NGSS and Mathematics Common Core Alignment Study of Exploring Physics Curriculum

Alignment by eUnit to NGSS Science and Engineering Practices

EXPLORING PHYSICS

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: 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.

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.

Detailed Table of Alignment by eUnit to NGSS Science and Engineering Practices:

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

Description of Science and Engineering Practices for Grades 9-12	Exploring Physics eUnits								
	1	2	3	4	5	6	7	8	9
Asking questions and defining problems in grades 9–12 builds from grades K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations. • Ask questions o that arise from careful observation of phenomena, or unexpected results, to clarify and/or seek additional information. o that arise from examining models or a theory, to clarify and/or seek additional information and relationships. o to determine relationships, including quantitative relationships, between independent and dependent variables. o to clarify and refine a model, an explanation, or an engineering problem. • Evaluate a question to determine if it is testable and relevant. • Ask questions that can be investigated within the scope of the school laboratory, research facilities, or field (e.g., outdoor environment) with available resources and, when appropriate, frame a hypothesis based on a model or theory. • Ask and/or evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set, or the suitability of a design. • Define a design problem that involves the development of a process or system with interacting components and criteria and constraints that may include social, technical, and/or environmental considerations.	M	M	M	M	M	M	M	M	S
Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds. • Evaluate merits and limitations of two different models of the same proposed tool, process, mechanism or system in order to select or revise a model that best fits the evidence or design criteria. • Design a test of a model to ascertain its reliability. • Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system. • Develop and/or use multiple types of models to provide mechanistic accounts and/or predict phenomena, and move flexibly between model types based on merits and limitations. • Develop a complex model that allows for manipulation and testing of a proposed process or system. • Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.	M	M	M	M	M	M	M	M	M
Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models. • Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigation's design to ensure variables are controlled. • Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. • Plan and conduct an investigation or test a design solution in a safe and ethical manner including considerations of environmental, social, and personal impacts. • Select appropriate tools to collect, record, analyze, and evaluate data. • Make directional hypotheses that specify what happens to a dependent variable when an independent variable is manipulated. • Manipulate variables and collect data about a complex model of a proposed process or system to identify failure points or improve performance relative to criteria for success or other variables.	M	M	M	M	M	M	M	M	S

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

Analyzing data in 9–12 builds on K–8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. • Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. • Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible. • Consider limitations of data analysis (e.g., measurement error, sample selection) when analyzing and interpreting data. • Compare and contrast various types of data sets (e.g., self-generated, archival) to examine consistency of measurements and observations. • Evaluate the impact of new data on a working explanation and/or model of a proposed process or system. • Analyze data to identify design features or characteristics of the components of a proposed process or system to optimize it relative to criteria for success.	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**
Mathematical and computational thinking at the 9-12 level builds on K-8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Create and/or revise a computational model or simulation of a phenomenon, designed device, process, or system. • Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations. • Apply techniques of algebra and functions to represent and solve scientific and engineering problems. • Use simple limit cases to test mathematical expressions, computer programs, algorithms, or simulations of a process or system to see if a model "makes sense" by comparing the outcomes with what is known about the real world. • Apply ratios, rates, percentages, and unit conversions in the context of complicated measurement problems involving quantities with derived or compound units (such as mg/mL, kg/m3, acre-feet, etc.).	**S**	**S**	**M**	**M**	**M**	**M**	**M**	**M**	**M**
Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables. • Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. • Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. • Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion. • Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.	**S**	**S**	**M**	**M**	**M**	**M**	**M**	**M**	**S**

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

Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science. • Compare and evaluate competing arguments or design solutions in light of currently accepted explanations, new evidence, limitations (e.g., trade-offs), constraints, and ethical issues. • Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments. • Respectfully provide and/or receive critiques on scientific arguments by probing reasoning and evidence, challenging ideas and conclusions, responding thoughtfully to diverse perspectives, and determining additional information required to resolve contradictions. • Construct, use, and/or present an oral and written argument or counter-arguments based on data and evidence. • Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge and student-generated evidence. • Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and/or logical arguments regarding relevant factors (e.g. economic, societal, environmental, ethical considerations).									
Obtaining, evaluating, and communicating information in 9–12 builds on K–8 experiences and progresses to evaluating the validity and reliability of the claims, methods, and designs. • Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions and/or to obtain scientific and/or technical information to summarize complex evidence, concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms. • Compare, integrate and evaluate sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a scientific question or solve a problem. • Gather, read, and evaluate scientific and/or technical information from multiple authoritative sources, assessing the evidence and usefulness of each source. • Evaluate the validity and reliability of and/or synthesize multiple claims, methods, and/or designs that appear in scientific and technical texts or media reports, verifying the data when possible. • Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (i.e., orally, graphically, textually, mathematically).	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**