SCIENCE AND ENGINEERING PRACTICES
PERFORMANCE EXPECTATIONS
PERFORMANCE INDICATOR
S.1A.2: DEVELOP AND USE MODELS

GRADE LEVEL PROGRESSIONS

|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|

Develop and use models to (1) understand or represent phenomena, processes, and relationships, (2) test devices or solutions, or (3) communicate ideas to others.

SPECIFIC CHANGES PER GRADE

- There are no changes in performance expectations between grade levels for students to develop and use models.

DEFINING CHARACTERISTICS

Scientists use models to represent simple and complex phenomena, systems, and processes, as well as to communicate these concepts to others. In engineering, models are used to analyze existing systems to look for flaws or test solutions and to visualize designs and communicate them to others. Whereas an individual’s mental model is a personalized way of conceptualizing a process or phenomenon, scientific models are conceptual models that serve as mechanisms for communicating information about processes or phenomena; that is, they are coherent and consistent, they can be shared with others, they are external, and they serve as analogs for processes and phenomena. And while scientists and engineers use mental models as part of the process of reasoning and testing, they use scientific models to communicate in a clear, unambiguous way. Both scientists and engineers, however, must be aware of the inherent limitations in using models to describe and communicate natural phenomena and artificial designs.

Types of models
- Structural: describing the physical arrangement of something
- Behavioral: describing the performances or actions of something
• Functional: describing how something works

*Models can be*--

• Simple diagrams
• Constructs
• Computer generated
• Analogies (comparing something complex with something more easily understood)
• Mathematical formulae
• Simulations of actions

In engineering, models can be used to build and test designs.

*Model practice elements:*

• Developing a model that embodies aspects of a theory and evidence
• Evaluating the model against empirical evidence and theory
• Using the model to illustrate, predict, and/or explain
• Revising that model to better fit evidence

*What a model is not:*

• An art project or construct for the sake of the construct itself (models should be used to learn or communicate science content)
• Descriptive only (models predict, explain, and help answer “how” or “why” questions)
• An all-inclusive interpretation or explanation (they may be subject to revision with more evidence or perhaps be limited by the type of model)

The goals for this practice are for students to construct 2-D drawings/diagrams and 3-D models that represent events or systems, to represent and explain phenomena through a variety of models, to discuss the limitations of precision of models, to use simulations to investigate, and to make and use models to test and compare the effectiveness of designs.

**INSTRUCTIONAL GUIDANCE AND CONSIDERATIONS**

*Developing models as a part of instructional design*

• Main question originating from some natural phenomena
• Develop an initial model to attempt to answer that question
• Conduct investigations to gather data as a means to assess and refine the initial model
• Critically examine evidence and ideas in the context of their model
• Evaluate models and ideas and develop a consensus model
• Apply the model to answer the initial question

*Strategies for effectively developing and using models in the classroom.*

• Include a driving question that addresses an important idea and provides coherence in the unit
• Models target how things happen, how they work, and why they work
• Focus on natural phenomena and data/observations from those phenomena
• Engage students in cycles of model evaluation and revision
• Models are based on empirical data and evidence
• Require students to use their models to explain natural phenomena
• Engage in the social nature of modeling (arguing from evidence, consensus building, application)
• Don't give them "the answer"
• Don't tell them their models are "wrong." Use questions to guide the process and their understanding

EVIDENCE OF MASTERY

Students who show evidence of mastery in this practice will be able to:
• Develop models from sources of evidence and scientific information. This means they should be able to use information (obtained through research or investigations) about some process or natural phenomena to develop and construct a functional, descriptive model that represents the process or phenomenon. This is not simply copying a pre-existing model from some source.
• Use models to communicate information about some natural phenomenon or process (cause and effect relationships, sequences, details, etc…).
• Use models to communicate a proposed and/or tested design or solution to a need or problem.
• Use models to test different variables of a natural process/phenomenon or solution/design.

CONNECTIONS WITH OTHER SCIENCE AND ENGINEERING PRACTICES

• Ask Questions (S.1A.1) and Plan and Carry Out Investigations (S.1A.3)
  o The use of models can serve as a source of prior knowledge for framing questions and problems as well as helping plan and conduct scientifically sound investigations and tests. Models may also serve as a way to answer scientific questions. The process of developing models may be the ultimately outcome of a question or problem and its subsequent investigation.
• Analyze and Interpret Data (S.1A.4) and Use Mathematics and Computational Thinking (S.1A.5)
  o Models may be applied to the analysis of data in an effort to apply scientific concepts to interpretation of the data. Mathematical models may also be a part of the analysis process. Analyzed data may serve as evidence that leads towards the development of a model to explain some process or phenomenon.
• Engage in Argument from Evidence (S.1A.7) and Construct Explanations (S.1A.6)
  o The process of argumentation and constructing explanations can lead to the development of models that are used as a way to communicate the concepts, processes, and phenomena that the evidence supports. Applying and using scientific models can also provide content context to the processes of argumentation and constructing explanations or designing effective solutions.
• Obtain, Evaluate, and Communicate Information (S.1A.8)
  o Models can be one source of information that students find and evaluate. Content information can also be applied in the processes of developing models to explain phenomena and/or processes.
- Construct Devices or Design Solutions (S.1B.1)
  - Engineers use models as a way of both communicating successful designs as well as a way to test designs or solutions when it is impractical to create a full-scale functioning design or solution to a problem or need.

### PERFORMANCE TASK EXAMPLES

The following are selected examples of performance tasks aligned with sample grade band content standards and performance indicators. The purpose of these examples is to illustrate what a performance task would look like that meets the performance expectations of both a given content performance indicator and the science and engineering performance indicator. Examples of performance tasks that do not meet the criteria of the science and engineering performance indicator are also provided for comparison. This list does not provide examples for every grade level.

<table>
<thead>
<tr>
<th>Grade</th>
<th>Subject</th>
<th>Example</th>
<th>Non-Example</th>
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<tbody>
<tr>
<td>K-2</td>
<td>Earth Science</td>
<td>Students conduct a series of observations to identify the effect of moving air on objects. Students develop visual models to communicate the cause and effect relationship between moving air and objects.</td>
<td>Students copy an existing model.</td>
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<tr>
<td>3-4</td>
<td>Astronomy</td>
<td>When presented with a traditional, visual model of the solar system, students evaluate and refine the model based on research to include the order, position, and composition of the planets.</td>
<td>Students provide a simple visual model based on an existing example.</td>
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<tr>
<td>7</td>
<td>Life Science</td>
<td>Students develop and use a model of a cell to communicate what occurs when an organelle fails.</td>
<td>Students construct a visual, labeled model of a cell from their notes.</td>
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<tr>
<td>High School</td>
<td>Physics</td>
<td>Given a claim that there is a relationship between electrical currents and magnetic fields, students are provided materials to conduct investigations to determine the exact nature of the relationship between electrical currents and magnetic fields and develop a model that they use to illustrate the relationship.</td>
<td>Students copy an existing model of magnetic fields.</td>
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