Draft for

MCPS High School Science

Physics Framework

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Physics 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 change. 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.mcps.k12.md.us/curriculum/science/hs/physics.htm

Physics Rationale

Goal

The goal of Physics is to stimulate wonder and awe about the physical world by explaining in detail how and why things happen the way they do using a small set of powerful fundamental principles.

Enduring Understandings

1. Nature to conserves certain inherent properties.
2. Units are a necessary part of measurement and can be used to establish relationships between concepts.
3. Energy is conserved in all closed systems but may be converted from one form to another.
4. Sources of error need to be analyzed in order to understand discrepancies between theory and experimental results.
5. A body creates fields in the space around it, which cause forces to act on similar bodies in that space.
6. The motion of a body can be predicted accurately by analyzing the forces acting on it.
7. Graphs are a valuable way to display relationships between variables.
8. Learning physics includes understanding its historical development over time.
9. Physics forms the foundation upon which many other disciplines are built.
10. Matter is composed of minute particles that are in constant motion and many macroscopic properties of matter can be attributed to those microscopic motions.
11. Many physical quantities have both size and direction in space, and both must be considered for the analysis of phenomena. (Comment not meant for publication: Some of the quantities that we associate with vectors are really tensors. . .)
12. Certain types of phenomena show behavior of both waves and particles.

Content

Physics is a pure science, fundamental to understanding natural phenomena, and vital to the development of technology. Historically, the underlying concepts of physics (matter, force, and energy) have served as the keystone of the sciences in that they describe how the physical world works; the same physical world in which all the other sciences reside. The laws of physics describe our universe from the tiniest subatomic particle to the largest galaxy. The theories of yesterday inspire the experiments of today, which then evolve into the practical applications of tomorrow. Today's technology is one example of building on ideas from physics. Basic principles of physics are applied in nearly all careers in modern society including medicine, industry, research, education, and engineering. Studying physics develops the ability to think logically, to understand fundamentals of technology, and to relate to scientists of other disciplines.

Instructional Approach

Instruction and learning are organized around the 5E's Inquiry Model. The teacher functions as facilitator or coach to nurture the students' growth to become independent learners. A variety of teaching strategies are used to promote inquiry, including laboratory experiments, demonstrations, direct instruction, visual presentations and cooperative learning, as appropriate to the lesson and prior knowledge of the students. Time is provided to ensure that problem analysis, as well as solution strategies, are addressed. Students synthesize unifying principles from the course of study, make interdisciplinary connections, and apply these understandings to real world situations. The teacher provides opportunities for students to use technology and apply their knowledge and skills to projects and learning experiences. Teachers engage students in effective techniques of reading, writing, and mathematics to extend their understandings of the content. Assessment is frequent, ongoing, and embedded in student learning experiences. Methods of evaluation incorporate rubrics and include pre-, formative, and summative assessment to evaluate teaching and learning. Teachers set high standards with challenging and rigorous expectations for all students and provide differentiation of instruction and learning as appropriate.

Physics Scope and Sequence

The following indicators come from Core Learning Goal 1 and are used throughout the course. All concept indicators, Goal 5, 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 Process 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 a 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 5 (Concepts of Physics) and are addressed by using Goal 1 (Skills and Processes) indicators as the primary vehicles of instruction.

Physics Concept Indicators
Students will be able to:

HS5.1 **The student will know and apply the laws of mechanics to explain the behavior of the physical world.**

HS5.1.1.1	distinguish between scalar and vector quantities (e.g., speed v. velocity; distance v. displacement).
HS5.1.1.2	symbolically represent vector quantities (angle for direction, length for magnitude).
HS5.1.1.3	graphically add vectors (same and opposite directions and at right angles).
HS5.1.1.4	resolve vectors into their components graphically and mathematically.
HS5.1.1.4.A	find the components of a vector mathematically (sine and cosine).
HS5.1.1.4.B	mathematically add vectors using their components.
HS5.1.2.A	analyze position-time graphs (compute average velocity and displacement, identify segments with constant velocity or non-zero accelerations).
HS5.1.2.B	determine displacement and acceleration from velocity-time graphs of motion at constant acceleration.
HS5.1.2.C	analyze the motion of an object moving in two dimensions in terms of constant accelerated motion.
HS5.1.2.D	compute the velocity and centripetal acceleration of an object in uniform circular motion.
HS5.1.2.1	use kinematic equations, to describe motion with a constant speed (position, velocity, and time).
HS5.1.2.2	use kinematic equations to describe motion with constant acceleration (position, velocity, acceleration, and time).
HS5.1.2.3	solve problems involving Galilean Relativity (linear frames of reference).
HS5.1.2.4	use kinematics equations in two dimensions to describe projectile motion.
HS5.1.2.5	solve problems for objects in free fall, given the local value of "g."
HS5.1.3.A	describe the force on an object in uniform circular motion ($F = \frac{mv^2}{r}$).
HS5.1.3.1	determine the effect of balanced forces ($F_{net} = 0$).
HS5.1.3.2	determine the effect of unbalanced forces ($F_{net} \neq 0$).
HS5.1.3.3	describe an object's motion using inertia (Newton's First Law).
HS5.1.3.4	Use the relationship among net force, mass, and acceleration to describe the motion of an object (Newton's Second Law).
HS5.1.3.4.A	draw a free-body diagram identifying forces acting on an object.
HS5.1.3.4.B	identify the difference between weight and mass.
HS5.1.3.5	solve problems using the concept of action/reaction (Newton's Third Law).
HS5.1.4.A	use Hooke's Law to analyze simple harmonic motion (compute the period, frequency, amplitude, position, maximum velocity, maximum acceleration, and equilibrium position)
HS5.1.4.B	use Kepler's Laws to describe planetary motion. (H)
HS5.1.4.1	describe the nature and behavior of friction (qualitative).

HS5.1.4.1.A solve qualitative and quantitative problems involving the force of friction (static and kinetic).

HS5.1.4.2 recognize the inverse square relationship of gravitational force (describe how the force changes as the distance changes).

HS5.1.4.2.A recognize that gravitational fields exist around any object with mass.

HS5.1.4.2.B use the Law of Universal Gravitation to determine the acceleration due to gravity for a planet.

HS5.1.4.3 describe qualitatively and quantitatively the relationship among force, work, energy, and power.

HS5.1.4.3.A identify conditions under which work is positive or negative.

HS5.1.4.4 use forces to relate impulse and momentum (qualitatively and quantitatively).

HS5.1.4.4.A describe qualitatively and quantitatively an object's momentum.

HS5.1.5.A apply the principles of the conservation of momentum in two dimensions. (H)

HS5.1.5.1 analyze systems involving conservation of momentum, including elastic and inelastic interactions (applications and calculation in one dimension).

HS5.1.5.2 analyze the total energy of a system with regard to the conservation of energy (relationship between potential energy and kinetic energy).

HS5.2 **The student will know and apply the laws of electricity and magnetism and explain their significant role in nature and technology.**

HS5.2.1.1 describe the inverse square relationship of electrical forces (describe how the force changes as the distance changes).

HS5.2.1.2 describe the attractive/repulsive nature of the forces between charges (dependence of force on the sign of the charges).

HS5.2.1.2.A describe the types of electrical charges (positive or negative in sign).

HS5.2.1.3 apply Coulomb's Law (describe the qualitative relationships).

HS5.2.2.1 qualitative description of the electric field created by a static charge distribution (point charge, line of charge, parallel plates).

HS5.2.2.1.A calculate the electric field for a point charge and for parallel plates.

HS5.2.2.1.B relate electrical potential difference to the work done on a charge in an electric field.

HS5.2.2.2 describe the magnetic field created by a moving charge (created by perpendicular motion, follows the right hand rule, quantitatively describe shape and direction of field surrounding a current carrying wire).

HS5.2.2.2.A identify the general properties of magnets (types, composition, alignment of magnetic domains, poles are in pairs, direction of field lines, shape of the Earth's magnetic field).

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HS5.2.2.2.B describe qualitatively how conductors and insulators respond to electric and/or magnetic fields (electromagnetic induction).

HS5.2.2.2.C describe the effect magnetic fields have on static or moving charges (magnetic field may exert a force on a charged moving particle, qualitatively describe using f = qvb).

HS5.2.3.1 describe electromagnetic induction (define and describe that a changing

magnetic field creates an electric current).

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HS5.2.3.1.A explain the effect electric and magnetic fields have on a simple circuits (magnetic force created on current carrying wire, magnetic effect on moving charges, follows the right hand rule, quantitatively f = bil).

HS5.2.3.2 describe how electromagnetic induction is applied to motors (energy transformations, transfer of energy, effect of magnetic forces on motors).

HS5.2.3.3 apply electromagnetic induction to generators (energy transformations, conservation of energy)

HS5.2.2.4a analyze simple D.C. series and parallel circuits (diagram of series and parallel circuits; use of meters to measure quantities in each circuit).

HS5.2.2.4b calculate equivalent resistance and power for circuits (series, parallel, combined).

HS5.2.2.4c calculate voltage, current, and resistance using Ohm's Law.

HS5.2.2.4d solve problems involving electric power (P=IV).

HS5.2.2.5 identify practical applications regarding electric currents (safety, grounding, circuit breakers, fuses).

HS5.3 ***The student will recognize and relate the laws of thermodynamics to practical applications.***

HS5.3.1.1 describe thermal equilibrium (conditions and definition, differentiate between heat energy and temperature).

HS5.3.1.2 describe modes of heat energy transfer (conduction, convection, radiation).

HS5.3.1.3 apply heat energy to the Law of Conservation of Energy.

HS5.3.1.4 explain the irreversibility of heat energy transformations.

HS5.3.1.5 solve problems involving heat transfer in closed systems using specific heat and calorimetry (describe and calculate).

HS5.4 ***The student will explain and demonstrate how vibrations and waves provide a model for our understanding of various physical phenomena.***

HS5.4.1.1 compare the transfer of energy waves (physical v electromagnetic – transmission media, relative speed; examples, such as light and sound).

HS5.4.1.2 describe longitudinal and transverse waves (direction of vibration relative to their direction of transmission; examples, such as light and sound).

HS5.4.2.1 describe the wavelength of a wave using diagrams and calculations.

HS5.4.2.2 describe qualitatively and quantitatively the relationship between the frequency and period of a wave and their relationship to the energy transmitted (T = 1/f).

HS5.4.2.3 solve problems involving the velocity of a wave ($v = \lambda f$).

HS5.4.2.4 describe the amplitude of a wave and its relationship to energy transmission.

HS5.4.3.A distinguish between real and virtual images (size, orientation, and positions for convex and concave mirrors, concave and convex lenses).

HS5.4.3.1a describe *reflection* (identify the incident, *reflected*, and transmitted waves using ray models and *the law of reflection).*

HS5.4.3.1b	apply the laws of reflection in *plane and concave mirrors* (locate images using equations and *ray diagrams).*
HS5.4.3.1.A	explain total internal reflection.
HS5.4.3.2a	*explain refraction (causes and resultant behavior* when it encounters a boundary between two media).
HS5.4.3.2.A	calculate the index of refraction and the speed of light in a medium.
HS5.4.3.2.B	use Snell's Law to solve refraction problems.
HS5.4.3.3	explain *diffraction (causes and relationship between wavelength and size of opening).*
HS5.4.3.4	describe *interference (constructive and destructive).*
HS5.4.3.5	*describe polarization of light (relation to type of wave, effect on intensity of light).*
HS5.4.3.6	*describe the Doppler effect (frequency shift).*

HS5.5 ***The student will investigate certain topics in modern physics.***

HS5.5.1.1 *explain the wave/particle duality in the nature of electromagnetic energy (mass-energy conversions–$E=mc^2$, electron-positron annihilation).*

HS5.5.1.2 describe the *photoelectric effect (relationship between current produced and frequency and intensity of the incident waves).*

HS5.5.2.1 describe *radioactive decay (half-life;* calculations of atomic number and mass for nuclei undergoing *alpha, beta, or gamma ray emission processes).*

HS5.5.2.2 *describe fission and fusion (distinguish between; compare with other sources of energy).*

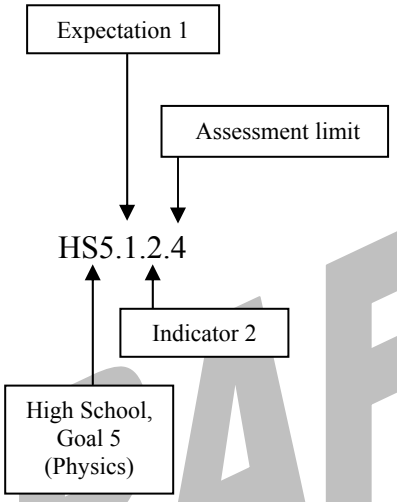
Explanation of Codes

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

HSG.E.I.A (for example: HS5.1.2.4)

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 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 that 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.