SCIENCE AND ENGINEERING PRACTICES
PERFORMANCE EXPECTATIONS
PERFORMANCE INDICATOR
S.1A.1: ASK QUESTIONS

<table>
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<th>Grade Level Progressions</th>
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| **K.S.1A.1**  
1.S.1A.1  
2.S.1A.1 | Ask and answer questions about the natural world using explorations, observations, or structured investigations. |
| **3.S.1A.1**  
4.S.1A.1 | Ask questions that can be (1) answered using scientific investigations or (2) used to refine models, explanations, or designs. |
| **5.S.1A.1** | Ask questions to (1) generate hypotheses for scientific investigations or (2) refine models, explanations, or designs. |
| **6.S.1A.1**  
7.S.1A.1  
8.S.1A.1 | Ask questions to (1) generate hypotheses for scientific investigations, (2) refine models, explanations, or designs, or (3) extend the results of investigations or challenge claims. |
| **H.B.1A.1**  
H.C.1A.1  
H.P.1A.1  
H.E.1A.1 | Ask questions to (1) generate hypotheses for scientific investigations, (2) refine models, explanations, or designs, or (3) extend the results of investigations or challenge scientific arguments or claims. |

**Specific Changes per Grade**

- In grades K-2, performance expectations include *asking and answering questions* through explorations, observations, and investigations.
- Starting in grade 3, performance expectations expand to include asking questions that will be *answered through investigations* or are used to *refine models, explanations, or designs*.
- The concept of a *scientific hypothesis* is introduced in grade 5.
- Starting in grade 6, performance expectations expand to include asking questions *based on the results of investigations*.
- Starting in grade 6, performance expectations expand to include asking questions to *challenge claims*.
- Starting in grade 9, performance expectations expand to include asking questions to *challenge scientific arguments*. 
Questions drive science and engineering. It is an essential practice to developing scientific habits of mind. These questions are driven by curiosity, by the desire to understand a phenomenon, or by the need to solve a problem. Asking real questions and defining real problems are not done for their own sake. In science, a question should always lead to an investigation to acquire the necessary evidence in an attempt to answer that question. In engineering, defining the problem should always lead to the designing and testing of a solution to that problem.

- Science begins with questions about phenomena, seeking to gather the evidence necessary to construct an explanation about the phenomena. Asking questions leads towards inquiry.
- Engineering begins with a problem, need, or desire and seeks to develop and test a solution to solve the problem, meet the need, or fulfill the desire. Defining problems leads towards design.

**Scientific vs. Non-scientific questions**
- Scientific questions can be addressed through quantifiable data. These data are reproducible through carrying out investigations and should be consistent across trials. This process leads towards a scientific explanation that is well supported by evidence from the data.
- Non-scientific questions do not lend themselves to the collection of quantifiable data or simply cannot be addressed through a structured, scientific investigation. In the case of the former, they cannot be answered through the acquisition of data that is reproducible across investigations. Answers to these questions will not be consistent because the data will not be consistent.

**The kinds of questions scientists ask**
- What exists and what happens?
- What causes it to happen?
- How does one know?
- What constitutes data?
- How can information (evidence, explanations, and models) about this phenomenon be communicated?

**The kind of questions engineers ask**
- What can be done to address this particular need or want?
- How can the need be better specified (criteria for success, constraints, what should be tested)?
- Why does this need exist?
- What tools and technologies are available or could be developed for addressing this need?
- How can the solution to the need be communicated?

The goals for this practice are for students to generate questions about phenomena, to distinguish scientific from non-scientific questions, to formulate and refine questions that can be tested, to
probe the premises of arguments, to identify needs and desires behind an engineering problem, and to define constraints and specifications for a solution.

**INSTRUCTIONAL GUIDANCE AND CONSIDERATIONS**

The best questions and problems are those posed or defined by the students. Questions can emerge in a variety of ways:

- Curiosity about some witnessed phenomena
- Prompted by sources of information (readings, videos, visuals, etc...)
- Inspired by explanatory models and theories of phenomena (making predictions, refining, revising, and applying existing models and theories)
- Answers to questions can lead to more questions
- Seeking different ways to solve a problem

**Strategies for generating questions**

- Engage in discussion around phenomena (can be familiar or novel)
- Categorize and distinguish questions into groups
- Distinguish between scientific and non-scientific questions
- Identify the purpose behind the questions (questions are not just for their own sake)

**Brainstorming variables to generate questions**

- In groups, brainstorm different things that affect the phenomenon you are learning about.
- Use this list to narrow down a single variable that can be investigated. (The rest of the items on your list become your controls in the investigation).
- Pose a researchable question related to the variable.
- Identify what you are testing (the independent variable) and what you plan to measure (the dependent variable).
- If your question contains both the thing you are testing and the thing you plan to measure, you have generated a testable question!

**Strategies for defining problems**

- Discuss a real or hypothetical scenario that needs to be addressed.
- Brainstorm possible constraints, challenges, concerns, and circumstances that might influence or limit the possible design of a solution or device.
- Use brainstorming to define a specific problem to be addressed.
- Make a list of what is already known about the problem and what still needs to be learned.
- Identify how a successful solution to the problem might look and how success will be measured.
EVIDENCE OF MASTERY

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

- Ask scientific questions. Scientific questions are questions about natural phenomena and/or processes that can be answered through scientific investigations and experimentations.
- Ask scientific questions that reflect or are based upon scientific information. Scientific information can include scientific informational texts and media, data from observations and measurements, models, natural phenomena and processes.
- Distinguish between scientific and non-scientific questions.
- Ask questions about authentic human needs and problems that will lead to designing solutions.
- Ask questions about the parameters related to human problems and needs.

CONNECTIONS WITH OTHER SCIENCE AND ENGINEERING PRACTICES

- Plan and Carry Out Investigations (S.1A.3)
  - The questions and problems define the purpose behind any investigation, whether it is to seek an answer to the question or to test a solution to a problem.
- Analyze and Interpret Data (S.1A.4) and Use Mathematics and Computations Thinking (S.1A.5)
  - Evidence and data acquired through investigation are analyzed and interpreted in order to construct an explanation that serves as an answer to the questions or to see if the proposed solution being tested is an effective solution to the problem.
- Engage in Argument from Evidence (S.1A.7) and Construct Explanations (S.1A.6)
  - Claims argued with acquired evidence are where possible answers or solutions are proposed, debated, and evaluated. Explanations and solutions arise when claims are vetted and stand up to being evaluated through the argumentation process. In either case, they serve as proposed and accepted answers to the initial questions and solutions to the initial problems.
- Obtain, Evaluate, and Communicate Information (S.1A.8) and Develop and Use Models (S.1A.2)
  - Information and models can serve to put questions into the context of the science content. They can also serve as a way to develop the necessary prior knowledge from which questions and problems can be proposed.
- Construct Devices or Design Solutions (S.1B.1)
  - Engineers identify problems in much the same was that scientists ask questions. Instead of leading to investigations, problems lead to the development and testing of solutions.
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.

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<th>Grade</th>
<th>Subject</th>
<th>Example</th>
<th>Non Example</th>
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<tr>
<td>K-2</td>
<td>Life Science</td>
<td>Students observe pill bugs for a given time period and are prompted to generate questions based on their observation of the pill bugs’ behavior.</td>
<td>Teacher provides a set of questions for students to answer about pill bugs.</td>
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<td>3-4</td>
<td>Earth Science</td>
<td>Students generate questions about water's effect on land forms prior to an investigation. They generate additional questions based on information gained through that investigation to refine models and understandings.</td>
<td>Teacher provides information on water's effect on landforms and has students answer teacher provided questions.</td>
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<td>5</td>
<td>Physical Science</td>
<td>Students generate questions, allowing them to make predictions about the relationships between different variables and solution rates.</td>
<td>Teacher directs students to conduct an investigation verifying that table salt dissolves faster in hot water than in cold water.</td>
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<tr>
<td>6</td>
<td>Life Science</td>
<td>Students conduct an investigation to determine the environmental factors that affect the development of flowering plants. Students use the data from the investigation to further question how those variables have different effects on plants.</td>
<td>Teacher provides scripted labs to test variables.</td>
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<tr>
<td>8</td>
<td>Physical Science</td>
<td>Students, when presented with the claim that waves transmit energy, generate questions that challenge that claim.</td>
<td>Teacher provides multiple examples of how waves transmit energy and provides a scripted lab to reinforce that waves transmit energy.</td>
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<td>High School</td>
<td>Biology</td>
<td>Students generate questions to evaluate quantitative data regarding the effects of greenhouse gas on the carbon cycle and global climate change.</td>
<td>Teacher presents conclusion from data about the effects of greenhouse gases on the carbon cycle and global climate change.</td>
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<td>High</td>
<td>Chemistry</td>
<td>Students plan and conduct a controlled</td>
<td>Students conduct a</td>
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<td>School</td>
<td>scientific investigation that generates mathematical data illustrating how mass is conserved in a chemical reaction. Students may use the outcome of the investigation to generate additional questions about different chemical reactions and how mass is conserved in those scenarios.</td>
<td>teacher-designed lab that verifies expected outcomes concerning the law of conservation of mass.</td>
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