge of DNA contributes to the evidence for life having evolved from common ancestors and provides a plausible mechanism for the origin of new traits.

History should not be overlooked. Learning about Darwin and what led him to the concept of evolution illustrates the interacting roles of evidence and theory in scientific inquiry. Moreover, the concept of evolution provided a framework for organizing new as well as "old" biological knowledge into a coherent picture of life forms.

Evolution and Diversity of Life

- Speciation and biological classification based on molecular evidence
- Variation of organisms within a species due to population genetics and gene frequency
- Diversity and adaption
- Historical development and evolution

Natural Selection and Other Mechanisms of Biological Evolution

- Undirected variation and environmental change
- Genetic drift, immigration, emigration and mutation
- History of life on Earth
    - Development of life on Earth
    - Geologic time
    - Fossils and the rock record

<u>Diversity and Interdependence of Life</u>

Clarification for Instruction

The concept of an ecosystem should bring coherence to the complex array of relationships among organisms and environments that students have encountered. Students' growing understanding of systems in general can suggest and reinforce characteristics of ecosystems: interdependence of parts, feedback, oscillation, inputs and outputs. Stability and change in ecosystems can be considered in terms of variables such as population size, number and kinds of species, and productivity.

Now students have a sufficient grasp of atoms and molecules to link the conservation of matter with the flow of energy in living systems. Energy can be accounted for by thinking of it as being stored in molecular configurations constituted during photosynthesis and released during oxidation. Organisms participate in the cycles of matter and flow of energy to survive and reproduce.

Given abundant resources, populations can increase at rapid rates. But living and non-living factors limit growth, resulting in ecosystems that can remain stable for long periods of time.

Ecosystems

Homeostasis

- Carrying capacity
- Equilibrium and disequilibrium

Energy Flow in Biological and Ecological Systems

Students expand their knowledge of energy flow to the interactions between climate, weather and biomes.

- Molecules in living things pass through food webs and are combined and recombined in different ways.

Note: Food webs, food chains and interactions between organisms within ecosystems are covered in upper elementary school and middle school; therefore they are not appropriate at the high school level.

Cells

The individual cell can be considered as a system itself (single-celled organism) and as part of larger systems, sometimes as part of a multicellular organism, and always as part of an ecosystem.

Clarification for Instruction

- The cell is a system that conducts a variety of functions for the survival of the organism. To maintain this system, materials need to enter and leave the cell through a cell membrane which serves as a boundary between the cell and its environment. Students should be asked to consider the variety of functions cells serve in the organism and how needed materials and information get to and from the cells. It may help students to understand the interdependency of cells if they think of an organism as a community of cells, each of which has some common tasks and some special jobs.
- The cell has specialized parts that perform specific functions. Discussion of what needs to be done in the cell is much more important than memorizing parts of the cell.
- The idea that protein molecules assembled by cells conduct the work that goes on inside and outside the cells in an organism can be learned without going into the biochemical details. It is sufficient for students to know that the molecules involved are different configurations of a few amino acids and that the different shapes of the molecules influence what they do.

Cell Structure and Function

- Structure, function and interrelatedness of cell organelles
  - Nucleus, chromosome, mitochondria, cell membrane, cell wall, cilia, flagella, plastids (chloroplast), ribosomes, endoplasmic reticulum, vacuole, Golgi Apparatus, lysosome, centriole
  - Homeostasis, energy transfers and transformation, transportation of molecules, disposal of wastes, synthesis of new molecules
- Eukaryotic cells and prokaryotic cells
- Viruses
- Internal features of cells and organelles, e.g., folded membranes increase surface area, phospholipids in the cell membrane aid in transporting proteins

Cellular Processes

- Characteristics of life regulated by cellular processes
- Photosynthesis, chemosynthesis, cellular respiration
- Cell division and differentiation
- Cell specialization

Model Curriculum: Instructional Strategies

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Learning Expectations:

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Instructional Resources:

This section will provide resources and examples for teaching the specific science content using inquiry and technological design as the basis. Science must be learned through application, so learning the processes and methods of science must be part of science in Ohio.

- Inquiry and/or technological design-based resources to develop lessons and labs
- Classroom portals to illustrate best practices in the field
- Differentiated learning resources to support the teaching of specific science topics
- Common misconceptions

Physical Science Syllabus

Course Title:	**Physical Science**

Course/Unit Overview

Physical Science is a high school introductory-level course which satisfies Ohio Core requirements (ODE, 2008). It introduces students to key concepts and theories that provide a foundation for further study in other sciences and advanced science disciplines. Physical Science comprises the systematic study of the physical world, as related to chemistry, physics and space science. Students engage in investigations to understand and explain the behavior of nature in a variety of inquiry and design scenarios that incorporate scientific reasoning, analysis, communication skills and real-world applications.

Course Content

Study of Matter

Clarification for Instruction

The study of the composition and transformation of matter constitutes the science discipline called chemistry. Chemistry is foundational to many other science disciplines. A guided study of the composition, properties and behavior of matter helps provide an understanding of how current theoretical models support observations made. Theoretical models explain phenomena and can be applied to real-world examples (hot/cold packs, cooking, medicine, fuel consumption, water treatment).

Elements are arranged in periodic patterns, as in groups (columns) and periods (rows), according to their properties. For example, specific properties allow for differentiation between metals, nonmetals, metalloids, trends in reactivity, and the phases of elements at room temperature. Mastery of the knowledge of these periodic patterns means that a learner is able to begin to use the predictive power of trends in the reactivity and atomic structure of elements to evaluate and apply conditions to various scenarios (theoretical, empirical and real-world).

Chemical reactions follow the law of conservation of matter. This concept helps guide the understanding for balancing chemical equations. It also is helpful when learning that some chemical reactions give off energy (exothermic) and some absorb energy (endothermic), for energy is neither created nor destroyed. The intersection of these concepts provide context for students to apply their knowledge to specific reactions, such as those classified as acid/base reactions. Use of the pH scale adds another level of (visual) support to guide conceptual understanding.

Conceptual understanding about the behavior of electrons can be applied to bonding along an ionic and covalent continuum. The strength of bonds varies. Colligative properties vary. Energy required and produced varies. Complete understanding provides the basis for application to real-world phenomena. For example, fusion is a process that occurs between the nuclei of two atoms and can produce energy. When small particles with great energy combine, they give off greater energy. This fusion process occurs inside stars and releases energy. Understanding this energy process can be applied to larger implications as in *powering* our universe.

Properties of Matter

- Describing Matter
  - Heterogeneous vs. homogeneous
  - Pure substances vs. mixtures
  - Compounds and elements
  - Atoms and molecules
- Change in the number of subatomic particles
  - Ions
  - Isotopes

- Periodic Trends of the Elements
  - Atomic structure
  - Reactivity
  - Metals, nonmetals, metalloids

Reactions of Matter

- Bonding
- Chemical reactions
- Nuclear reactions (fusion)

Forces and Motion

Clarification for Instruction

Distance and time associated with observing moving objects is measured to evaluate, speed, velocity and acceleration. This segment focuses on the connection between motion and various types of forces as related to Newton's laws of motion for linear motion only (two dimensional motion is discussed in later grade levels). Newton's First Law states that when an object has no net force acting on it, it will either be at rest or stay in motion at a constant speed in a straight line. Newton's Second Law states that when an object is accelerating, it means there is net force acting on the object and that net force is equivalent to the mass of the object multiplied by its acceleration. Newton's Third Law states that when a force acts on an object, the object exerts an equal force that acts in the opposite direction of the original force (rotational forces are excluded at this level). Additionally, although frictional force always acts to oppose motion, it is one of the reasons motion is possible in most real-world situations.

This segment includes conceptual as well as mathematical representations of kinetic energy and gravitational potential energy. Thus, mathematical reasoning can be used to evaluate various relationships, both theoretical and real-world (some practical examples are roller coasters, objects on ramps, moving cars, walking and pendulum). In addition, predictive evaluation also can then be applied when comparing both quantities of energy in a system when given appropriate information (mass, height and speed), and how these quantities change with changes in mass, height and speed.

Energy transformations can be traced through more complex systems where individual kinds of energy (e.g., kinetic or gravitational potential, chemical, electrical) may not always be conserved, but that the total amount of all kinds of energy (including thermal, sound, light, kinetic, potential, etc.) is conserved.

Energy is often transported/transferred by waves, which can be reflected, refracted, diffracted, etc. Wave phenomena, as a form of energy, are the foundation for this entire segment. Some waves are disturbances through various kinds of media (sound through air, water waves) by which energy is transferred. The properties of waves depend on the medium/field through which there is propagation or movement. Examples such as Doppler effect provide concrete representations of the behavior of waves and their effects as recognized by human senses. Furthermore, light is more than just what people can detect with their eyes, which it is just one form of electromagnetic radiation, and electromagnetic radiation is the only type of wave that can be propagated in the absence of a medium.

Kinematics (descriptions of motion)

- Displacement
- Speed
- Velocity
- Acceleration

Forces of Nature

- Gravitation
- Electromagnetic
- Nuclear

Dynamics (cause of motion)

- Newton's Laws
  - *Constant velocity*
  - *Objects accelerating*
  - *Opposing, but equal forces – related to momentum*

Energy

- Conservation of energy (using data and calculations)
- Work
- Power

Waves (via light and sound)

- Energy transfer
- Behavior
  - Refraction
  - Reflection
  - Diffraction
  - Interference
  - Doppler Shift

<u>The Universe</u>

Clarification for Instruction

The formation of the elements with atomic mass less than that of iron occurs through the process of fusion in the core of stars. As different elements are fused in the core of a star, the star evolves over time and goes through stages. In the main sequence stage, hydrogen is fused into helium. Following this stage, most stars become red giants. Some stars that are massive enough will end in a supernova explosion, which may leave behind a remnant core (either neutron star or black hole). The supernova explosion creates elements heavier than iron and disperses them into space. Other stars that are not massive enough (like the Sun) will end in a planetary nebula with a white dwarf core at its center. HR-diagrams have been useful in describing these stages and facilitating a more complete picture of stellar evolution. It is a tool that illustrates the relationship between the energy emitted by a star and its surface temperature (color), thus its stage of evolution. The relationship between a star's color and its temperature provides context for a discussion of blackbodies (stars).

Galaxies are gravitationally bound systems that contain hundreds of billions of stars as well as gas and dust. Galaxies can have different shapes and sizes, and contain variable amounts of gas and dust. The shape of the galaxy indicates the relative amount of gas and dust as compared to stars.

Galaxies contribute to the theoretical evidence for the Big Bang theory. Astronomers have observed that most galaxies in the universe are moving away from Earth. This has been measured using redshift. A galaxy's spectrum is shifted to the red end due to its motion away from Earth. Galaxies that are further away are moving faster, meaning that the space between galaxies is expanding. This motion is evidence that supports the Big Bang theory because it indicates that the universe is therefore expanding. Other evidence that supports the Big Bang theory is the discovery of Cosmic Microwave Background Radiation (CMBR). This radio noise is evidence of a hot beginning to the universe, which is consistent with the Big Bang theory. Using radio wave detectors, astronomers have been able to observe background radiation from space which then provides evidence for an original hot expanding universe. Modern technology has allowed scientists to complete various measurements of objects in the universe. For example, the peak wavelength of CMBR is in the microwave part of the electromagnetic spectrum. This has allowed astronomers to find that the temperature of universe is ~3K (Kelvin) which indicates the age of the universe (~14 billion years).

Stars

- Formation; stages of evolution

- Fusion in stars

Galaxies

- Constituents
  - Dust
  - Gas
  - Stars
- Morphology
  - Spiral
  - Elliptical
  - Irregular

Origin of the Universe

- Redshift
- Microwave Background Radiation
- Big Bang theory

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- Common misconceptions

Environmental Science Syllabus

Course Title:	Environmental Science

Course/Unit Overview

Environmental Science is a high school level course which satisfies the Ohio Core advanced science requirements (ODE, 2008). Environmental Science incorporates biology, chemistry, physics and physical geology and introduces students to key concepts, principles and theories within environmental science. Students engage in investigations to understand and explain the behavior of nature in a variety of inquiry and design scenarios that incorporate scientific reasoning, analysis, communication skills and real-world applications.

Course Content

Historical Environmental Issues and Information

This topic explores the background and history of environmental actions and laws. This includes investigations on a local, national and global level.

- Resource use and conservation
- Environmental issues through time
  - Population changes
  - Waste management: sewage, hazardous and solid waste
  - Land use: development, zoning and agriculture (point source and non-point source contamination, thermal pollution)
  - Water: surface and ground water protection, Clean Water Act
  - Air: primary and secondary contamination, greenhouse gases, Clean Air Act
  - Industry changes, permits and regulations (point source and non-point source contamination, thermal pollution)
- Changes in Environmental Law and Regulation in the United States

Patterns and Cycles on Earth

This topic focuses on biogeochemical cycles and the connection to Earth's spheres (hydrosphere, atmosphere, biosphere and lithosphere). This includes an understanding of the cause and effect of climate change.

- Conservation of matter, physical and chemical changes that impact the environment
- Movement of matter and energy through the lithosphere, atmosphere, hydrosphere and biosphere
- Ocean and atmospheric currents, transfer of energy, global climate (including el Niño, la Niña trends)

Concepts and Principles of Environmental Science

The principles of Environmental Science include principles from other science disciplines (such as biology), but are applied to environmental issues.

- Abiotic factors that influence ecosystems
- Ecosystem equilibrium *
- Climate and populations
- Evolution, natural selection, adaptation and sustainability
- Human risk factors

Global Issues

This topic adds to the historical perspective at the beginning of the course, by applying current issues and laws. Developing and using population models, collecting and analyzing water quality data, connecting to real-world, on-going issues (can be local, national or global) students will understand firsthand the issues listed below.

- Human population
- Drinking water quality and availability
- Climate change
- Deforestation
- Waste disposal (solid and hazardous)

Earth's Resources

This topic goes beyond what was part of earlier renewable and nonrenewable energy resources to learn about the effectiveness and efficiency for differing varieties at a local, state, national, and global level. In addition, Earth's resources (abiotic and biotic) as they relate to environmental issues (such as mining) are included.

- Energy resources
  - Renewable and nonrenewable energy sources and efficiency
  - Alternate energy sources and efficiency***
  - Resource availability
  - Mining
- Air (primary and secondary air pollution, greenhouse gases)
- Water (potable water, importance of wetlands, groundwater, hypoxia, eutrophication)**
- Soil (desertification, mass wasting, sediment contamination)

* Performance Based Assessment Task, *Invasive Species*, ODE/Stanford OPAPP can be implemented here
**Performance Based Assessment Task, *Got Fresh Water?*, ODE/Stanford OPAPP can be implemented here
***Performance Based Assessment Task, *Renewable Energy Resources*, ODE/Stanford OPAPP can be implemented here

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Chemistry Syllabus

Course Title:	Chemistry

Course/Unit Overview

Chemistry is a high school level course which satisfies advanced science requirements of the Ohio Core (ODE, 2008). It introduces students to key concepts and theories that provide a foundation for further study in other sciences as well as advanced science disciplines. Chemistry comprises a systematic study of the predictive physical interactions of matter and subsequent events that occur in the natural world. The study of matter through the exploration of classification, its structure and its interactions is how this course is organized. Students engage in investigations to understand and explain the behavior of matter in a variety of inquiry and design scenarios that incorporate scientific reasoning, analysis, communication skills and real-world applications. An understanding of leading theories and how they have informed current knowledge prepares students with higher order cognitive capabilities of evaluation, prediction, and application.

Course Content

Classifying Matter

Clarification for Instruction

Effective communication in science requires students to describe matter using skills which accurately quantify and qualify materials. These skills require students to master using metric prefixes, significant digits, scientific notation, standard units, derived units, error analysis, dimensional analysis, etc. In essence, students are well-versed in communicating findings using numbers to describe and distinguish specific characteristics of various materials with standardized language.

- Scientific measurement and communications
- Distinguishing characteristics of different materials

Structure of Matter

Clarification of Instruction

The changes, and thereby reactions, that matter undergoes are directly connected to the structure of the atoms from which the matter is composed. These changes, which occur at either the atomic level and/or the subatomic level, incur variation in the energy associated with each constituent. Energy changes that occur at the subatomic level require and result in tremendous energy changes. Societal implications for such changes are vast and the study thereof potentially provides students with a broader perspective in which their knowledge is applied to not only immediate experiences, but to global conditions affecting Earth and its future well-being.

- Atomic structure
  - Evolution of atomic models/theory
  - Properties of valence electrons
  - Computations based on number of subatomic particles-atomic number, atomic mass, percent abundance
- Periodic Variation
  - Electron configuration
  - Atomic size, ionization, electronegativity
  - Properties: density, melting point, phase at room temperature, conductivity
- Nuclear changes and reactions
  - Nuclear Stability
  - Nuclear equations (alpha, beta)
  - Radioactive decay
    - Unstable nucleus, nuclear force

- Decay of nucleus (integer level half-life and characteristics of products)
- Fission

Interactions of Matter

Clarification of Instruction

The interactions that matter undergoes can be studied from an intramolecular perspective, as well as an intermolecular perspective (from the intramolecular perspective, students study how atoms come together to form various materials and how those materials respond under various conditions). From the intermolecular perspective, materials behave in varied ways according to characteristic properties. For example, some atoms lose electrons thereby differentiating a material from one which is inert and does not. Some atoms have bonding structures that make materials very strong and therefore useful in situations requiring hard and strong structures. Some materials have atomic structures that only them to they be diffused, while others have high *flow* capacity.

Intramolecular

- Nomenclature
- Chemical Bonding
- Reactions
- Stoichiometry
- Acids/Bases
  - Differentiation between acids and bases
  - Calculation of Hydronium and hydroxide ions
  - Identification of common acid/bases

Intermolecular

- Properties of solids, liquids and gases
- Changes of State (energy consideration of phase changes)
  - Gas
  - Behavior
  - Laws
  - Measuring

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Physical Geology Syllabus

Course Title:	Physical Geology

Course/Unit Overview

Physical Geology is a high school level course which satisfies the Ohio Core advanced science requirements (ODE, 2008). Physical geology incorporates chemistry, physics and environmental science, and introduces students to key concepts, principles and theories within geology. Students engage in investigations to understand and explain the behavior of nature in a variety of inquiry and design scenarios that incorporate scientific reasoning, analysis, communication skills and real-world applications.

Course Content

Part 1

Part 1 of this course begins with the building blocks of the lithosphere, minerals and rocks.

Minerals

The crystalline structure of molecules contributes to its physical properties.

- Atoms, elements and chemical bonding (ionic, covalent, metallic)
- Crystallinity (crystal structure)
- Criteria of a mineral (crystalline solid, occurs in nature, inorganic, defined chemical composition)
- Physical properties of minerals (hardness, luster, cleavage, streak, crystal shape, fluorescence, flammability, magnetism, density/specific gravity, malleability)

Rocks

The characteristics of a rock reflect its geologic history.

Igneous

- Mafic and felsic rocks and minerals
- Intrusive (igneous structures: dikes, sills, batholiths, pegmatites)
- Extrusive (volcanic activity, volcanoes, cinder cones, composite, shield)
- Cooling rate and Bowen's Reaction Series (continuous and discontinuous branches)

Metamorphic

- Pressure, stress, temperature, and compressional forces
- Foliated (regional), non-foliated (contact)
- Parent rock and degrees of metamorphism
- Metamorphic zones (where metamorphic rocks are found)

Sedimentary

- Division of sedimentary rocks and minerals (chemical clastic/physical, organic)
- Depositional environments

Part 2

Part 2 of this course builds upon the individual smaller units of the lithosphere to see how the characteristics and formation of rocks and minerals can be used to determine Earth's history and to understand the varying geologic processes of Earth.

Geologic Time

The history of the Earth is broken up into a hierarchical set of divisions for describing geologic time.

- Relative and absolute age

  Principles to determine relative age
  - Original horizontality, superposition, cross-cutting relationships

Determining absolute age
- Radiometric dating (isotopes, radioactive decay)
- Appropriate applications of radiometric dating (which isotopes to use in which situations, rock types)

- The geologic time scale
  - Comprehending geologic time
  - Climate changes evident through the rock record
  - Fossil record

Plate Tectonics

- Evidence for structure of the Earth
  - Seismic waves, S and P waves, velocities, reflection, refraction of seismic waves
  - Structure of Earth (note: specific layers were part of 8th grade)
    - Lithosphere, Asthenosphere, Mohorovicic discontinuity (Moho)
    - Composition of Earth's core
  - Gravity, magnetism and isostasy
  - Thermal energy (geothermal gradient and heat flow)
- Historical data and observations (note: this would include a review of Continental Drift and Sea-Floor Spreading found in 8th grade)
  - Paleomagnetism and magnetic anomalies
  - Paleoclimatology
- Plate motion (note: introduced in 8th grade)
  - Causes, evidence and measuring of plate motion
  - Characteristics of oceanic and continental plates
  - Relationship of plate movement and geologic events and features

Earth Systems

The Earth is dynamic, continually changing and cycling. There are four basic spheres of Earth: the lithosphere, hydrosphere, atmosphere and biosphere. There is no process or phenomenon that occurs in complete isolation within each sphere; each interacts with another. This section is a culmination of the material from earlier in the course and concentrates on the interaction between the spheres as they relate to geologic processes.

- The Ocean
  - Tides and currents
  - Thermal energy and water density
  - Waves and coastal processes
  - Ocean features (ridges, trenches, island systems, abyssal zone, shelves, slopes, reefs, island arcs, alluvial fans, deltas)
- Surface and ground water *
  - Streams (channels, streambeds, floodplains, cross-bedding)
  - Potable water
  - Wetlands
  - Flood hazards
- Soils
  - Weathering, erosion and mass wasting
- Earth's mineral resources
- Climate and climate change
- Glaciers and glaciation

- Evidence of past glaciers (including features formed through erosion or deposition)
- Glacial deposition and erosion (including features formed through erosion or deposition)
- Data from ice cores
  - How to determine glacial age
  - Historical changes (amounts, locations, particulate matter)
  - Climate changes evidence
  - Fossil record
- Glacial distribution and causes of glaciation
- Types of glaciers - Continental (ice sheets), alpine/valley (piedmont, valley, cirque, ice caps)
- Glacial structure, formation and movement
- Glacial deposition and erosion (including features formed through erosion or deposition)

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Physics Syllabus

Course Title:	Physics

Course/Unit Overview

Physics is a high school level course which satisfies advanced science requirements of the Ohio Core (ODE, 2008). It introduces students to key concepts and theories that provide a foundation for further study in science and scientific literacy. Physics is a systematic study of the predictive physical interactions of matter and subsequent events that occur in the natural world. Students engage in investigations to understand and explain the behavior of nature in a variety of inquiry and design scenarios that incorporate scientific reasoning, analysis, communication skills and real-world applications.

Course Content

<u>Motion in Two Dimensions and Periodic Motion</u>

Clarification for Instruction

One-dimensional to two-dimensional motion, the ideas of displacement, velocity and acceleration that were introduced in Physical Science are developed further in this topic. Simple examples of projectile, oscillating (spring systems, pendulums), and circular motion are used to demonstrate these different types of motion.

- Vectors (two-dimensional)
- Projectile motion
- Circular motion
- Linear and two-dimensional periodic motion

<u>Forces and Two-Dimensional Motion</u>

Clarification for Instruction

Gravitational force acts between all masses and always creates a force of attraction (introduced in Grade 8 and Physical Science). Application of Newton's Universal Law of Gravitation is used to explain how two objects that are gravitationally bound orbit a common center of mass. Incorporating spring forces (in static and cases of oscillatory motion), air resistance and friction are included in this topic. Also included are Newton's laws of motion (for objects in free fall and calculating terminal velocity when air resistance plays a significant role) and the application of Newton's laws of motion to analyze, mathematically describe and predict the effects of forces on the two-dimensional motions of objects. The effect of the gravitational force in producing a two-dimensional orbit around an object can be calculated. Newton's second law which describes the effect of forces on the motion of an object (namely balanced forces result in a constant velocity or no velocity, unbalanced forces) should be used to determine the rate of change in the velocity which is proportional to the net force applied.

Momentum is the product of the mass and the velocity of an object. Since mass is a scalar quantity and velocity is a vector quantity, momentum is a vector quantity. When objects collide, the collision can be either elastic or inelastic. For elastic collisions, both momentum and energy are conserved. For inelastic collisions, only momentum is conserved. The momentum of two objects should be calculated before and after either an elastic or inelastic collision, given the appropriate information. In this topic, one-dimensional and two-dimensional collisions are included. All components of momentum are conserved in collisions, in the absence of external forces (within a closed system).

- Newton's Laws with balanced forces

- Newton's Laws with unbalanced forces
- Momentum, conservation of momentum
- Vectors (one- and two-dimensional)

Energy, energy transformations and energy conservation

Clarification for Instruction

Building on Physical Science (kinetic and gravitational potential energy), two-dimensional mathematical representations will be used for kinetic and potential energy in the context of springs, collisions or circular motion. In a closed system, energy is conserved and can be accounted for; however, in the real world, energy is transformed into unusable forms, generally as thermal energy. Energy transformations and conservation of energy will be evaluated in scenarios that include damped periodic motion, friction and production of thermal energy.

Force acting over a distance is work. Work will change the energy of a system so that when a pendulum is raised, work is done on it to raise the mass and give it gravitational potential energy. Then the pendulum can convert the gravitational potential energy to kinetic energy (motion). Power is the amount of work done in a given amount of time (work over time). Work and power are calculated in systems (e.g., springs, collisions or circular motion).

Energy transformation and conservation will be evaluated and calculated in conduction, convection and radiation (building upon Grade 7 and Physical Science). In any of these processes, the total energy is conserved. (Energy is always conserved.)

- Work and power
- Energy transformation and conservation
- Collisions
- Thermal energy production, friction
- Energy conservation under conduction, convection and radiation

Interactions of energy and matter – waves

Clarification for Instruction

In interactions of energy and matter, energy often travels through matter in the form of waves. To build upon Physical Science, the measurable properties of waves (wavelength, frequency, amplitude) are used to mathematically describe properties of materials (index of refraction, reflectivity).

The behavior of light at an interface between materials with different indices of refraction such as air and glass and air and water also are included in this topic. The laws of reflection and refraction can be used to predict the geometric path of light through thin optical elements using ray diagrams and the location and sizes of images in mirrors, thin lenses and pinholes. The interference of waves through narrow slits and prisms (simple geometries) are calculated.

Observed wavelength of a wave depends upon the relative motion of the source and the observer. The Doppler equation is used to determine the change in wavelength and/or frequency due to the motion of a (sound or light) source or observer.

Note: Basis of redshift has been introduced in Physical Science.

- Wave properties
    - Frequency-wavelength relationship (mathematically)

- Index of refraction, material properties (calculating)
- Speeds (velocities) of waves in different media (calculating)

- Light phenomena (quantitative)
  - Ray diagrams (propagation of light)
  - Snell's Law
  - Law of Reflection (equal angles)
  - Young's Experiment (diffraction)
  - Light colors (absorption, reflection, transmission)
- Doppler effect (quantitative)

Electricity and Magnetism
Clarification for Instruction
The strength of the force between two charges can be calculated. How electricity is produced in a generator (electric charges in motion produce magnetic fields and a changing magnetic field creates an electric field), designing working DC circuits, using resistors, energy source, switches and light bulbs in DC circuits (both parallel and series), measuring the current and voltage in different parts of a simple series and/or parallel circuit with multiple resistors (and/or light bulbs) and Kirchoff's Law also are included in this topic.

Increasing the voltage increases current if the resistance stays the same (use simple resistors, diodes, or LEDs; here, use of nonlinear resistors is excluded). For many materials, current is proportional to the voltage. Ohm's Law states that the voltage is equal to the current times the resistance.

- Coulomb's Law (electrostatic force between two charges)
- Induction (moving magnet through a coil produces electric field)
- Ampere's Law (moving charge or current produces magnetic field)
- Electric generators (relative motion between a conducting coil and a magnet can produce an electric current)
- DC circuits – parallel and series
  - Basics of Kirchoff's Law
- Properties of materials related to the electrical conduction
  - Ohm's Law

Model Curriculum: Instructional Strategies
The model curriculum section will be developed for release in March 2011. This is where science methods, processes and skills will be housed.

Clarification for Instruction:
This will be a more detailed description of each topic. This will help set content limits and depth of knowledge for a specific topic.

Learning Expectations:
This will be the section that outlines what a student should be able to do for each topic. A range of cognitive levels will be represented as well as differing depths of knowledge. This section will integrate the content knowledge with science methods, processes and skills.

Instructional Resources:
This section will provide resources and examples for teaching the specific science content using inquiry and technological design as the basis. Science must be learned through application, so learning the processes and methods of science must be part of science in Ohio.

- Inquiry and/or technological design-based resources to develop lessons and labs
- Classroom portals to illustrate best practices in the field
- Differentiated learning resources to support the teaching of specific science topics
- Common misconceptions