Middle School Science – Science and Engineering Practices (SEPs)

	Asking Questions and Defining Problems	
	Description:	
	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. Engineering questions clarify problems to determine criteria for successful solutions and identify constraints to solve problems about the designed world. Both scientists and engineers also ask questions to clarify ideas.	
	Evidence Outcome Description (The Learner Can…)	**Indicators of Success (Evidence comes from common formative assessments, interim assessments, and summative assessments)**
Exceeds (Level 4)	• Exceeding expectations (Level 4) performance is demonstrated through the mastery of a large majority (all or mostly all) of the Level 3 descriptors. Students performing at Level 3 show command of the Level 2 and Level 1 indicators with mastery of at least half of the Level 3 indicators.	•
Level 3	• Ask questions that arise from careful observation of phenomena, models, or unexpected results, to clarify and/or seek additional information. • Ask questions to identify and/or clarify evidence and/or the premise(s) of an argument. • Ask questions to determine relationships between independent and dependent variables and relationships in models. • Ask questions to clarify and/or refine a model, an explanation, or an engineering problem. • 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. • Ask questions that challenge the premise(s) of an argument or the interpretation of a data set. • 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. (Engineering)	

	Developing and Using Models	
	Description:	
	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. 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 revised scientific explanations and proposed engineered systems. Measurements and observations are used to revise models and designs.	
	Evidence Outcome Description (The Learner Can…)	**Indicators of Success (Three or more assignments, assessments, or demonstrations of student mathematics include)**
Exceeds (Level 4)	• Exceeding expectations (Level 4) performance is demonstrated through the mastery of a large majority (all or mostly all) of the Level 3 descriptors. Students performing at Level 3 show command of the Level 2 and Level 1 indicators with mastery of at least half of the Level 3 indicators.	
Level 3	• Evaluate limitations of a model for a proposed object or tool. • 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. • 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.	

	Planning and Carrying Out Investigations	
	Description:	
	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. Engineering investigations identify the effectiveness, efficiency, and durability of designs under different conditions.	
	Evidence Outcome Description (The Learner Can…)	**Indicators of Success (Three or more assignments, assessments, or demonstrations of student mathematics include)**
Exceeds (Level 4)	• Exceeding expectations (Level 4) performance is demonstrated through the mastery of a large majority (all or mostly all) of the Level 3 descriptors. Students performing at Level 3 show command of the Level 2 and Level 1 indicators with mastery of at least half of the Level 3 indicators.	•
Level 3	• 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. • Evaluate the accuracy of various methods for collecting data. • 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. (Engineering)	•

	Analyzing and Interpreting Data	
	Description:	
	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 tabulations, 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. 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 with 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.	
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Exceeds (Level 4)	• Exceeding expectations (Level 4) performance is demonstrated through the mastery of a large majority (all or mostly all) of the Level 3 descriptors. Students performing at Level 3 show command of the Level 2 and Level 1 indicators with mastery of at least half of the Level 3 indicators.	○
Level 3	• 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. • Apply concepts of statistics and probability (including mean, median, mode, and variability) to analyze and characterize data, using digital tools when feasible. • 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 (e.g., multiple trials). • 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. (Engineering)	

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Level 2	• Ask questions about what would happen if a variable is changed. • 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. • Use prior knowledge to describe problems that can be solved. (Engineering) • 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. (Engineering)		• Identify limitations of models. • 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. • Develop a diagram or simple physical prototype to convey a proposed object, tool, or process. (Engineering) • Use a model to test cause and effect relationships or interactions concerning the functioning of a natural or designed system. (Engineering)	•	• 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. • Evaluate appropriate methods and/or tools for collecting data. • 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. (Engineering)		• Represent data in tables and/or various graphical displays (bar graphs, pictographs, and/or pie charts) to reveal patterns that indicate relationships. • Analyze and interpret data to make sense of phenomena, using logical reasoning, mathematics, and/or computation. • 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. (Engineering) • Use data to evaluate and refine design solutions. (Engineering)	
Level 1	• Ask questions based on observations to find more information about the natural and/or designed worlds. • Ask and/or identify questions that can be answered by an investigation. • Define a simple problem that can be solved through the development of a new or improved object or tool. (Engineering)	•	• Distinguish between a model and the actual object, process, and/or events the model represents. • Compare models to identify common features and differences. • Develop and/or use a model to represent amounts, relationships, relative scales (bigger, smaller), and/or patterns in the natural and designed world(s). • Develop a simple model based on evidence to represent a proposed object or tool. (Engineering)	•	• Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence to answer a question. • Evaluate different ways of observing and/or measuring a phenomenon to determine which way can answer a question. • 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. (Engineering) • Make predictions based on prior experiences.	•	• 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). • Analyze data from tests of an object or tool to determine if it works as intended. (Engineering)	
Suggested Student Evidence:	Driving Question Board Progress Tracker Notice/Wonder Charts Exit Tickets							

	Middle School Science – Science and Engineering Practices (SEPs)							
	Using Mathematics and Computational Thinking		**Constructing Explanations and Designing Solutions**		**Engaging in Argument from Evidence**		**Obtaining, Evaluating, and Communicating Information**	
	Description:		**Description:**		**Description:**		**Description:**	
	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. Mathematical and computational approaches enable scientists and engineers to predict the behavior of systems and test the validity of such predictions.		The end-products of science are explanations and the end-products of engineering are solutions. 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. 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.		Argumentation is the process by which evidence-based conclusions and solutions are reached. 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. Scientists and engineers use argumentation to listen to, compare, and evaluate competing ideas and methods based on merits. 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.		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. 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.	
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Level 3	• Decide when to use qualitative vs. quantitative data. • Use digital tools (e.g., computers) to analyze very large data sets for patterns and trends. • Use mathematical representations to describe and/or support scientific conclusions and design solutions. • 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. (Engineering)		• 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. • 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. • Apply scientific reasoning to show why the data or evidence is adequate for the explanation or conclusion. • Apply scientific ideas or principles to design, construct, and/or test a design of an object, tool, process or system. (Engineering) • Undertake a design project, engaging in the design cycle, to construct and/or implement a solution that meets specific design criteria and constraints. (Engineering) • Optimize performance of a design by prioritizing criteria, making tradeoffs, testing, revising, and retesting. (Engineering)		• 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. • 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. (Engineering) • Evaluate competing design solutions based on jointly developed and agreed-upon design criteria. (Engineering)	•	• 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). • 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. • 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. • Communicate scientific and/or technical information (e.g., about a proposed object, tool, process, system) in writing and/or through oral presentations.	
	Evidence Outcome Description (The Learner Can…)	**Indicators of Success (Three or more assignments, assessments, or demonstrations of student mathematics include)**	**Evidence Outcome Description (The Learner Can…)**	**Indicators of Success (Three or more assignments, assessments, or demonstrations of student mathematics include)**	**Evidence Outcome Description (The Learner Can…)**	**Indicators of Success (Three or more assignments, assessments, or demonstrations of student mathematics include)**	**Evidence Outcome Description (The Learner Can…)**	**Indicators of Success (Three or more assignments, assessments, or demonstrations of student mathematics include)**

Level 2	• Organize simple data to reveal patterns that suggest relationships. • Describe, measure, estimate, and/or graph quantities such as area, volume, weight, and time to address scientific and engineering questions and problems. • Create and/or use graphs and/or charts generated from simple algorithms to compare alternative solutions to an engineering problem. (Engineering)		• Construct an explanation of observed relationships (e.g., the distribution of plants in the back yard). • Use evidence (e.g., measurements, observations, patterns) to construct or support an explanation or design a solution to a problem. • Identify the evidence that supports particular points in an explanation. • Apply scientific ideas to solve design problems. (Engineering) • Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution. (Engineering)	•	• Compare and refine arguments based on an evaluation of the evidence presented. • Distinguish among facts, reasoned judgement based on research findings, and speculation in an explanation. • Respectfully provide an 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. • 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. (Engineering)		• Read and comprehend grade-appropriate complex texts and/or 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. • 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. • Obtain and combine information from books and/or other reliable media to explain phenomena or solutions to a design problem. • Communicate scientific and/or technical information orally and/or in written formats, including various forms of media and may include tables, diagrams, and charts.	
Level 1	• Use counting and numbers to identify and describe patterns in the natural and designed world(s). • Describe, measure, and/or compare quantitative attributes of different objects and display the data using simple graphs. • Use quantitative data to compare two alternative solutions to a problem.	•	• Use information from observations (firsthand and from media) to construct and evidence-based account for natural phenomena. • Use tools and/or materials to design and/or build a device that solves a specific problem or a solution to a specific problem. (Engineering) • Generate and/or compare multiple solutions to a problem. (Engineering)	•	• 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 indicated 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. • Make a claim about the effectiveness of an object, tool, or solution that is supported by relevant evidence. (Engineering)	•	• 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). • Describe how specific images (e.g., a diagram showing how a machine works) support a scientific or engineering idea. • 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. • 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. (Engineering)	
Suggested Student Evidence:								