

Draft for

MCPS High School Science

Earth/Space Systems Science Framework

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Earth/Space Systems Curriculum Revision Team

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This draft Framework was created by teachers as a first step in the current revision of the course curriculum. Its purpose is to serve as a vehicle for review, discussion and critique by concerned stakeholders who are encouraged to provide written feedback to the Science Office for specific improvements and changes. Comments will be collected and reviewed and appropriate changes will be made. This will lead to the new course curriculum, which will align with and exceed the Maryland Learning Outcomes.

Frameworks are intended to provide the underlying structure of a course and contain two major components: 1) the Rationale and 2) the Scope and Sequence. The Rationale contains the goal, enduring understandings, content description, and instructional approach description of the course. The Scope and Sequence is a collection of the course indicators. This course Framework will lead to course Blueprints which will describe the “why, what and how” for each unit. Blueprints will lead to the Curriculum Guide which will contain concept maps, model lesson plans, model assessments, and other course resources.

This document can be found online at:

<http://www.montgomeryschoolsmd.org/curriculum/science/>

Earth/Space Systems Science Rationale

Goal

Students in Earth/Space Systems Science understand the dynamic processes of interrelated systems on and inside the Earth and in its surrounding space environment by applying skills in observation and research, utilizing technology and community resources.

Enduring Understandings

1. The Earth/space systems (atmosphere, cryosphere, hydrosphere, geosphere, biosphere, and astrosphere) are distinct but interrelated and governed by physical laws.
2. Problems involving Earth/space systems can be observed and understood through the acquisition, management, and analysis of data gathered from various sources and viewpoints in an environment of team collaboration and individual accountability.
3. Material and energy imbalances within and among Earth/space systems give rise to events over a variety of time scales, some of which have an impact on human activities.
4. Earth/Space Systems Science is continually expanding and changing, as are the methods of viewing and measuring the systems.

Content

Earth/Space Systems Science is organized into six interrelated systems or “spheres”: atmosphere, hydrosphere, cryosphere, geosphere, biosphere, and astrosphere. Matter and energy flow through and among these spheres in ways that are consistent with physical and chemical laws. This flow of matter and energy causes each sphere to change constantly and results in natural events that can be observed and measured. Describing how each sphere is changing over time involves the understanding of past events compared to present conditions. The past and the present are, in turn, used to predict future changes in each sphere and in the Earth/space system as a whole. Earth/space scientists organize their investigation around research themes, bringing together and synthesizing the content of a wide variety of disciplines, collecting and analyzing data from a number of viewpoints and across a number of time scales. They work collaboratively, manipulate large quantities of data, and look for ways to apply technology to the research task. Research themes include local and global climate change, stratospheric ozone depletion, volcanism and earthquakes, circulation of rock in the mantle and core, weathering and erosion of surface materials, severe weather outbreaks, droughts and floods, the cycling of carbon, and the dynamics of other planets and stars. The discovery of additional interconnections among spheres and new ways to observe and measure known interconnections lead to the identification of new research themes.

Instructional Approach

The study of Earth/Space Systems Science occurs in a dynamic learning environment. Resources and information on Earth systems can be gathered from a variety of sources and viewpoints such as direct sampling, arrays of instruments and detectors on the surface, orbiting satellites, and deep-space probes. The students explore several of the interrelated spheres within each broad topic of study. Modules in the course may be interchanged to give teachers flexibility in focusing student’s activities to investigate current natural events. Modules are designed to provide differentiated instruction based on variations in student learning modalities and on the time needed to master course objectives.

Students work in collaborative groups with individual accountability to investigate background materials, participate in scientific experiments, and act as primary researchers. The teacher serves as facilitator or mentor of the research project. Using information and skills from inquiry-based activities within a module, students design a research project using authentic data collected from primary sources. This approach follows the 5E model of engagement, exploration, explanation, extension, and evaluation. Technology is infused into every aspect of the investigative process.

Assessment is frequent, ongoing, and embedded in student learning experiences. Methods of evaluation include self-assessment, peer review, and performance assessment of research products. In each module the final assessment is performance based compared against a rubric designed specifically for that module. Students in the final assessment show mastery in appropriate scientific method, research skills, data management and analysis, writing, applied mathematics, critical thinking skills, and use of technology.

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Earth/Space Systems Science Scope and Sequence

The Scope and Sequence is identified by numbered goals, expectations, and indicators. The indicators from the Maryland State Performance Program Core Learning Goal 1 are shown here. These are used throughout the course. All concept indicators, Goal 2, are addressed by using Goal 1 indicators as the primary vehicles of instruction. Their placement at the beginning of this document does not imply that they are taught first or that they are taught only at the beginning of the course.

Skills and Processes Indicators

The student will:

- HS1.1.1 *recognize that real problems have more than one solution and decisions to accept one over another are made on the basis of many issues.*
- HS1.1.2 *modify or affirm scientific ideas according to accumulated evidence.*
- HS1.1.3 *critique arguments that are based on faulty, misleading data or on the incomplete use of numbers.*
- HS1.1.4 *recognize data that are biased.*
- HS1.1.5 *explain factors that produce biased data (incomplete data, using data inappropriately, conflicts of interest, etc.).*
- HS1.2.1 *identify meaningful, answerable scientific questions.*
- HS1.2.2 *pose meaningful, answerable scientific questions.*
- HS1.2.3 *formulate a working hypothesis.*
- HS1.2.4 *test a working hypothesis.*
- HS1.2.5 *select appropriate instruments and materials to conduct an investigation.*
- HS1.2.6 *identify appropriate methods for conducting an investigation (independent and dependent variables, proper controls, repeat trials, appropriate sample size, etc.).*
- HS1.2.7 *use relationships discovered in the lab to explain phenomena observed outside the laboratory.*
- HS1.2.8 *defend the need for verifiable data.*
- HS1.3.1 *develop and demonstrate skills in using lab and field equipment to perform investigative techniques.*
- HS1.3.2 *recognize safe laboratory procedures.*
- HS1.3.3 *demonstrate safe handling of the chemicals and materials of science.*
- HS1.3.4 *learn the use of new instruments and equipment by following instructions in a manual or from oral direction.*
- HS1.4.1 *organize data appropriately using techniques such as tables, graphs, and webs (for graphs: axes labeled with appropriate intervals, independent and dependent variables on correct axes and appropriate title).*
- HS1.4.2 *analyze data to make predictions, decisions, or draw conclusions.*
- HS1.4.3 *use experimental data from various investigators to validate results.*
- HS1.4.4 *determine the relationships between quantities and develop the mathematical model that describes these relationships.*
- HS1.4.5 *check graphs to determine that they do not misrepresent results.*
- HS1.4.6 *describe trends revealed by data.*

- HS1.4.7 *determine the sources of error that limit the accuracy or precision of experimental results.*
- HS1.4.8 *use models and computer simulations to extend his/her understanding of scientific concepts.*
- HS1.4.9 *use analyzed data to confirm, modify, or reject an hypothesis.*
- HS1.5.1 *demonstrate the ability to summarize data (measurements/observations).*
- HS1.5.2 *explain scientific concepts and processes through drawing, writing, and/or oral communication.*
- HS1.5.3 *use computers and/or graphing calculators to produce the visual materials (tables, graphs, and spreadsheets) that will be used for communicating results.*
- HS1.5.4 *use tables, graphs, and displays to support arguments and claims in both written and oral communication.*
- HS1.5.5 *create and/or interpret graphics. (scale drawings, photographs, digital images, field of view, etc.)*
- HS1.5.6 *read a technical selection and interpret it appropriately.*
- HS1.5.7 *use, explain, and/or construct various classification systems.*
- HS1.5.8 *describe similarities and differences when explaining concepts and/or principles.*
- HS1.5.9 *communicate conclusions derived through a synthesis of ideas.*
- HS1.6.1 *use ratio and proportion in appropriate situations to solve problems.*
- HS1.6.2 *use computers and/or graphing calculators to perform calculations for tables, graphs, or spreadsheets.*
- HS1.6.3 *express and/or compare small and large quantities using scientific notation and relative order of magnitude.*
- HS1.6.3.A *select appropriate units to describe quantities.*
- HS1.6.4 *manipulate quantities and/or numerical values in algebraic equations.*
- HS1.6.5 *judge the reasonableness of an answer.*
- HS1.7.1 *apply the skills, processes, and concepts of the course to societal issues.*
- HS1.7.2 *identify and evaluate the impact of scientific ideas and/or advancements in technology on society.*
- HS1.7.3 *describe the role of science in the development of literature, art, and music.*
- HS1.7.4 *recognize mathematics as an integral part of the scientific process.*
- HS1.7.5 *investigate career possibilities in the various areas of science.*
- HS1.7.6 *explain how development of scientific knowledge leads to the creation of new technology and how technological advances allow for additional scientific accomplishments.*

The following indicators come from MSPP Core Learning Goal 2 (Concepts of Earth/Space Science) and are addressed by using Goal 1 (Skills and Processes) indicators as the primary vehicles of instruction.

Earth/Space Systems Science Concept Indicators

The student will:

HS2.1 *The student will identify and describe techniques used to investigate the universe and Earth.*

- HS2.1.1.1 *describe the purpose and advantage of current tools used to study the universe (i.e., optical and radio telescopes, spectrometers).*
- HS2.1.1.2 *describe the purpose and advantage of current delivery systems used to study the universe (i.e., satellite-based, ground-based, space probe).*
- HS2.1.1.3 *describe the purpose and advantage of current techniques used to study the universe (i.e., imaging, spectroscopy).*
- HS2.1.2.1 *describe the purpose and advantage of current tools used to study the atmosphere, land, and water on Earth (i.e., spectrometers, seismograph; e.g. school-based weather station micronetworks, probeware with remote data collection capability, radiosonde, profiler, flowmeter).*
- HS2.1.2.2 *describe the purpose and advantage of current delivery systems used to study the atmosphere, land, and water on Earth (i.e., satellite-based, ground-based).*
- HS2.1.2.3 *describe the purpose and advantage of current techniques used to study the atmosphere, land, and water on Earth (i.e., imaging, Geographic Information Systems, spectroscopy, Doppler, epicenter location/time-travel graphs).*

HS2.2 *The student will describe natural forces and apply them to the study of Earth/Space Science.*

- HS2.2.1.A *demonstrate the interrelationship of the atmosphere, hydrosphere, cryosphere, geosphere, biosphere, and astrosphere.*
- HS2.2.1.1 *explain the role of Newton's Universal Law of Gravitation in the formation and operation of the universe.*
- HS2.2.1.2 *explain the role of the Big Bang Theory in the formation, structure, and evolution of the Universe.*
- HS2.2.1.3 *explain the role of forces in stellar structure and evolution (i.e., life cycles of stars, stellar systems).*
- HS2.2.1.4 *explain the role of forces in the formation and evolution of our solar system (i.e., Nebular Theory).*
- HS2.2.1.5 *explain the role of Kepler's Laws in the operation of our solar system.*
- HS2.2.1.6 *explain the role and influence of solar phenomena on Earth's systems (i.e., thermonuclear process, sunspot cycle, coronal mass ejection, flares, solar wind, auroras)*
- HS2.2.2.1 *explain the role and interaction of revolution, rotation, and gravity on the Sun-Moon-Earth system (i.e., seasons: change in solar angle, yearly variation in length of day/night, absorption/reflection/scattering of insolation, solstices and equinoxes, rotation/revolution/precession, yearly variation of the Sun's altitude and azimuth).*
- HS2.2.2.2 *explain the role and interaction of revolution, rotation and gravity on eclipses in the*

Sun-Moon-Earth system (i.e., lunar, solar, total, annular).

HS2.2.2.3 *explain the role and interaction of revolution, rotation, and gravity on the relationship between lunar phases and tides.*

HS2.3 *The student will explain how the transfer of energy and matter affect Earth systems.*

HS2.3.1.A *describe ways that atmospheric and oceanic circulation influence each other (e.g., wind-driven currents, monsoon patterns, El Niño, La Niña, North Atlantic Oscillation).*

HS2.3.1.B *describe ways that energy transfer affects the atmosphere and hydrosphere (e.g., microclimates, interaction between land and water surfaces and lowest layers of the atmosphere).*

HS2.3.1.1 *describe ways that energy transfer affects the atmospheric circulation (i.e., conduction, convection, radiation, pressure gradients, general global circulation, Coriolis effect).*

HS2.3.1.2 *describe ways that energy transfer affects the oceanic circulation (i.e., density differences, Coriolis effect).*

HS2.3.2.A *explain how variation in energy transfer affects global phenomena (e.g., mantle convection, seismic activity, volcanism, mountain building).*

HS2.3.2.1 *explain how variation in energy transfer affects global climate change (i.e., radiation, aerosols, particulates, continental movement, El Niño, La Niña).*

HS2.3.2.2 *explain how variation in energy transfer affects global temperature change (i.e., greenhouse gases, sea ice, glaciers, sea level, shifting of biomes, radiative properties of clouds).*

HS2.4 *The student will analyze the dynamic nature of the geosphere.*

HS2.4.1.1 *compare the origin and structure of igneous, metamorphic, and sedimentary rocks using concepts of the structure of matter (i.e., atoms, molecules, isotopes).*

HS2.4.1.2a *compare the physical properties (density, specific gravity, hardness) of common rock-forming mineral groups in igneous, sedimentary, and metamorphic rocks.*

HS2.4.1.2b *compare the chemical composition of common rock-forming mineral groups in igneous, sedimentary, and metamorphic rocks.*

HS2.4.1.3 *compare the origin, texture (grain size, shape), and mineral composition (qualitative and quantitative) of common rock groups.*

HS2.4.2.1 *explain how the transfer of energy causes and controls destructive processes in the rock cycle (i.e., weathering, erosion, subsidence, melting).*

HS2.4.2.2 *explain how the transfer of energy causes and controls constructive processes in the rock cycle (i.e., lithification, deformation, metamorphism, cooling/crystallization, deposition).*

HS2.4.2.3 *explain how the transfer of energy causes and controls landform change (i.e., surface and ground water, glacial processes; e.g., wave action processes, wind-driven processes).*

HS2.4.3.1 *explain changes in Earth's surface using continental drift (i.e., evidences from rock, structure, climate, fossils, jigsaw fit).*

HS2.4.3.2 *explain changes in Earth's surface using sea floor spreading (i.e., evidences from age of sea floor rock, magnetic reversals caused by outer core circulation, seismic*

- activity, volcanism, mountain building, ocean ridges).*
- HS2.4.3.3 *explain changes in Earth's surface using the Theory of Plate Tectonics (i.e., crustal plate composition, mantle circulation, divergent/convergent/ transform fault boundaries, subduction zones, trenches, island arcs, hot spots, island chains, seismic activity, volcanism, mountain building).*

HS2.5 *The student will investigate methods that geologists use to determine the history of Earth.*

- HS2.5.1.A *apply principles of relative dating to events in the history of other objects in our solar system (e.g., superposition of craters, cracks, lava flows).*
- HS2.5.1.1 *apply principles of relative dating to events in Earth's geologic and biologic past (i.e., superposition in rock columns, core samples, unconformities, uniformitarianism, crosscutting relationships, correlation of rock layers, fossils).*
- HS2.5.1.2 *apply principles of absolute dating to events in Earth's geologic and biologic past (e.g., radiometric dating).*
- HS2.5.2 *compare events in Earth's history that have been grouped according to similarities (i.e., geologic time scale and magnitude, era, period, epoch).*
- HS2.5.2.A *correlate major events in Earth history time scale (e.g., appearances of life forms, extinctions, impacts, mountain building, positions of continents).*

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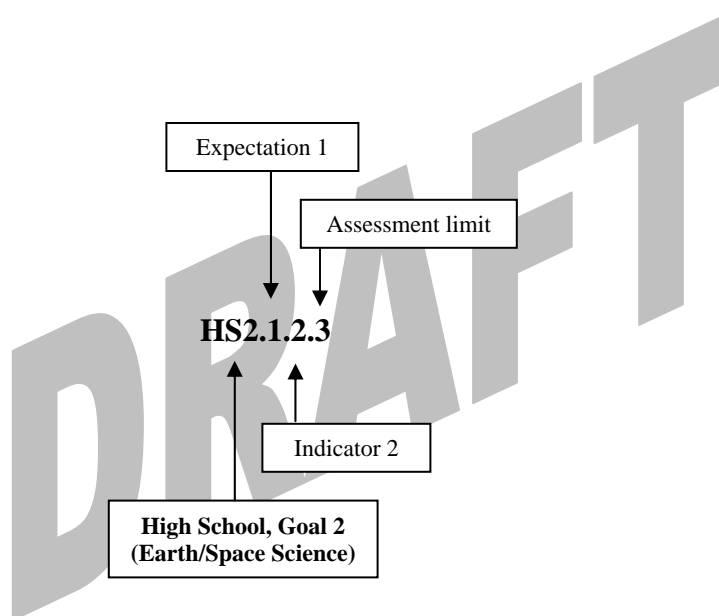
Explanation of Codes

Items that appear in MCPS High School Curriculum documents are numbered according to the sequence

HSG.E.I.A (for example: HS2.1.2.3)

- HS = High School
- G = the goal as it occurs in the MSPP document (1 = Skills and Processes, 2 = Earth Science, 3 = Biology, 4 = Chemistry, 5 = Physics, 6 = Environmental Science)
- E = the expectation; written in italics if it is from the MSPP document
- I = the indicator; written in italics if it is from the MSPP document
- A = the assessment limit or “at least” item written as a number; a Goal 1 item combines the indicator and assessment limit and, therefore, does not have a number in this position; written in italics if it is from the MSPP document

Example



- Additional decimal places refer to MCPS extensions to the HSPP assessment limit or “at least” item.
- Italics identify the wording or intent of the HSPP Core Learning Goal.
- Capital Letters identify MCPS expectations, indicators, or assessment limits that are not found in the MSPP Core Learning Goals. Small letters, such as “a” or “b,” identify a MSPP indicator that is divided into separate MCPS indicators.
- (H) identifies an item that is assessed in Honors level courses.

Maryland School Performance Program Core Learning Goals

Goal 1: Skills and Processes

The student will demonstrate ways of thinking and acting inherent in the practice of science. The student will use the language and instruments of science to collect, organize, interpret, calculate, and communicate information.

Goal 2: Concepts of Earth/Space Science

The student will demonstrate the ability to use scientific skills and processes (Core Learning Goal 1) to explain the physical behavior of the environment, Earth, and the universe.

Goal 3: Concepts of Biology

The student will demonstrate the ability to use the scientific skills and processes (Core Learning Goal 1) and major biological concepts to explain the uniqueness and interdependence of living organisms, their interactions with the environment, and the continuation of life on earth.

Goal 4: Concepts of Chemistry

The student will demonstrate the ability to use scientific skills and processes (Core Learning Goal 1) to explain composition and interactions of matter in the world in which we live.

Goal 5: Concepts of Physics

The student will demonstrate the ability to use scientific skills and processes (Core Learning Goal 1) to explain and predict the outcomes of certain interactions which occur between matter and energy.

Goal 6: Environmental Science

The student will demonstrate the ability to use scientific skills and processes (Core Learning Goal 1) and major environmental science concepts to understand interrelationships of the natural world and to analyze environmental issues and their solutions.