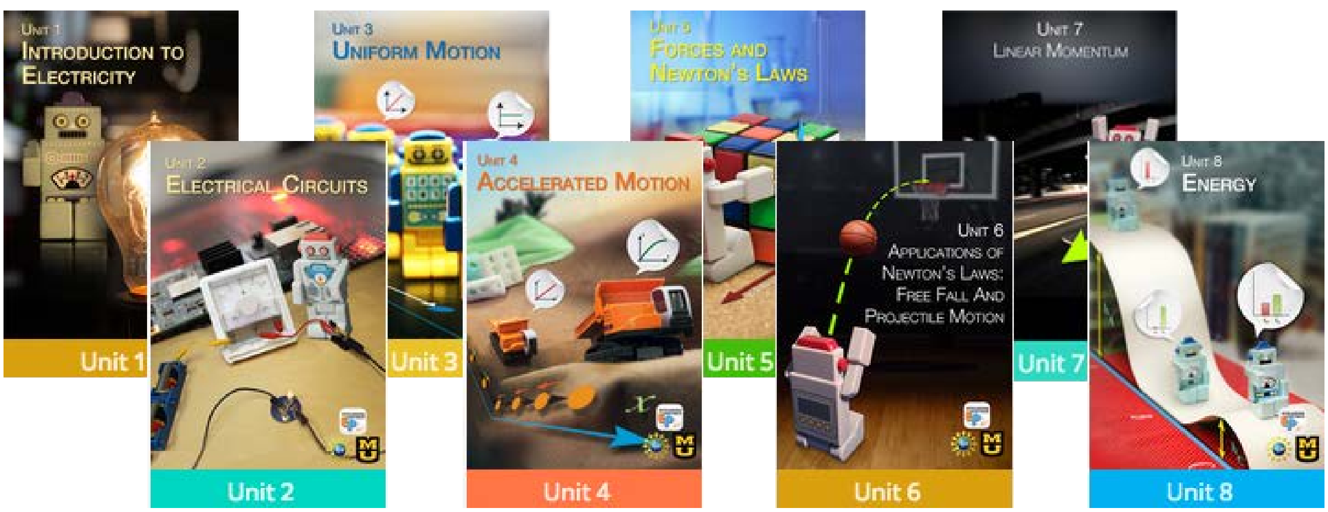
Exploring Physics Curriculum App
NGSS and Mathematics Common Core
Alignment Study

Key Findings
and
Alignment by eUnit to NGSS Disciplinary Core Ideas

NGSS Alignment was conducted by the Biological Sciences Curricular Study (BSCS), Colorado Springs, Co, 2014.



Exploring Physics, The Curriculum App is an interactive inquiry- and modeling-based conceptual physics curriculum. It combines hands-on activities with a discussion-based pedagogy where students construct mental models of scientific concepts. The content covers a full year's conceptual physics curriculum for 9th grade through early college.

Exploring Physics is compatible with iPad, PC, Mac and Chromebook platforms.

www.exploringphysics.com

This alignment study focused on one subject area taught during one year of high school, and compared it to all of high school physical science ideas and practices as well as all the high school math standards and practices. No single curriculum is intended to engage students thoroughly in all aspects of the disciplinary core ideas, science practices, math standards and math practices at once. Rather, with this alignment study, BSCS highlighted standards that are most closely connected and supported by the curriculum. It is assumed that other ideas, practices, and standards that are not aligned to or emphasized by this curriculum are more appropriately covered in other subjects and grade levels during high school (i.e., trigonometry, geometry, chemistry).

For reference, Exploring Physics eUnits are listed below		
1. Introduction to Electricity	4. Accelerated Motion	7. Linear Momentum
2. Electrical Circuits	5. Forces and Newton's Laws	8. Energy
3. Uniform Motion	6. Applications of Newton's Laws: Free Fall and Projectile Motion	9. Waves (in preparation)

Next Generation Science Standards: Disciplinary Core Ideas

The closest connections between the curriculum and the NGSS came within three of the four domains in Physical Science: PS2: Forces and Interactions, PS3: Energy, and PS4: Waves. There were very brief connections to PS1: Matter and Its Interactions, as these DCIs tend to be more traditionally taught within a chemistry course.

- All DCIs for PS2: Forces and Interactions were addressed within the curriculum
- Almost all DCIs for PS3: Energy were addressed within the curriculum. The two DCIs not addressed were about 1) availability of energy limits what can occur in a system, and 2) solar cells are human-made devices that captures sun's energy.
- Almost all DCIs for PS4: Waves (addressed in an upcoming eUnit). The three DCIs not addressed include: 1) information can be digitized, stored in a computer system, and sent over long distances via pulse waves, 2) photoelectric materials, and 3) information technologies.

Next Generation Science Standards: Science and Engineering Practices

All Science and Engineering practices were well supported in the curriculum and seen in all eight units. Some of the practices, noted below, hinge on how the curriculum is implemented by the teacher in the classroom.

Science Practice 2: Developing and Using Models was the most strongly supported practice in all eight units, earning the highest score. Students were consistently engaging in and using models in all eight units.

Science Practice 5: Using Mathematics and Computational Thinking and Science Practice 6: Constructing Explanations and Designing Solutions were also present in all units, with some to most of the elements of these two practices covered.

Science Practice 4: Analyzing and Interpreting Data is present in all units. Students are most frequently engaged this practice during labs.

Science Practice 1: Asking Questions and Defining Problems and Science Practice 3: Planning and Carrying Out Investigations will be strongly supported if teachers plan lessons so that students are given the opportunity to ask their own questions, define their own problems, plan an investigations (without any "hints" or clues), and then determine ways to evaluate and modify the investigations for more reliable results.

Science Practice, SP7, Engaging in Argument from Evidence, is dependent on teachers in the classroom, outside of the written curriculum, and is encouraged in the teacher guides. For example, teachers could promote discussion among students where students could compare and evaluate arguments and evidence and critique the reasoning of their peers.

Next Generation Science Standards: Cross-Cutting Concepts

Cross-cutting concepts, by nature, are those concepts that are intended to cut across topic areas, units of study, grade levels, and disciplines. As such, the evidence for cross-cutting concepts at minimum needed to have been found across the curriculum, rather than in just one or two examples. There was evidence of the following cross-cutting concepts being well-integrated into the curriculum (some to more or lesser extents):

- Patterns
- Cause and Effect
- Scale, Proportion, and Quantity
- Systems and System Models
- Energy and Matter

There was not enough evidence to find a link between the following two cross-cutting concepts:

- Structure and Function
- Stability and Change

Next Generation Science Standards: Performance Expectations

Alignment to NGSS performance expectations included both full and partial alignment to these important assessment measures. Full alignment indicates that students can successfully complete the Performance Expectations as a result of the DCIs and Practices evident in the curriculum. Partial alignment indicates that students could partially complete the Performance Expectations as a result of the curriculum.

Full Alignment was found on the following Performance Expectations:

- 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-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-PS3-4.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-PS4-1. (refers to upcoming eUnit on Waves) Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.

Partial Alignment was found to the following Performance Expectations:

- 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-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 positions of particles (objects).
- 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.

Alignment scheme

A four-level scheme was chosen: Not aligned, Some Alignment, Mostly Aligned, and Fully Aligned. These levels are defined as:

- Not aligned: No evidence was found OR evidence found, but at a lower grade level.
- Some Alignment: Evidence for part of the idea, practice, or standard was found OR students had somewhat superficial engagement with the idea, practice, or standard OR students only had a few opportunities with this idea, practice, or standard.
- Mostly Aligned: Evidence for part or all of the idea, practice, or standard was found AND/OR students had more meaningful engagement with the idea, practice, or standard AND/OR students had multiple opportunities with this idea, practice, or standard [at least 1 AND].
  Fully Aligned: Evidence for all of the idea, practice, or standard was found AND students had meaningful engagement with the idea, practice, or standard AND students had multiple opportunities with this idea, practice, or standard.

Alignment key:		No Alignment	**S**	**S**: Some alignment	**M**	Mostly aligned	**F**	Fully aligned

Detailed Table of Alignment by eUnit to NGSS Disciplinary Core ideas:

NGSS DISCIPLINARY CORE IDEA	Exploring Physics eUnits								
	1	2	3	4	5	6	7	8	9
HS-PS1 MATTER AND ITS INTERACTIONS									
PS1.A: Structure and Properties of Matter									
a. Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons.	**S**	**S**							
b. The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states.	*Content usually covered in a Chemistry course*								
c. The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms.									
d. A stable molecule has less energy than the same set of atoms separated; one must provide at least this energy in order to take the molecule apart.									
PS1.B Chemical Reactions									
a. Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy.	*Content usually covered in a Chemistry course*								
b. In many situations, a dynamic and condition-dependent balance between a reaction and the reverse reaction determines the numbers of all types of molecules present.									
c. The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions.									
PS1.C Nuclear Processes									
a. Nuclear processes, including fusion, fission, and radioactive decays of unstable nuclei, involve release or absorption of energy. The total number of neutrons plus protons does not change in any nuclear process.									
HS-PS2 FORCES AND INTERACTIONS									
PS2.A: Forces and Motion									
a. Newton's second law accurately predicts changes in the motion of macroscopic objects.				**M**	**F**	**F**	**S**	**S**	
b. Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object.							**F**		
c. If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system.							**F**		
PS2.B: Types of Interactions									
a. Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant	**S**	**S**			**S**	**S**			

Alignment key:		No Alignment	S	**S**: Some alignment	M	Mostly aligned	F	Fully aligned

NGSS DISCIPLINARY CORE IDEA	Exploring Physics eUnits								
	1	2	3	4	5	6	7	8	9
objects.									
b. Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields.					S	S			
c. Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects.	S	S			S				
HS-PS3 ENERGY									
PS3.A Definitions of Energy									
a. Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms.	S	S						F	
b. At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy.	S	S						M	S
c. These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as a combination of energy associated with the motion of particles and energy associated with the configuration (relative position of the particles). In some cases the relative position energy can be thought of as stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space.									S
d. "Electrical energy" may mean energy stored in a battery or energy transmitted by electric currents.	F								
PS3.B Conservation of Energy and Energy Transfer									
a. Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system.								F	
b. Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems.								F	S
c. Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g. relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior.	S	S						F	
d. The availability of energy limits what can occur in any system.									
e. Uncontrolled systems always evolve toward more stable states—that is, toward more uniform energy distribution (e.g., water flows downhill, objects hotter than surrounding environment cool down).								S	

Alignment key:		No Alignment	S	**S**: Some alignment	M	Mostly aligned	F	Fully aligned

NGSS DISCIPLINARY CORE IDEA	Exploring Physics eUnits								
	1	2	3	4	5	6	7	8	9
PS3.C Relationships Between Energy and Forces									
a. When two objects interacting through a field change relative position, the energy stored in the field is changed.								S	
PS3.D Energy in Chemical Processes									
a. Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment.								S	
b. Solar cells are human-made devices that likewise capture the sun's energy and produce electrical energy.									
HS-PS4 WAVES									
PS4.A Wave Properties									
a. The wavelength and frequency of a wave are related to one another by the speed of travel of the wave, which depends on the type of wave and the medium through which it is passing.									M
b. Information can be digitized (e.g., a picture stored as the values of an array of pixels); in this form, it can be stored reliably in computer memory and sent over long distances as a series of wave pulses.									
c. Waves can add or cancel one another as they cross, depending on their relative phase (i.e., relative position of peaks and troughs of the waves), but they emerge unaffected by each other. (Boundary: The discussion at this grade level is qualitative only; it can be based on the fact that two different sounds can pass a location in different directions without getting mixed up.)									S
PS4.B: Electromagnetic Radiation									
a. Electromagnetic radiation (e.g., radio, microwaves, light) can be modeled as a wave of changing electric and magnetic fields or as particles called photons. The wave model is useful for explaining many features of electromagnetic radiation, and the particle model explains other features.									S
b. When light or longer wavelength electromagnetic radiation is absorbed in matter, it is generally converted into thermal energy (heat). Shorter wavelength electromagnetic radiation (ultraviolet, X-rays, gamma rays) can ionize atoms and cause damage to living cells.									S
c. Photoelectric materials emit electrons when they absorb light of a high-enough frequency.									
PS4.C: Information Technologies and Instrumentation									
a. Multiple technologies based on the understanding of waves and their interactions with matter are part of everyday experiences in the modern world (e.g., medical imaging, communications, scanners) and in scientific research. They are essential tools for producing, transmitting, and capturing signals and for storing and interpreting the information contained in them.									