

Extract from Appendix E – DCI progression within NGSS

	K-2	3-5	6-8	9-12
ETS1.B Developing Possible Solutions	Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem’s solutions to other people.	<ul style="list-style-type: none"> • Testing a solution involves investigating how well it performs under a range of likely conditions. • Research on a problem should be carried out before beginning to design a solution. Testing a solution involves investigating how well it performs under a range of likely conditions. • At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs. • Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved. 	<ul style="list-style-type: none"> • A solution needs to be tested, and then modified on the basis of the test results in order to improve it. • Models of all kinds are important for testing solutions. • There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem. • There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. • Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. 	<ul style="list-style-type: none"> • When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. • Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs.

	K-2	3-5	6-8	9-12
PS1.A Structure of matter (includes PS1.C Nuclear processes)	Matter exists as different substances that have observable different properties. Different properties are suited to different purposes. Objects can be built up from smaller parts.	Because matter exists as particles that are too small to see, matter is always conserved even if it seems to disappear. Measurements of a variety of observable properties can be used to identify particular materials.	The fact that matter is composed of atoms and molecules can be used to explain the properties of substances, diversity of materials, states of matter, phase changes, and conservation of matter.	The sub-atomic structural model and interactions between electric charges at the atomic scale can be used to explain the structure and interactions of matter, including chemical reactions and nuclear processes. Repeating patterns of the periodic table reflect patterns of outer electrons. A stable molecule has less energy than the same set of atoms separated; one must provide at least this energy to take the molecule apart.

APPENDIX F – Science and Engineering Practices in NGSS

Science and Engineering Practices	K–2 Condensed Practices	3–5 Condensed Practices	6–8 Condensed Practices	9–12 Condensed Practices
<p>1. Asking Questions and Defining Problems</p> <p>A practice of science is to ask and refine questions that lead to descriptions and explanations of how the natural and designed world(s) works and which can be empirically tested.</p> <p>Engineering questions clarify problems to determine criteria for successful solutions and identify constraints to solve problems about the designed world.</p> <p>Both scientists and engineers also ask questions to clarify ideas.</p>	<p>Asking questions and defining problems in K–2 builds on prior experiences and progresses to simple descriptive questions that can be tested.</p>	<p>Asking questions and defining problems in 3–5 builds on K–2 experiences and progresses to specifying qualitative relationships.</p>	<p>Asking questions and defining problems in 6–8 builds on K–5 experiences and progresses to specifying relationships between variables, and clarifying arguments and models.</p>	<p>Asking questions and defining problems in 9–12 builds on K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations.</p>
	<ul style="list-style-type: none"> Ask questions based on observations to find more information about the natural and/or designed world(s). 	<ul style="list-style-type: none"> Ask questions about what would happen if a variable is changed. 	<ul style="list-style-type: none"> Ask questions <ul style="list-style-type: none"> that arise from careful observation of phenomena, models, or unexpected results, to clarify and/or seek additional information. to identify and/or clarify evidence and/or the premise(s) of an argument. to determine relationships between independent and dependent variables and relationships in models.. to clarify and/or refine a model, an explanation, or an engineering problem. 	<ul style="list-style-type: none"> Ask questions <ul style="list-style-type: none"> that arise from careful observation of phenomena, or unexpected results, to clarify and/or seek additional information. that arise from examining models or a theory, to clarify and/or seek additional information and relationships. to determine relationships, including quantitative relationships, between independent and dependent variables. to clarify and refine a model, an explanation, or an engineering problem.
	<ul style="list-style-type: none"> Ask and/or identify questions that can be answered by an investigation. 	<ul style="list-style-type: none"> Identify scientific (testable) and non-scientific (non-testable) questions. Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause and effect relationships. 	<ul style="list-style-type: none"> Ask questions that require sufficient and appropriate empirical evidence to answer. Ask questions that can be investigated within the scope of the classroom, outdoor environment, and museums and other public facilities with available resources and, when appropriate, frame a hypothesis based on observations and scientific principles. 	<ul style="list-style-type: none"> 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.
			<ul style="list-style-type: none"> Ask questions that challenge the premise(s) of an argument or the interpretation of a data set. 	<ul style="list-style-type: none"> 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.
	<ul style="list-style-type: none"> Define a simple problem that can be solved through the development of a new or improved object or tool. 	<ul style="list-style-type: none"> Use prior knowledge to describe problems that can be solved. Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost. 	<ul style="list-style-type: none"> Define a design problem that can be solved through the development of an object, tool, process or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions. 	<ul style="list-style-type: none"> 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.

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<p>2. Developing and Using Models</p> <p>A practice of both science and engineering is to use and construct models as helpful tools for representing ideas and explanations. These tools include diagrams, drawings, physical replicas, mathematical representations, analogies, and computer simulations.</p> <p>Modeling tools are used to develop questions, predictions and explanations; analyze and identify flaws in systems; and communicate ideas. Models are used to build and revise scientific explanations and proposed engineered systems. Measurements and observations are used to revise models and designs.</p>	<p>Modeling in K–2 builds on prior experiences and progresses to include using and developing models (i.e., diagram, drawing, physical replica, diorama, dramatization, or storyboard) that represent concrete events or design solutions.</p>	<p>Modeling in 3–5 builds on K–2 experiences and progresses to building and revising simple models and using models to represent events and design solutions.</p>	<p>Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.</p>	<p>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 world(s).</p>
	<ul style="list-style-type: none"> Distinguish between a model and the actual object, process, and/or events the model represents. Compare models to identify common features and differences. 	<ul style="list-style-type: none"> Identify limitations of models. 	<ul style="list-style-type: none"> Evaluate limitations of a model for a proposed object or tool. 	<ul style="list-style-type: none"> 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.
	<ul style="list-style-type: none"> Develop and/or use a model to represent amounts, relationships, relative scales (bigger, smaller), and/or patterns in the natural and designed world(s). 	<ul style="list-style-type: none"> Collaboratively develop and/or revise a model based on evidence that shows the relationships among variables for frequent and regular occurring events. Develop a model using an analogy, example, or abstract representation to describe a scientific principle or design solution. Develop and/or use models to describe and/or predict phenomena. 	<ul style="list-style-type: none"> Develop or modify a model—based on evidence – to match what happens if a variable or component of a system is changed. Use and/or develop a model of simple systems with uncertain and less predictable factors. Develop and/or revise a model to show the relationships among variables, including those that are not observable but predict observable phenomena. Develop and/or use a model to predict and/or describe phenomena. Develop a model to describe unobservable mechanisms. 	<ul style="list-style-type: none"> 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.
<ul style="list-style-type: none"> Develop a simple model based on evidence to represent a proposed object or tool. 	<ul style="list-style-type: none"> Develop a diagram or simple physical prototype to convey a proposed object, tool, or process. Use a model to test cause and effect relationships or interactions concerning the functioning of a natural or designed system. 	<ul style="list-style-type: none"> Develop and/or use a model to generate data to test ideas about phenomena in natural or designed systems, including those representing inputs and outputs, and those at unobservable scales. 	<ul style="list-style-type: none"> 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. 	

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<p>3. Planning and Carrying Out Investigations</p> <p>Scientists and engineers plan and carry out investigations in the field or laboratory, working collaboratively as well as individually. Their investigations are systematic and require clarifying what counts as data and identifying variables or parameters.</p> <p>Engineering investigations identify the effectiveness, efficiency, and durability of designs under different conditions.</p>	<p>Planning and carrying out investigations to answer questions or test solutions to problems in K–2 builds on prior experiences and progresses to simple investigations, based on fair tests, which provide data to support explanations or design solutions.</p> <ul style="list-style-type: none"> With guidance, plan and conduct an investigation in collaboration with peers (for K). Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence to answer a question. 	<p>Planning and carrying out investigations to answer questions or test solutions to problems in 3–5 builds on K–2 experiences and progresses to include investigations that <u>control variables</u> and provide evidence to support explanations or design solutions.</p> <ul style="list-style-type: none"> Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered. 	<p>Planning and carrying out investigations in 6–8 builds on K–5 experiences and progresses to include investigations that use <u>multiple variables</u> and provide evidence to support explanations or solutions.</p> <ul style="list-style-type: none"> Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim. Conduct an investigation and/or evaluate and/or revise the experimental design to produce data to serve as the basis for evidence that meet the goals of the investigation. 	<p>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.</p> <ul style="list-style-type: none"> 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.
	<ul style="list-style-type: none"> Evaluate different ways of observing and/or measuring a phenomenon to determine which way can answer a question. 	<ul style="list-style-type: none"> Evaluate appropriate methods and/or tools for collecting data. 	<ul style="list-style-type: none"> Evaluate the accuracy of various methods for collecting data. 	<ul style="list-style-type: none"> Select appropriate tools to collect, record, analyze, and evaluate data.
	<ul style="list-style-type: none"> Make observations (firsthand or from media) and/or measurements to collect data that can be used to make comparisons. Make observations (firsthand or from media) and/or measurements of a proposed object or tool or solution to determine if it solves a problem or meets a goal. Make predictions based on prior experiences. 	<ul style="list-style-type: none"> Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution. Make predictions about what would happen if a variable changes. Test two different models of the same proposed object, tool, or process to determine which better meets criteria for success. 	<ul style="list-style-type: none"> Collect data to produce data to serve as the basis for evidence to answer scientific questions or test design solutions under a range of conditions. Collect data about the performance of a proposed object, tool, process, or system under a range of conditions. 	<ul style="list-style-type: none"> 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.

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<p>4. Analyzing and Interpreting Data</p> <p>Scientific investigations produce data that must be analyzed in order to derive meaning. Because data patterns and trends are not always obvious, scientists use a range of tools—including tabulation, graphical interpretation, visualization, and statistical analysis—to identify the significant features and patterns in the data. Scientists identify sources of error in the investigations and calculate the degree of certainty in the results. Modern technology makes the collection of large data sets much easier, providing secondary sources for analysis.</p> <p>Engineering investigations include analysis of data collected in the tests of designs. This allows comparison of different solutions and determines how well each meets specific design criteria—that is, which design best solves the problem within given constraints. Like scientists, engineers require a range of tools to identify patterns within data and interpret the results. Advances in science make analysis of proposed solutions more efficient and effective.</p>	<p>Analyzing data in K–2 builds on prior experiences and progresses to collecting, recording, and sharing observations.</p>	<p>Analyzing data in 3–5 builds on K–2 experiences and progresses to introducing quantitative approaches to collecting data and conducting multiple trials of qualitative observations. When possible and feasible, digital tools should be used.</p>	<p>Analyzing data in 6–8 builds on K–5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis.</p>	<p>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.</p>
	<ul style="list-style-type: none"> Record information (observations, thoughts, and ideas). Use and share pictures, drawings, and/or writings of observations. Use observations (firsthand or from media) to describe patterns and/or relationships in the natural and designed world(s) in order to answer scientific questions and solve problems. Compare predictions (based on prior experiences) to what occurred (observable events). 	<ul style="list-style-type: none"> Represent data in tables and/or various graphical displays (bar graphs, pictographs, and/or pie charts) to reveal patterns that indicate relationships. 	<ul style="list-style-type: none"> Construct, analyze, and/or interpret graphical displays of data and/or large data sets to identify linear and nonlinear relationships. Use graphical displays (e.g., maps, charts, graphs, and/or tables) of large data sets to identify temporal and spatial relationships. Distinguish between causal and correlational relationships in data. Analyze and interpret data to provide evidence for phenomena. 	<ul style="list-style-type: none"> 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.
		<ul style="list-style-type: none"> Analyze and interpret data to make sense of phenomena, using logical reasoning, mathematics, and/or computation. 	<ul style="list-style-type: none"> Apply concepts of statistics and probability (including mean, median, mode, and variability) to analyze and characterize data, using digital tools when feasible. 	<ul style="list-style-type: none"> 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.
	<ul style="list-style-type: none"> Analyze data from tests of an object or tool to determine if it works as intended. 	<ul style="list-style-type: none"> Compare and contrast data collected by different groups in order to discuss similarities and differences in their findings. Analyze data to refine a problem statement or the design of a proposed object, tool, or process. Use data to evaluate and refine design solutions. 	<ul style="list-style-type: none"> Consider limitations of data analysis (e.g., measurement error), and/or seek to improve precision and accuracy of data with better technological tools and methods. Analyze and interpret data to determine similarities and differences in findings. Analyze data to define an optimal operational range for a proposed object, tool, process or system that best meets criteria for success. 	<ul style="list-style-type: none"> 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.

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<p>5. Using Mathematics and Computational Thinking</p> <p>In both science and engineering, mathematics and computation are fundamental tools for representing physical variables and their relationships. They are used for a range of tasks such as constructing simulations; solving equations exactly or approximately; and recognizing, expressing, and applying quantitative relationships.</p> <p>Mathematical and computational approaches enable scientists and engineers to predict the behavior of systems and test the validity of such predictions.</p>	<p>Mathematical and computational thinking in K–2 builds on prior experience and progresses to recognizing that mathematics can be used to describe the natural and designed world(s).</p>	<p>Mathematical and computational thinking in 3–5 builds on K–2 experiences and progresses to extending quantitative measurements to a variety of physical properties and using computation and mathematics to analyze data and compare alternative design solutions.</p>	<p>Mathematical and computational thinking in 6–8 builds on K–5 experiences and progresses to identifying patterns in large data sets and using mathematical concepts to support explanations and arguments.</p>	<p>Mathematical and computational thinking in 9–12 builds on K–8 and experiences 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.</p>
	<ul style="list-style-type: none"> Decide when to use qualitative vs. quantitative data. 	<ul style="list-style-type: none"> Decide if qualitative or quantitative data are best to determine whether a proposed object or tool meets criteria for success. 		
	<ul style="list-style-type: none"> Use counting and numbers to identify and describe patterns in the natural and designed world(s). 	<ul style="list-style-type: none"> Organize simple data sets to reveal patterns that suggest relationships. 	<ul style="list-style-type: none"> Use digital tools (e.g., computers) to analyze very large data sets for patterns and trends. 	<ul style="list-style-type: none"> Create and/or revise a computational model or simulation of a phenomenon, designed device, process, or system.
	<ul style="list-style-type: none"> Describe, measure, and/or compare quantitative attributes of different objects and display the data using simple graphs. 	<ul style="list-style-type: none"> Describe, measure, estimate, and/or graph quantities such as area, volume, weight, and time to address scientific and engineering questions and problems. 	<ul style="list-style-type: none"> Use mathematical representations to describe and/or support scientific conclusions and design solutions. 	<ul style="list-style-type: none"> Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations.
	<ul style="list-style-type: none"> Use quantitative data to compare two alternative solutions to a problem. 	<ul style="list-style-type: none"> Create and/or use graphs and/or charts generated from simple algorithms to compare alternative solutions to an engineering problem. 	<ul style="list-style-type: none"> Create algorithms (a series of ordered steps) to solve a problem. Apply mathematical concepts and/or processes (such as ratio, rate, percent, basic operations, and simple algebra) to scientific and engineering questions and problems. Use digital tools and/or mathematical concepts and arguments to test and compare proposed solutions to an engineering design problem. 	<ul style="list-style-type: none"> 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.).

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<p>6. Constructing Explanations and Designing Solutions</p> <p><i>The end-products of science are explanations and the end-products of engineering are solutions.</i></p> <p>The goal of science is the construction of theories that provide explanatory accounts of the world. A theory becomes accepted when it has multiple lines of empirical evidence and greater explanatory power of phenomena than previous theories.</p> <p>The goal of engineering design is to find a systematic solution to problems that is based on scientific knowledge and models of the material world. Each proposed solution results from a process of balancing competing criteria of desired functions, technical feasibility, cost, safety, aesthetics, and compliance with legal requirements. The optimal choice depends on how well the proposed solutions meet criteria and constraints.</p>	<p>Constructing explanations and designing solutions in K–2 builds on prior experiences and progresses to the use of evidence and ideas in constructing evidence-based accounts of natural phenomena and designing solutions.</p>	<p>Constructing explanations and designing solutions in 3–5 builds on K–2 experiences and progresses to the use of evidence in constructing explanations that specify variables that describe and predict phenomena and in designing multiple solutions to design problems.</p>	<p>Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.</p>	<p>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.</p>
	<ul style="list-style-type: none"> Use information from observations (firsthand and from media) to construct an evidence-based account for natural phenomena. 	<ul style="list-style-type: none"> Construct an explanation of observed relationships (e.g., the distribution of plants in the back yard). 	<ul style="list-style-type: none"> Construct an explanation that includes qualitative or quantitative relationships between variables that predict(s) and/or describe(s) phenomena. Construct an explanation using models or representations. 	<ul style="list-style-type: none"> Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables.
		<ul style="list-style-type: none"> Use evidence (e.g., measurements, observations, patterns) to construct or support an explanation or design a solution to a problem. 	<ul style="list-style-type: none"> Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students’ own experiments) 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 construct, revise and/or use an explanation for real-world phenomena, examples, or events. 	<ul style="list-style-type: none"> 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.
		<ul style="list-style-type: none"> Identify the evidence that supports particular points in an explanation. 	<ul style="list-style-type: none"> Apply scientific reasoning to show why the data or evidence is adequate for the explanation or conclusion. 	<ul style="list-style-type: none"> 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.
<ul style="list-style-type: none"> Use tools and/or materials to design and/or build a device that solves a specific problem or a solution to a specific problem. Generate and/or compare multiple solutions to a problem. 	<ul style="list-style-type: none"> Apply scientific ideas to solve design problems. Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution. 	<ul style="list-style-type: none"> Apply scientific ideas or principles to design, construct, and/or test a design of an object, tool, process or system. Undertake a design project, engaging in the design cycle, to construct and/or implement a solution that meets specific design criteria and constraints. Optimize performance of a design by prioritizing criteria, making tradeoffs, testing, revising, and re-testing. 	<ul style="list-style-type: none"> 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. 	

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<p>7. Engaging in Argument from Evidence</p> <p><i>Argumentation is the process by which evidence-based conclusions and solutions are reached.</i></p> <p>In science and engineering, reasoning and argument based on evidence are essential to identifying the best explanation for a natural phenomenon or the best solution to a design problem.</p> <p>Scientists and engineers use argumentation to listen to, compare, and evaluate competing ideas and methods based on merits.</p> <p>Scientists and engineers engage in argumentation when investigating a phenomenon, testing a design solution, resolving questions about measurements, building data models, and using evidence to evaluate claims.</p>	<p>Engaging in argument from evidence in K–2 builds on prior experiences and progresses to comparing ideas and representations about the natural and designed world(s).</p> <ul style="list-style-type: none"> Identify arguments that are supported by evidence. Distinguish between explanations that account for all gathered evidence and those that do not. Analyze why some evidence is relevant to a scientific question and some is not. Distinguish between opinions and evidence in one’s own explanations. Listen actively to arguments to indicate agreement or disagreement based on evidence, and/or to retell the main points of the argument. Construct an argument with evidence to support a claim. 	<p>Engaging in argument from evidence in 3–5 builds on K–2 experiences and progresses to critiquing the scientific explanations or solutions proposed by peers by citing relevant evidence about the natural and designed world(s).</p> <ul style="list-style-type: none"> Compare and refine arguments based on an evaluation of the evidence presented. Distinguish among facts, reasoned judgment based on research findings, and speculation in an explanation. Respectfully provide and receive critiques from peers about a proposed procedure, explanation or model by citing relevant evidence and posing specific questions. Construct and/or support an argument with evidence, data, and/or a model. Use data to evaluate claims about cause and effect. 	<p>Engaging in argument from evidence in 6–8 builds on K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world(s).</p> <ul style="list-style-type: none"> Compare and critique two arguments on the same topic and analyze whether they emphasize similar or different evidence and/or interpretations of facts. Respectfully provide and receive critiques about one’s explanations, procedures, models and questions by citing relevant evidence and posing and responding to questions that elicit pertinent elaboration and detail. Construct, use, and/or present an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. 	<p>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.</p> <ul style="list-style-type: none"> 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 and challenging ideas and conclusions, responding thoughtfully to diverse perspectives, and determining what additional information is required to resolve contradictions. Construct, use, and/or present an oral and written argument or counter-arguments based on data and evidence.
	<ul style="list-style-type: none"> Make a claim about the effectiveness of an object, tool, or solution that is supported by relevant evidence. 	<ul style="list-style-type: none"> Make a claim about the merit of a solution to a problem by citing relevant evidence about how it meets the criteria and constraints of the problem. 	<ul style="list-style-type: none"> Make an oral or written argument that supports or refutes the advertised performance of a device, process, or system, based on empirical evidence concerning whether or not the technology meets relevant criteria and constraints. Evaluate competing design solutions based on jointly developed and agreed-upon design criteria. 	<ul style="list-style-type: none"> 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).

APPENDIX F – Science and Engineering Practices in NGSS

Science and Engineering Practices	K–2 Condensed Practices	3–5 Condensed Practices	6–8 Condensed Practices	9–12 Condensed Practices
<p>8. Obtaining, Evaluating, and Communicating Information</p> <p>Scientists and engineers must be able to communicate clearly and persuasively the ideas and methods they generate. Critiquing and communicating ideas individually and in groups is a critical professional activity.</p> <p>Communicating information and ideas can be done in multiple ways: using tables, diagrams, graphs, models, and equations as well as orally, in writing, and through extended discussions. Scientists and engineers employ multiple sources to obtain information that is used to evaluate the merit and validity of claims, methods, and designs.</p>	<p>Obtaining, evaluating, and communicating information in K–2 builds on prior experiences and uses observations and texts to communicate new information.</p>	<p>Obtaining, evaluating, and communicating information in 3–5 builds on K–2 experiences and progresses to evaluating the merit and accuracy of ideas and methods.</p>	<p>Obtaining, evaluating, and communicating information in 6–8 builds on K–5 experiences and progresses to evaluating the merit and validity of ideas and methods.</p>	<p>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.</p>
	<ul style="list-style-type: none"> • Read grade-appropriate texts and/or use media to obtain scientific and/or technical information to determine patterns in and/or evidence about the natural and designed world(s). 	<ul style="list-style-type: none"> • Read and comprehend grade-appropriate complex texts and/or other reliable media to summarize and obtain scientific and technical ideas and describe how they are supported by evidence. • Compare and/or combine across complex texts and/or other reliable media to support the engagement in other scientific and/or engineering practices. 	<ul style="list-style-type: none"> • Critically read scientific texts adapted for classroom use to determine the central ideas and/or obtain scientific and/or technical information to describe patterns in and/or evidence about the natural and designed world(s). 	<ul style="list-style-type: none"> • 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.
	<ul style="list-style-type: none"> • Describe how specific images (e.g., a diagram showing how a machine works) support a scientific or engineering idea. 	<ul style="list-style-type: none"> • Combine information in written text with that contained in corresponding tables, diagrams, and/or charts to support the engagement in other scientific and/or engineering practices. 	<ul style="list-style-type: none"> • Integrate qualitative and/or quantitative scientific and/or technical information in written text with that contained in media and visual displays to clarify claims and findings. 	<ul style="list-style-type: none"> • 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.
	<ul style="list-style-type: none"> • Obtain information using various texts, text features (e.g., headings, tables of contents, glossaries, electronic menus, icons), and other media that will be useful in answering a scientific question and/or supporting a scientific claim. 	<ul style="list-style-type: none"> • Obtain and combine information from books and/or other reliable media to explain phenomena or solutions to a design problem. 	<ul style="list-style-type: none"> • Gather, read, synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or not supported by evidence. • Evaluate data, hypotheses, and/or conclusions in scientific and technical texts in light of competing information or accounts. 	<ul style="list-style-type: none"> • 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.
	<ul style="list-style-type: none"> • Communicate information or design ideas and/or solutions with others in oral and/or written forms using models, drawings, writing, or numbers that provide detail about scientific ideas, practices, and/or design ideas. 	<ul style="list-style-type: none"> • Communicate scientific and/or technical information orally and/or in written forms, including various forms of media as well as tables, diagrams, and charts. 	<ul style="list-style-type: none"> • Communicate scientific and/or technical information (e.g. about a proposed object, tool, process, system) in writing and/or through oral presentations. 	<ul style="list-style-type: none"> • 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 (including orally, graphically, textually, and mathematically).

Extract from NGSS Appendix G - Crosscutting Concepts

1. Patterns

Progression Across the Grades
<i>In grades Pre-K-2</i> , students can recognize that patterns in the natural and human designed world can be observed, used to describe phenomena, and used as evidence.
<i>In grades 3-5</i> , students can identify similarities and differences in order to sort and classify natural objects and designed products. They identify patterns related to time, including simple rates of change and cycles, and to use these patterns to make predictions.
<i>In grades 6-8</i> , students can recognize that macroscopic patterns are related to the nature of microscopic and atomic-level structure. They identify patterns in rates of change and other numerical relationships that provide information about natural and human designed systems. They use patterns to identify cause and effect relationships, and use graphs and charts to identify patterns in data.
<i>In grades 9-12</i> , students can observe patterns in systems at different scales and cite patterns as empirical evidence for causality in supporting their explanations of phenomena. They recognize classifications or explanations used at one scale may not be useful or need revision using a different scale; thus requiring improved investigations and experiments. They use mathematical representations to identify certain patterns and analyze patterns of performance in order to reengineer and improve a designed system.

2. Cause and effect: Mechanism and explanation

Progression Across the Grades
<i>In grades Pre-K-2</i> , students can learn that events have causes that generate observable patterns. They design simple tests to gather evidence to support or refute their own ideas about causes.
<i>In grades 3-5</i> , students can routinely identify and test causal relationships and use these relationships to explain change. They understand events that occur together with regularity might or might not signify a cause and effect relationship.
<i>In grades 6-8</i> , students can classify relationships as causal or correlational, and recognize that correlation does not necessarily imply causation. They use cause and effect relationships to predict phenomena in natural or designed systems. They also understand that phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.
<i>In grades 9-12</i> , students can understand that empirical evidence is required to differentiate between cause and correlation and to make claims about specific causes and effects. They suggest cause and effect relationships to explain and predict behaviors in complex natural and designed systems. They also propose causal relationships by examining what is known about smaller scale mechanisms within the system. They recognize changes in systems may have various causes that may not have equal effects.

3. Scale, proportion and quantity

Progression Across the Grades
<i>In grades Pre-K-2</i> , students can use relative scales (e.g., bigger and smaller; hotter and colder; faster and slower) to describe objects. They use standard units to measure length.
<i>In grades 3-5</i> , students can recognize natural objects and observable phenomena exist from the very small to the immensely large. They use standard units to measure and describe physical quantities such as weight, time, temperature, and volume.
<i>In grades 6-8</i> , students can observe time, space, and energy phenomena at various scales using models to study systems that are too large or too small. They understand phenomena observed at one scale may not be observable at another scale, and the function of natural and designed systems may change with scale. They use proportional relationships (e.g., speed as the ratio of distance traveled to time taken) to gather information about the magnitude of properties and processes. They represent scientific relationships through the use of algebraic expressions and equations.
<i>In grades 9-12</i> , students can understand the significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. They recognize patterns observable at one scale may not be observable or exist at other scales, and some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly. Students use orders of magnitude to understand how a model at one scale relates to a model at another scale. They use algebraic thinking to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth).

4. Systems and system models

Progression Across the Grades
<i>In grades Pre-K-2</i> , students can understand objects and organisms can be described in terms of their parts; and systems in the natural and designed world have parts that work together.
<i>In grades 3-5</i> , students can understand that a system is a group of related parts that make up a whole and can carry out functions its individual parts cannot. They can also describe a system in terms of its components and their interactions.
<i>In grades 6-8</i> , students can understand that systems may interact with other systems; they may have sub-systems and be a part of larger complex systems. They can use models to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems. They can also learn that models are limited in that they only represent certain aspects of the system under study.
<i>In grades 9-12</i> , students can investigate or analyze a system by defining its boundaries and initial conditions, as well as its inputs and outputs. They can use models (e.g., physical, mathematical, computer models) to simulate the flow of energy, matter, and interactions within and between systems at different scales. They can also use models and simulations to predict the behavior of a system, and recognize that these predictions have limited precision and reliability due to the assumptions and approximations inherent in the models. They can also design systems to do specific tasks.

5. Energy and matter: Flows, cycles, and conservation

Progression Across the Grades
<i>In grades Pre-K-2</i> , students can observe objects may break into smaller pieces, be put together into larger pieces, or change shapes.
<i>In grades 3-5</i> , students can learn matter is made of particles and energy can be transferred in various ways and between objects. Students observe the conservation of matter by tracking matter flows and cycles before and after processes and recognizing the total weight of substances does not change.
<i>In grades 6-8</i> , students can learn matter is conserved because atoms are conserved in physical and chemical processes. They also learn within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter. Energy may take different forms (e.g. energy in fields, thermal energy, energy of motion). The transfer of energy can be tracked as energy flows through a designed or natural system.
<i>In grades 9-12</i> , students can learn that the total amount of energy and matter in closed systems is conserved. They can describe changes of energy and matter in a system in terms of energy and matter flows into, out of, and within that system. They also learn that energy cannot be created or destroyed. It only moves between one place and another place, between objects and/or fields, or between systems. Energy drives the cycling of matter within and between systems. In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved.

6. Structure and function

Progression Across the Grades
<i>In grades Pre-K-2</i> , students can observe the shape and stability of structures of natural and designed objects are related to their function(s).
<i>In grades 3-5</i> , students can learn different materials have different substructures, which can sometimes be observed; and substructures have shapes and parts that serve functions.
<i>In grades 6-8</i> , students can model complex and microscopic structures and systems and visualize how their function depends on the shapes, composition, and relationships among its parts. They analyze many complex natural and designed structures and systems to determine how they function. They design structures to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used.
<i>In grades 9-12</i> , students can investigate systems by examining the properties of different materials, the structures of different components, and their interconnections to reveal the system's function and/or solve a problem. They infer the functions and properties of natural and designed objects and systems from their overall structure, the way their components are shaped and used, and the molecular substructures of their various materials.

7. Stability and change

Progression Across the Grades
<i>In grades Pre-K-2</i> , students can observe some things stay the same while other things change, and things may change slowly or rapidly.
<i>In grades 3-5</i> , students can measure change in terms of differences over time, and observe that change may occur at different rates. Students learn some systems appear stable, but over long periods of time they will eventually change.
<i>In grades 6-8</i> , students can explain stability and change in natural or designed systems by examining changes over time, and considering forces at different scales, including the atomic scale. Students learn changes in one part of a system might cause large changes in another part, systems in dynamic equilibrium are stable due to a balance of feedback mechanisms, and stability might be disturbed by either sudden events or gradual changes that accumulate over time
<i>In grades 9-12</i> , students can understand much of science deals with constructing explanations of how things change and how they remain stable. They quantify and model changes in systems over very short or very long periods of time. They see some changes are irreversible, and negative feedback can stabilize a system, while positive feedback can destabilize it. They recognize systems can be designed for greater or lesser stability.