### Grade Level Progressions

<table>
<thead>
<tr>
<th>Grade</th>
<th>Performance Expectations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>K.S.1A.5</strong></td>
<td>Use mathematical thinking to (1) recognize and express quantitative observations, (2) collect and analyze data, or (3) understand patterns and relationships.</td>
</tr>
<tr>
<td><strong>1.S.1A.5</strong></td>
<td>Use mathematical and computational thinking to (1) recognize and express quantitative observations, (2) collect and analyze data, or (3) understand patterns and relationships.</td>
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<tr>
<td><strong>2.S.1A.5</strong></td>
<td>Use mathematical and computational thinking to (1) express quantitative observations using appropriate English or metric units, (2) collect and analyze data, or (3) understand patterns, trends and relationships.</td>
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<tr>
<td><strong>3.S.1A.5</strong></td>
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<tr>
<td><strong>4.S.1A.5</strong></td>
<td>Use mathematical and computational thinking to (1) express quantitative observations using appropriate English or metric units, (2) collect and analyze data, or (3) understand patterns, trends and relationships between variables.</td>
</tr>
<tr>
<td><strong>5.S.1A.5</strong></td>
<td>Use mathematical and computational thinking to (1) express quantitative observations using appropriate metric units, (2) collect and analyze data, or (3) understand patterns, trends and relationships.</td>
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<tr>
<td><strong>6.S.1A.5</strong></td>
<td>Use mathematical and computational thinking to (1) use and manipulate appropriate metric units, (2) collect and analyze data, (3) express relationships between variables for models and investigations, or (4) use grade-level appropriate statistics to analyze data.</td>
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<tr>
<td><strong>7.S.1A.5</strong></td>
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<tr>
<td><strong>8.S.1A.5</strong></td>
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<tr>
<td><strong>H.B.1A.5</strong></td>
<td>Use mathematical and computational thinking to (1) use and manipulate appropriate metric units, (2) express relationships between variables for models and investigations, and (3) use grade-level appropriate statistics to analyze data.</td>
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<tr>
<td><strong>H.C.1A.5</strong></td>
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<td><strong>H.P.1A.5</strong></td>
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<tr>
<td><strong>H.E.1A.5</strong></td>
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</tbody>
</table>

### Specific Changes per Grade

- In grades K-1 performance expectations include being able to recognize and express *quantitative observations*.
- Starting in grade 1, performance expectations expand to include using *computational thinking* as well as mathematics.
In this context, computational thinking includes the use of technology and tools to analyze, manipulate, and represent sets of data (e.g. computer spreadsheets and graphing tools).

- Starting in grade 2, performance expectations expand to include using appropriate English or metric units.
- Starting in grade 2, performance expectations expand to include understanding trends as well as patterns and relationships.
  - In this context, the distinction between a pattern and a trend is that patterns are repeated sequences of data whereas trends represent the general direction or progression of a change or development of a natural phenomenon or process.
- Starting in grade 4, performance expectations expand to include using mathematics and computational thinking to understand relationships between variables.
- Starting in grade 5, students should use metric units only. English units of measure are no longer appropriate to gather as data from this grade forward.
- Starting in grade 6, performance expectations expand to include using mathematics and computational thinking to use and manipulate metric units.
  - In this context, manipulate refers to converting metric units for use with specific equations, such as density.
- Starting in grade 6, performance expectations expand to include using mathematics and computational thinking to express relationships between variables for models and investigations.
- Starting in grade 6, performance expectations expand to include using grade-level appropriate statistics to analyze data.
- Note that although the high school science performance indicators for this practice no longer specify that students collect and analyze data, it is expected and inferred that students will collect and analyze data as part of this practice.

DEFINING CHARACTERISTICS

Mathematics allows for a clear, consistent means of defining, describing, and communicating about natural phenomena and engineered designs in a precise way. Computational thinking and tools allow for the development of simulations to describe and test phenomena and the design and evaluation of solutions. They both allow for simulations that are used to test a variety of theories and solutions. They are essential for the analysis and representation of data.

**Mathematics**
All science is ultimately based in mathematics. Mathematics produces consistency, reliability, and reproducibility in science and engineering. Mathematics allows for the numerical representation of:

- Variables
- Relationships
- Predictions
- Models

**Quantitative Models**
Quantitative models are mechanisms for organizing and representing data in such a way that it can be analyzed and interpreted through the application of mathematical and statistical tools.

- Data tables
• Graphs of relationships
• Statistical displays (pie graphs)
• Pictorial science models

Computational Thinking
Computational thinking is a way of using computers to help us apply mathematical and statistical approaches and tools to model and understand the world. This includes:
  • Simulation software
  • Efficient ways to collect extensive data
  • Engineering simulations

Big Data
We are immersed in a world of vast amounts of data that informs scientific discovery and design innovation. The goals for this practice are for students to recognize quantities and use appropriate scientific units, to recognize that simulations are based on mathematical models, to use mathematical models with real-world phenomena, and to use mathematical and statistical methods in analyzing data.

**INSTRUCTIONAL GUIDANCE AND CONSIDERATIONS**

Goals for using math in the classroom
  • Using quantities and units
  • Mathematical relationships in data

Goals for using computational thinking in the classroom.
  • Organizing, manipulating, and representing large amounts of data
  • Building mathematical models
  • Running simulations

Quantitative reasoning progression
  • Quantitative action - applying mathematical attributes/measurements to objects and relationships
  • Quantitative literacy - describing objects, relationships, and processes mathematically
  • Quantitative interpretation - using models to identify trends and patterns, and make predictions
  • Quantitative modeling - creating and revising mathematical representations to explain phenomena

Ways students use math and computational thinking in science
  • Using basic mathematics to make calculations and measurements
  • Interpreting graphs and models
  • Making predictions
  • Creating scientific mathematical models
  • Using computer simulations and models to analyze extensive amounts of data (big data).

Suggested prompts for the application of mathematics to scientific models or graphs.
### Questions

- What are the variables in this model?
- What does the model illustrate?
- What conclusions can you make from the model?
- How do certain factors influence one or more variables?
- What is the mathematical relationship between variables?
- What measurements are associated with the model?
- What trends and patterns are evident in the data/model?

### Tasks

- Identify and describe (quantitatively) the parts and processes in the model
- Make predictions based off the model

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**Creating simple mathematical models**

- Describe and study observable phenomena.
- Quantify their observations with measurements.
- Illustrate the data graphically.
- Write a mathematical formula to describe the trend in the model.
- Make quantitative predictions using the model.

**Progression**

These tasks are represented by increasing levels of complexity in order to scaffold classroom engagements as appropriate to the skills of the students. This is not intended to imply that less complex tasks are not appropriate for students capable of more complex mathematical practices.

- Using quantities and units as sources of data
- Making measurement using tools
- Organizing data into charts and graphs
- Using spreadsheets to organize and make calculations
- Using words and symbols to represent mathematical relationships
- Using probes to gather large amounts of data
- Running simulations as sources of data

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**EVIDENCE OF MASTERY**

Students who show evidence of mastery in this practice will be able to:

- Recognize and communicate quantitative data using appropriate methods and units (Kindergarten only uses non-standard units).
- Use computational thinking and resources to organize, manipulate, and represent large sets of data (beginning in 1st grade).
- Determine and distinguish relationships, patterns, and trends in data and models.
- Use grade-level appropriate statistics to analyze data (beginning in 6th grade). Grade level appropriateness of statistics is determined by the specific grade level math standards.
CONNECTIONS WITH OTHER SCIENCE AND ENGINEERING PRACTICES

- Ask Questions (S.1A.1) and Plan and Carry Out Investigations (S.1A.3)
  - The data that comes out of investigations (which themselves are derived from questions and problems) is analyzed and interpreted in an effort to look for patterns, trends, relationships, anomalies, outliers, etc...
- Analyze and Interpret Data (S.1A.4)
  - It is through the application of mathematics that data is analyzed and interpreted in order to identify trends, patterns, and relationships.
  - Computational thinking involves data using computers and other technological devices to analyze, interpret, organize, and communicate data, including very large sets of “big data”.
- Engage in Argument from Evidence (S.1A.7) and Construct Explanations (S.1A.6)
  - After data is analyzed and interpreted, the trends, patterns, relationships, etc… are used as evidence to support claims made using the data. They are also used in constructing viable explanations supported by the evidence/data as well as in designing and refining solutions based on the analysis of test data.
- Develop and Use Models (S.1A.2) and Obtain, Evaluate, and Communicate Information (S.1A.8)
  - Information and models provide content context and prior knowledge necessary in applying scientific principles and concepts to the analysis and interpretation of data in order to accurately determine the significance of the data as evidence (causation, relationships, etc…)
  - Data, once analyzed, can be used to develop models that describe scientific phenomena and processes.
- Construct Devices or Design Solutions (S.1B.1)
  - Engineers apply mathematics and computational thinking in the analysis and interpretations of the results of tests conducted in order to use the data as evidence in evaluating the efficacy of their designs of solutions.

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 are 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>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Life Science</td>
<td>Students grow plants and make measurements throughout the process. Students enter data about the growth over time into a spreadsheet and generate</td>
<td>Students observe the stages of plant growth without utilizing</td>
</tr>
<tr>
<td>Grade</td>
<td>Subject</td>
<td>Description</td>
<td>Example</td>
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</tr>
<tr>
<td>2</td>
<td>Life Science</td>
<td>Students conduct observations of pill bugs in order to describe how they react to changes in their environment. Students enter data in a spreadsheet to generate graphs to understand and communicate patterns, trends, and relationships among changes in the environment and behavior. Students observe pill bugs and teacher provides explanation of behaviors.</td>
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<tr>
<td>5</td>
<td>Physical Science</td>
<td>Students collect data on distance and time as cars move down ramps. Students calculate velocities and enter data spreadsheets to create graphs to predict how changes in variables will affect motion. Students collect data on distance and time as cars move down ramps. Students calculate velocities.</td>
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</tr>
<tr>
<td>7</td>
<td>Physical Science</td>
<td>Using experimentally acquired data, students calculate density from mass and volume, enter data in spreadsheets, and generate graphs. Graphs are used to describe the relationship among mass, volume, and density. Students convert units. Students match calculated densities to actual densities to calculate percent error. Students use the graph to predict densities as either mass or volume change. Students calculate the density of various objects.</td>
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<tr>
<td>High School</td>
<td>Chemistry</td>
<td>Using experimentally acquired data, students calculate and express relationships among variables for investigations where they predict the quantities of reactants required and the products produced in a given chemical reaction. Balancing teacher-generated equations</td>
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