Florida Interim Assessment Item Bank and Test Platform

Item Specifications

Science
Physics
Grades 9–12

GREAT SEAL OF THE STATE OF FLORIDA
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FLORIDA DEPARTMENT OF EDUCATION
www.fldoe.org

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Tallahassee, Florida
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I. Introduction

The U.S. Department of Education awarded a Race to the Top grant to Florida in August 2010. An important component of this grant focused on the development of high-quality assessment items and balanced assessments for use by districts, schools, and teachers. The assessment items will be stored in the Florida Interim Assessment Item Bank and Test Platform (IBTP), a statewide secure system which allows Florida educators to search the item bank, export test items, and generate customized high-quality assessments for computer-based delivery or paper-and-pencil delivery. The IBTP allows Florida educators to determine what students know and are able to do relative to instruction on Florida's Next Generation Sunshine State Standards and the Common Core State Standards (CCSS).

A. Purpose of the Item Specifications

The *Item Specifications* define the expectations for content, standards alignment, and format of assessment items for the Item Bank and Test Platform. The *Item Specifications* are intended for use by item writers and reviewers in the development of high-quality assessment items.

B. Scope

The *Item Specifications* provide general and grade-specific guidelines for the development of all Grades 9–12 Physics assessment items available in the Florida Interim Assessment Item Bank.

C. Standards Alignment

Items developed for the Florida Interim Assessment Item Bank and Test Platform will align to the Next Generation Sunshine State Standards for Science and, where appropriate and applicable, the Common Core State Standards for Mathematics and Literacy in Science and Technical Subjects.

1. Next Generation Sunshine State Standards

Florida's Next Generation Sunshine State Standards (NGSSS) for Science provide the basis for science teaching and learning in Florida's public schools. For Grades 9–12 Physics, the NGSSS are divided into benchmarks that identify what a student should know and be able to do in each course. The NGSSS are available at *http://www.floridastandards.org/homepage/index.aspx*.

2. Common Core State Standards

Selected standards from the Common Core State Standards for Mathematics and Literacy in Science and Technical Subjects have been embedded in Florida's course descriptions for Grades 6–12 science courses to provide support for science literacy and mathematics skills. Appendix B of this document provides a list of the CCSS Mathematics and Literacy Standards associated with the Grades 9–12 Physics courses. Assessment items for Physics should be aligned to one or more of the associated CCSS, whenever appropriate, in addition to the targeted physics benchmark.

II. Criteria for Item Development

Science item writers for the Florida Interim Assessment Item Bank must have a comprehensive knowledge of science curriculum based on the Next Generation Sunshine State Standards and an understanding of the range of cognitive abilities of the target student population. Item writers should understand and consistently apply the guidelines established in this document. Item writers are expected to use their best judgment in writing items that measure the science benchmarks of the NGSSS and the CCSS, where appropriate, without introducing extraneous elements that reflect bias for or against a group of students.

A. Overall Considerations for Item Development

These guidelines are provided to ensure the development of high-quality assessment items for the Florida Interim Assessment Item Bank.

1. Each item should be written to measure primarily one NGSSS benchmark; however, other benchmarks may also be addressed for some item types.
2. Whenever possible, each item will also be aligned to a secondary CCSS Mathematics and/or Literacy standard applicable to a particular grade.
3. Items should be appropriate for students in terms of grade-level instruction, experience and difficulty, cognitive development, and reading level. The reading level of the test items should be on grade level. (Refer to the glossaries in CPALMS for each course.)
4. Of the assessment items associated with a given benchmark, 50% or more should meet or exceed the cognitive level (DOK) of the benchmark.
5. Each item should be written clearly and unambiguously to elicit the desired response.
6. Items should not disadvantage or exhibit disrespect to anyone in regard to age, gender, race, ethnicity, language, religion, socioeconomic status, disability, occupation, or geographic region.

B. Item Contexts

The context in which an item is presented is called the item context or scenario. These guidelines are provided to assist item writers with development of items within an appropriate context.

1. The item context should be designed to interest students at the targeted level. Scenarios should be appropriate for students in terms of grade-level experience and difficulty, cognitive development, and reading level.
2. The context should be directly related to the question asked. The context should lead the student cognitively to the question. Every effort should be made to keep items as concise as possible without losing cognitive flow or missing the overall idea or concept.
3. Information and/or data in items must be accurate and verifiable using reliable sources. Source documentation should accompany items as needed.

4. All item scenarios, graphics, diagrams, and illustrations must be age-, grade-, and experience-appropriate.
5. Item contexts and illustrations depicting individuals conducting laboratory investigations should include proper safety equipment and model safe laboratory procedures.
6. Scenarios describing scientific investigations should model current science methodology and adhere to the Intel International Science and Engineering Fair Rules and Guidelines unless otherwise noted in the benchmark clarification statements. These rules and guidelines can be found using the Document Library link at: *http://www.societyforscience.org/ISEF*.
7. Items or illustrations may include, but are not limited to, the following common laboratory tools: dissection equipment, electronic balance, flask, hot plate, meter stick, petri dish, pH sensor, pipette, probe, prism, pulley, test strips, triple-beam balance, battery, beaker, compass, eyedropper, flashlight, graduated cylinder, light bulb, magnet, metric measuring tape, metric ruler, microscope, microscope slide, model, safety goggles, spring scales, stopwatch, telescope, test tube, thermometer, and topographic map.
8. The item content should be timely but not likely to become dated.

C. Use of Media

Media can be used to provide either necessary or supplemental information—that is, some media contain information that is necessary for answering the question, while other media support the context of the question. Items may include diagrams, illustrations, charts, tables, audio files, or video files unless otherwise noted in the Individual Benchmark Specifications.

1. Items should not begin with media. Media in items is always preceded by text.
2. All visual media (tables, charts, graphs, photographs, etc.) should be titled. Titles should be in all caps, boldfaced, and centered, and may be placed above or below the visual media.

D. Item Style and Format

This section presents stylistic guidelines and formatting directions that should be followed while developing items.

1. Items should be clear and concise and should use vocabulary and sentence structure appropriate for the assessed grade level. Writers should refer to the resources provided during item writer training and to the glossaries in CPALMS.
2. The words *most likely* or *best* should be used only when appropriate to the question.
3. At Grades 9–12, temperatures should be given in degrees Celsius unless otherwise noted in the Individual Benchmark Specifications.

4. Metric units of measure should be used in scenarios addressing mass, length, weight, and/or volume. International System of Units (SI) should be used unless otherwise noted in the Individual Benchmark Specifications.
5. The first occurrence of units of measure should be written out in the item stem, e.g., kilograms (kg). In graphics, an abbreviation may be used (e.g., g or cm). To avoid confusion between the preposition *in* and the abbreviation for inches, only units of measure in graphics should be presented, e.g., height (cm) NOT height (in cm).
6. In titles of tables and charts and in labels for axes, the unit of measure should be included, preferably in lowercase and in parentheses, e.g., height (m).
7. Items requiring art should be to scale whenever possible. If not possible, a not-to-scale text box should be included at the bottom left of the art.
8. Graphics in items should be clearly labeled and contain all necessary information.
9. Items referring to new developments or discoveries should include phrases similar to *according to current knowledge* or *based on current knowledge*.
10. Items using the word *not* should emphasize the word *not* using all uppercase letters (e.g., Which of the following is NOT an example of . . .). The word *not* should be used sparingly.
11. As appropriate, boldface type should be used to emphasize key words in the item (e.g., **least**, **most**, **greatest**, **percent**, **best**).
12. Masculine pronouns should NOT be used to refer to both sexes. Name(s) should be used whenever possible to avoid gender-specific pronouns (e.g., instead of "The student will make changes so that he . . .", use "John and Maria will make changes so that they . . .").
13. Grades 9–12 items may express values using scientific notation
14. Decimal numbers between –1 and 1 should have a leading zero.
15. SI units should be expressed in a single type of unit when possible (e.g., 1.4 kilograms instead of 1 kilogram 400 grams).
16. Commas should be used in numbers greater than or equal to 1,000 except for numbers having an SI unit. In this case, numbers with four digits should be presented without a comma or a space (e.g., 9960 meters). Numbers with more than four digits should be presented with a thin space inserted in place of a comma (e.g., 10 123 kilograms).
17. In most cases, scenarios involving elements, chemical formulas, or chemical symbols and/or equations should be written out followed by the abbreviation, e.g., carbon dioxide (CO_2).
18. In the item stem, values needed to compute answers should be presented as numerals.

E. Item Types

This section presents guidelines for development of the following types of items:

- Selected Response (SR)—1 point
- Gridded Response (GR)—1 point
- Short Response (SHR)—1 point
- Constructed Response (CR)—2 points
- Extended Response (ER)—4 points
- Essay Response (ESR)—6 points
- Performance Task (PT)—1–10 points

1. Selected Response (SR) Items (1 point)

Selected response items require students to choose an answer from the choices given. Each item consists of a stem and either three or four answer options, depending on the grade level (see #3 below). One of the answer options is the correct answer, and the remaining options are called distractors. Selected response items may also include a stimulus and/or passage.

1. SR items should take approximately one minute per item to answer.
2. SR items are worth one point each.
3. SR items for grades K, 1, and 2 should have three answer options (A, B, and C). SR items for all other grades and courses should have four answer options (A, B, C, and D).
4. SR items must have only one correct answer option.
5. During item development and review, the correct response should be indicated.
6. During item development and review, the rationale for distractors (incorrect answer choices) should be indicated. The rationale should include information explaining why a student would select that distractor.
7. Distractor rationales should represent computational or conceptual errors or misconceptions commonly made by students who have not mastered the assessed concepts.
8. Each distractor should be a believable answer (i.e., plausible, but incorrect).
9. All answer options should be written in a style appropriate to the question asked. For example, a “how” question should have answer options that explain how.
10. Options should have parallel structure whenever possible. Test item options should not have an outlier (e.g., an answer option that is significantly longer than or different from the other options).
11. Items should not be clued or answered by information in the stem or other options.

12. Options such as *none of the above*, *all of the above*, *not here*, *not enough information*, or *cannot be determined* should not be used as answer options.
13. If an option is a single word or a phrase, the option should start with a lowercase letter. If an option is a sentence, the sentence should be conventionally capitalized and punctuated. Options that are imperatives should be treated as sentences.
14. Answer options that are single words should be arranged in alphabetical or reverse alphabetical order.
15. Answer options that are phrases or sentences should be arranged from shortest to longest or longest to shortest.
16. Numerical answer options should be arranged in ascending or descending order.
17. Numerical answer options that represent relative magnitude or size should be arranged as they are shown in the stem or in some other logical order.
18. When the item requires the identification of a choice from the item stem, table, chart, or illustration, the options should be arranged as they are presented in the item stem, table, chart, or illustration.
19. If the answer options for an item are neither strictly numerical nor denominate numbers, the options should be arranged by the logic presented in the item, by alphabetical order, or by length.

2. Gridded Response (GR) Items (1 point)

Gridded response questions are worth 1 point each. The questions require students to solve problems and mark their answers by filling in the appropriate bubbles for the numbers on answer grids. Students must accurately complete the grid to receive credit for their answers.

3. Short Response (SHR) Items (1 point)

Short response items usually include a scenario and instructions on how to respond. The recommended time allotment for a student to respond is 3 minutes. A complete answer is worth 1 point. There are no partial points for this item type.

4. Constructed Response (CR) Items (2 points)

Constructed response items usually include a scenario and instructions on how to respond. The recommended time allotment for a student to respond is 5 minutes. A complete answer is worth 2 points and a partial answer is worth

1 point. The constructed response holistic rubric and exemplar specific to each item are used for scoring as follows:

SCORING RUBRIC	
2	A score of two indicates that the student has demonstrated a thorough understanding of the scientific concepts and/or procedures embodied in the task. The student has completed the task correctly, in a scientifically sound manner. When required, student explanations and/or interpretations are clear and complete. The response may contain minor flaws that do not detract from the demonstration of a thorough understanding.
1	A score of one indicates that the student has provided a response that is only partially correct. For example, the student may arrive at an acceptable conclusion or provide an adequate interpretation, but may demonstrate some misunderstanding of the underlying scientific concepts and/or procedures. Conversely, a student may arrive at an unacceptable conclusion or provide a faulty interpretation, but could have applied appropriate and scientifically sound concepts and/or procedures.
0	A score of zero indicates that the student has not provided a response or has provided a response that does not demonstrate an understanding of the scientific concepts and/or procedures embodied in the task. The student's explanation may be uninterpretable, lack sufficient information to determine the student's understanding, contain clear misunderstandings of the underlying scientific concepts and/or procedures, or may be incorrect.

Exemplars: A specific exemplar should be developed for each constructed response item. Exemplars will be used as scoring guides and should be specific to the item, but not so specific as to discount multiple correct answers. Exemplars should include a clear and defensible description of the top score point, and contain straightforward language that is accurate, complete, and easy to interpret.

5. **Extended Response (ER) Items (4 points)**

Extended response items include a scenario and instructions on how to respond and are worth 4 score points. However, ER items are usually more complex than SHR items and 2-point CR items. The recommended time allotment for a student to respond is 10–15 minutes. The extended response holistic rubric and exemplar specific to each item are used for scoring as follows:

SCORING RUBRIC	
4	A score of four indicates that the student has demonstrated a thorough understanding of the scientific concepts and/or procedures embodied in the task. The student has completed the task correctly, used scientifically sound procedures, and provided clear and complete explanations and interpretations. The response may contain minor flaws that do not detract from a demonstration of a thorough understanding.
3	A score of three indicates that the student has demonstrated an understanding of the scientific concepts and/or procedures embodied in the task. The student's response to the task is essentially correct, but the scientific procedures, explanations, and/or interpretations provided are not thorough. The response may contain minor flaws that reflect inattentiveness or indicate some misunderstanding of the underlying scientific concepts and/or procedures.
2	A score of two indicates that the student has demonstrated only a partial understanding of the scientific concepts and/or procedures embodied in the task. Although the student may have arrived at an acceptable conclusion or provided an adequate interpretation of the task, the student's work lacks an essential understanding of the underlying scientific concepts and/or procedures. The response may contain errors related to misunderstanding important aspects of the task, misuse of scientific procedures/processes, or faulty interpretations of results.
1	A score of one indicates that the student has demonstrated a very limited understanding of the scientific concepts and/or procedures embodied in the task. The student's response is incomplete and exhibits many flaws. Although the student's response has addressed some of the conditions of the task, the student has reached an inadequate conclusion and/or provided reasoning that is faulty or incomplete. The response exhibits many flaws or may be incomplete.
0	A score of zero indicates that the student has not provided a response or has provided a response that does not demonstrate an understanding of the scientific concepts and/or procedures embodied in the task. The student's explanation may be uninterpretable, lack sufficient information to determine the student's understanding, contain clear misunderstandings of the underlying scientific concepts and/or procedures, or may be incorrect.

Exemplars: A specific exemplar should be developed for each extended response item. Exemplars will be used as scoring guides and should be specific to the item, but not so specific as to discount multiple correct answers. Exemplars should include a clear and defensible description of the top score point, and contain straightforward language that is accurate, complete, and easy to interpret.

6. **Essay Response (ESR) Items (6 points)**

Essay response items consist of asking a general question or providing a stimulus (such as an article or research paper on a relevant topic), and asking the students to express their thoughts or provide facts about the topic using logic and reason. Essay response items encompass a higher level of thinking and a broader range of skills that includes CCSS literacy standards, both of which are critical to future success in higher education and the workforce.

In most cases, essay responses will go beyond a single paragraph in length, with a distinct introduction, body, and conclusion. An essay response will be worth a total of 6 points, with a rubric structure similar to that of the 4-point extended response. Students should be given about 20 to 30 minutes to complete each item.

Exemplars: A specific exemplar should be developed for each essay response item. Exemplars will be used as scoring guides and should be specific to the item, but not so specific as to discount multiple correct answers. Exemplars should include a clear and defensible description of the top score point, and contain straightforward language that is accurate, complete, and easy to interpret.

7. **Performance Task (PT) Items (1–10 points)**

Performance tasks are used to measure students' ability to *demonstrate* knowledge and skills from one or more benchmarks of the NGSSS and the CCSS. Specifically, performance tasks may require students to create a product, demonstrate a process, or perform an activity that demonstrates proficiency in science. They are evaluated using customized scoring rubrics, and each task may be worth 1–10 points. Performance tasks may have the following characteristics:

1. Performance tasks may cover a short time period or may cover an extended period of time.
2. Performance tasks must contain clear and explicit directions for understanding and completing the required component tasks and producing the objective output.
3. All tasks, skills, and/or behaviors required by the performance tasks must be objective, observable, and measurable.
4. All necessary equipment, materials, and resources should be referenced within the text of the performance task.
5. Performance tasks should elicit a range of score points.
6. Performance tasks generally require students to organize, apply, analyze, synthesize, and/or evaluate concepts.

7. Performance tasks may measure performance in authentic situations and outside the classroom, where appropriate and practical.
8. Typical response formats include demonstrations, laboratory performance, oral presentations, exhibits, or other products.
9. Every performance task requires a companion rubric to be used for scoring purposes. Rubrics should meet the following criteria:
    a. The rubrics and performance tasks should be developed in tandem to ensure compatibility.
    b. Rubrics must be specific to the individual requirements of each performance task; generic rubrics are not acceptable.
    c. The rubric must allow for efficient and consistent scoring.
    d. The customized rubric will also serve as an exemplar and should include a clear and defensible description of the top score point, and contain straightforward language that is accurate, complete, and easy to interpret.
    e. The highest score descriptor should allow for all foreseeable methods of correctly and thoroughly completing all requirements of the performance task.

A performance task may address one or more benchmarks or standards and may be composed of multiple items. The expectation is the performance tasks will include a demonstration of the student's mastery of the benchmark or standard. Items are expected to have rubrics.

F. Complex Stimuli and Reading Passages

The cross-curricular focus on aligning Florida IBTP items with the Common Core State Standards for mathematics and literacy make complex reading passages important components of the item bank. A passage is a segment of written work, followed by a series of questions that assess the student's comprehension of reading and the content presented. Some science items will be associated with a reading passage, while others will be standalone items.

G. Readability

Items must be written with readability in mind. In addition, vocabulary must be appropriate for the grade level being tested. The following sources provide information about the reading level of individual words:

Taylor, Stanford E. *EDL Core Vocabularies: Reading, Mathematics, Science, and Social Studies*. Austin, TX: Steck-Vaughn-EDL, 1989.

Mogilner, Alijandra. *Children's Writer's Word Book*. Cincinnati, OH: Writer's Digest Books, 1992.

H. Cognitive Complexity

1. Overview

Florida's adoption of the Common Core State Standards (CCSS) for Mathematics and English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects presents Florida with an opportunity to revise its current Depth of Knowledge (DOK) Model of Cognitive Complexity. More information about Florida's Depth of Knowledge levels is available online at *http://www.cpalms.org/cpalms/dok.aspx*.

2. **Levels of Depth of Knowledge for Science**

   Interpreting and assigning Depth of Knowledge levels to objectives within science standards and assessment items is an essential requirement of alignment analysis. Please note that, in science, "knowledge" can refer to content knowledge, knowledge of science processes, and nature of science.

   Level 1 (Recall) is the recall of information such as a fact, definition, or term, as well as performing a simple science process or procedure. Level 1 only requires students to demonstrate a rote response; use a well-known formula; follow a set, well-defined procedure (like a recipe); or perform a clearly defined series of steps. Standards that lend themselves to simple word problems that can be directly translated into and solved by a formula are considered Level 1. Some examples that represent but do not constitute all of Level 1 performance are:

   - Recall or recognize a fact, term, or property.
   - Represent in words or diagrams a scientific concept or relationship.
   - Provide or recognize a standard scientific representation for simple phenomena.
   - Perform a routine procedure, such as measuring length.
   - Identify familiar forces (e.g., pushes, pulls, gravitation, friction, etc.)
   - Identify objects and materials as solids, liquids, or gases.

   Level 2 (Basic Application of Concepts & Skills) includes the engagement of some mental processing beyond recalling or reproducing a response. The content knowledge or process involved is more complex than in Level 1. Level 2 requires that students make some decisions as to how to approach the question or problem. Level 2 activities include making observations and collecting data; classifying, organizing, and comparing data; and representing and displaying data in tables, graphs, and charts.

   Some action verbs, such as "explain," "describe," or "interpret," may be classified at different DOK levels, depending on the complexity of the action. For example, interpreting information from a simple graph, which requires reading information from the graph, is at Level 2. An activity that requires interpretation from a complex graph, such as making decisions regarding features of the graph that should be considered and how information from the graph can be aggregated, is at Level 3. Some examples that represent but do not constitute all of Level 2 performance are:

   - Specify and explain the relationships among facts, terms, properties, and variables.
   - Identify variables, including controls, in simple experiments.
   - Distinguish between experiments and systematic observations.

- Describe and explain examples and non-examples of science concepts.
- Select a procedure according to specified criteria and perform it.
- Formulate a routine problem given data and conditions.
- Organize and represent data.

Level 3 (Strategic Thinking & Complex Reasoning) requires reasoning, planning, using evidence, and a higher level of thinking than the previous two levels. The cognitive demands at Level 3 are complex and abstract. The complexity results not only from the fact that there could be multiple answers, a possibility for both Levels 1 and 2, but also because the multi-step task requires more demanding reasoning. In most instances, requiring students to explain their thinking is at Level 3; requiring a very simple explanation or a word or two should be at Level 2. An activity that has more than one possible answer and requires students to justify the response they give would most likely be at Level 3.

Experimental designs in Level 3 typically involve more than one dependent variable. Other Level 3 activities include drawing conclusions from observations; citing evidence and developing a logical argument for concepts; explaining phenomena in terms of concepts; and using concepts to solve non-routine problems. Some examples that represent but do not constitute all of Level 3 performance are:

- Identify research questions and design investigations for a scientific problem.
- Design and execute an experiment or systematic observation to test a hypothesis or research question.
- Develop a scientific model for a complex situation.
- Form conclusions from experimental data.
- Cite evidence that living systems follow the laws of conservation of mass and energy.
- Explain how political, social, and economic concerns can affect science, and vice versa.
- Create a conceptual or mathematical model to explain the key elements of a scientific theory or concept.
- Explain the physical properties of the Sun and its dynamic nature and connect them to conditions and events on Earth.
- Analyze past, present, and potential future consequences to the environment resulting from various energy production technologies.

Level 4 (Extended Thinking & Complex Reasoning) standards and assessment items have the same high cognitive demands as Level 3 with the additional requirement that students work over an extended period of time or with extended effort. Students are required to make several connections—relating ideas within the content area or among content areas—and have to select or devise one approach among many alternatives for how the situation or problem can be solved. Standards, goals, and objectives can be stated in such a way as to expect students to perform extended thinking. Many, but not all, performance assessments and open-ended assessment activities requiring significant thought will be at Level 4.

Level 4 requires complex reasoning and an extended period of time either for a science investigation relevant to a standard or for carrying out the complex analysis and synthesis required of an assessment item. For example, a standard or performance task that calls for the student to use evidence from multiple fields of scientific inquiry in supporting a scientific claim might be classified at Level 4, depending upon the complexity of the analysis. In any event, an activity or performance task associated with a Level 4 standard will require an extended period of time for a student to accomplish.

It is important to reiterate that the extended time period is not a distinguishing factor if the required work is only repetitive and does not require the application of significant conceptual understanding and higher-order thinking. For example, an activity that calls upon a student to measure the water temperature from a river each day for a month before constructing a graph would be classified as at Level 2. On the other hand, an activity that calls upon a student to conduct a complex river study that requires taking into consideration a number of variables would be at Level 4. Some examples that represent but do not constitute all of a Level 4 performance are:

- Based on provided data from a complex experiment that is novel to the student, deduce the fundamental relationships among several variables.
- Conduct an investigation, from specifying a problem to designing and carrying out an experiment and analyzing data and forming conclusions.
- Explain how a particular scientific theory (e.g., evolution, plate tectonics, atomic theory, etc.) is supported by evidence from multiple lines of inquiry.
- Produce a detailed report of a scientific experiment or systematic observation, and infer conclusions based upon evidence obtained.
- Write a detailed history of the development of an important scientific concept (e.g., atomic theory, gravitation) and explain how current conceptions developed from prior ones.

I. Item Difficulty

Item writers will not be expected to make a prediction of difficulty for each item created. However, item writers should develop items that reflect a range of difficulty levels.

J. Universal Design

The application of universal design principles helps develop assessments that are usable to the greatest number of students, including students with disabilities and nonnative speakers of English. To support the goal of providing access to all students, the items in the Florida Interim Assessment Item Bank maximize readability, legibility, and compatibility with accommodations, and item development includes a review for potential bias and sensitivity issues.

Items must allow for the widest possible range of student participation. Item writers must attend to the best practices suggested by universal design, including, but not limited to,

- reduction in wordiness;
- avoidance of ambiguity;
- selection of reader-friendly construction and terminology; and
- consistently applied concept names and graphic conventions.

Universal design principles also inform decisions about item layout and design, including, but not limited to, type size, line length, spacing, and graphics.

K. Sample Items

Appendix A of this document contains a selection of sample items. The sample items represent a range of cognitive complexities and item types.

III. Review Procedures for Florida Interim Assessment Item Bank Items

Prior to being included in the Florida Interim Assessment Item Bank, items must pass several levels of review as part of the item development process.

A. Review for Item Quality

Assessment items developed for the Florida Interim Assessment Item Bank are reviewed by Florida educators, the FDOE, and the Item Bank contractors to ensure the quality of the items, including grade-level appropriateness, standards alignment, accuracy, and other criteria for overall item quality.

B. Review for Bias and Sensitivity

Items are reviewed by groups of Florida educators generally representative of Florida's geographic regions and culturally diverse population. Items are reviewed for the following kinds of bias: gender, racial, ethnic, linguistic, religious, geographic, and socioeconomic. Item reviews also include consideration of issues related to individuals with disabilities.

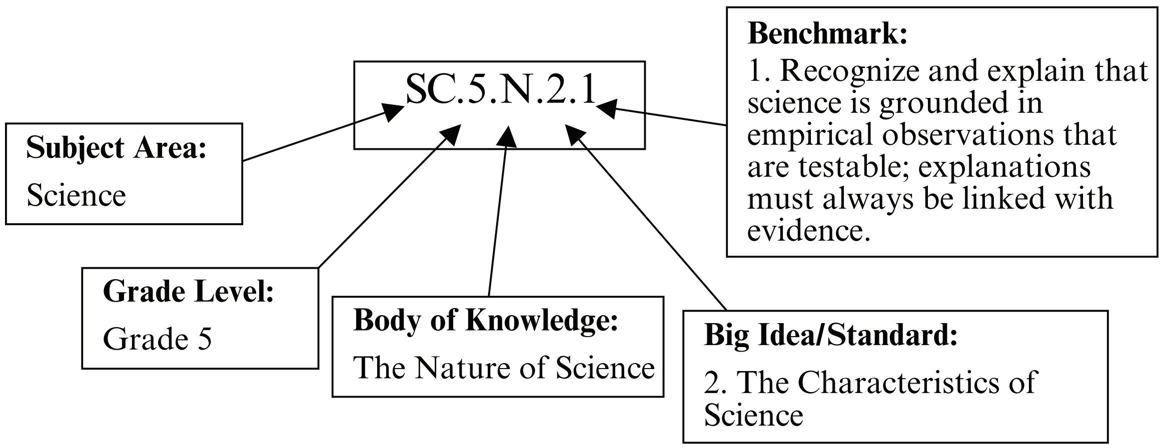
This review is to ensure that the primary purpose of assessing student achievement is not undermined by inadvertently including in the item bank any material that students, parents, or other stakeholders may deem inappropriate. Reviewers are asked to consider the variety of cultural, regional, philosophical, political, and religious backgrounds throughout Florida and to determine whether the subject matter will be acceptable to Florida students, their parents, and other members of Florida communities.

IV. Guide to the Individual Benchmark Specifications

A. Benchmark Classification System

Each benchmark in the NGSSS is labeled with a system of numbers and letters.

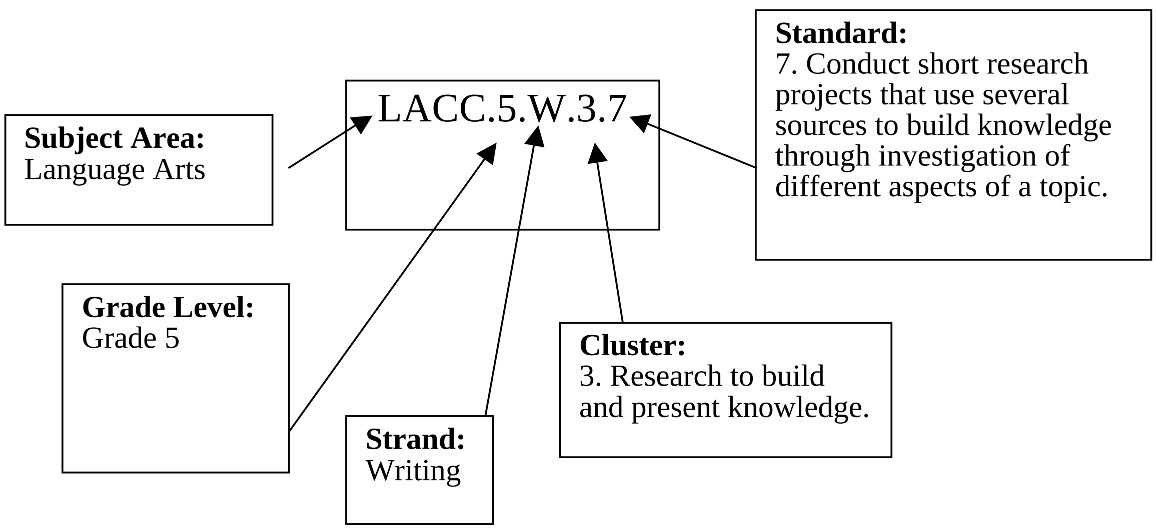
- The two letters in the *first position* of the code identify the **Subject Area**.
- The number(s) in the *second position* represent the **Grade Level**.
- The letter in the *third position* represents the **Body of Knowledge**.
- The number in the *fourth position* represents the **Big Idea/Standard**.
- The number in the *last position* identifies the specific **Benchmark**.



B. Common Core State Standard Classification System

Each standard in the CCSS is also labeled with a system of numbers and letters.

- The four letters in the *first position* of the code identify the **Subject Area**.
- The number(s) in the *second position* represent the **Grade Level**.
- The letter in the *third position* represents the **Strand**.
- The number in the *fourth position* represents the **Cluster**.
- The number in the *last position* identifies the specific **Standard**.



V. Definitions of Benchmark Specifications

The *Item Specifications* identify how the benchmarks in Florida's NGSSS and the CCSS are assessed by items in the Florida Interim Assessment Item Bank. For each assessed benchmark, the following information is provided in the Individual Benchmark Specifications section.

Body of Knowledge/ Strand	refers to the general category of science knowledge (Earth/Space Science, Life Science, Physical Science, and Nature of Science).
Standard/Big Idea	refers to a main idea or description statement of general expectations regarding knowledge and skill development.
Benchmark	refers to specific statements of expected student achievement.
Common Core State Standard Connections	refers to the Common Core Literacy and Mathematics Standards that are closely related to the benchmark. (See Appendix B for a list of CCSS standards associated with this course/grade band.)
Benchmark Clarifications	explain how achievement of the benchmark will be demonstrated by students. The clarification statements explain what students are expected to do when responding to the question.
Content Limits	define the range of content knowledge and degree of difficulty that should be assessed in the items for the benchmark. Content limits may be used to identify content beyond the scope of the targeted benchmark if the content is more appropriately assessed by another benchmark. These statements help to provide validity by ensuring the test items are clearly aligned to the targeted benchmark.

VI. Individual Benchmark Specifications

This section of the *Item Specifications* provides benchmark-specific guidance for assessment item development based on the NGSSS Physics benchmarks for Grades 9–12.

A. Grades 9–12 Physics Item Specifications

Course Number: 2003380

Benchmark SC.912.E.5.2	
Body of Knowledge/ Strand	**Earth and Space Science**
Standard	**5: Earth in Space and Time**
Benchmark	**SC.912.E.5.2: Identify patterns in the organization and distribution of matter in the universe and the forces that determine them.**
Common Core State Standard Connections	Indicate appropriate alignments to the Grades 9–12 CCSS Mathematics and/or Literacy Standards for Science whenever applicable. (See Appendix B.)
Benchmark Clarifications	Students will • classify and distinguish among types of celestial bodies; and • describe the forces that affect the organization and distribution of matter in the universe.
Content Limits	Assessment will be limited to the distribution of normal matter, and items will not assess dark matter or dark energy. Items will not • require the use of the formula for the law of universal gravitation or the gravitational constant; or • require memorization of quantitative astronomical data. Items may include • images of galaxies with shapes easily identified as spiral, elliptical, or irregular; and • a chart listing the properties of one or more celestial bodies.

Benchmark SC.912.E.5.6	
Body of Knowledge/ Strand	**Earth and Space Science**
Standard	**5: Earth in Space and Time**
Benchmark	**SC.912.E.5.6: Develop logical connections through physical principles, including Kepler's and Newton's laws about the relationships and the effects of Earth, Moon, and Sun on each other.**
Common Core State Standard Connections	Indicate appropriate alignments to the Grades 9–12 CCSS Mathematics and/or Literacy Standards for Science whenever applicable. (See Appendix B.)
Benchmark Clarifications	Students will • explain the relative positions and motion of the Earth, Moon, and Sun using physical principles, including Kepler's and Newton's laws; • describe the physical principles that can be applied to the relationships among the Earth, Moon, and Sun, including Kepler's and Newton's laws; and • use the relative positions and motion of the Earth, Moon, and Sun to explain their effects on each other, such as the phases of the Moon, tides, seasons, and eclipses.
Content Limits	Items will not • require use of mathematical formulas for Kepler's laws of motion; or • assess the characteristics of the Moon, Sun, or Earth in isolation. Items may include diagrams of the relative position and motion of the Earth, Moon, and/or Sun. Items may be in the form of labeled illustrations. Items may address celestial bodies other than the Earth, Moon, and Sun.

Benchmark SC.912.N.1.1	
Body of Knowledge/ Strand	**Nature of Science**
Standard	**1: The Practice of Science**
Benchmark	**SC.912.N.1.1 Define a problem based on a specific body of knowledge, for example, biology, chemistry, physics, and earth/ space science, and do the following:** **1. pose questions about the natural world,** **2. conduct systematic observations,** **3. examine books and other sources of information to see what is already known,** **4. review what is known in light of empirical evidence,** **5. plan investigations,** **6. use tools to gather, analyze, and interpret data (this includes the use of measurement in metric and other systems and also the generation and interpretation of graphical representations of data, including data tables and graphs),** **7. pose answers, explanations, or descriptions of events,** **8. generate explanations that explicate or describe natural phenomena (inferences),** **9. use appropriate evidence and reasoning to justify these explanations to others,** **10. communicate results of scientific investigations, and** **11. evaluate the merits of the explanations produced by others.**
Common Core State Standard Connections	Indicate appropriate alignments to the Grades 9–12 CCSS Mathematics and/or Literacy Standards for Science whenever applicable. (See Appendix B.)
Benchmark Clarifications	Students will • evaluate or define a scientific investigation using evidence of scientific thinking and/or problem solving; • identify or define test variables (independent variables) and/or outcome variables (dependent variables) in a given scientific investigation; • interpret and/or analyze data to make predictions and/or defend conclusions; • distinguish between an experiment and other types of scientific investigations where variables cannot be controlled; and • explain how hypotheses are valuable.
Content Limits	Items will address physics only.

Benchmark SC.912.N.1.2	
Body of Knowledge/ Strand	**Nature of Science**
Standard	**1: The Practice of Science**
Benchmark	**SC.912.N.1.2: Describe and explain what characterizes science and its methods.**
Common Core State Standard Connections	Indicate appropriate alignments to the Grades 9–12 CCSS Mathematics and/or Literacy Standards for Science whenever applicable. (See Appendix B.)
Benchmark Clarifications	Students will • describe and explain science as a body of knowledge and processes based on scientific method; • recognize that science involves cause and effect relationships; and • describe and explain scientific method in the following steps: – Ask a question – Research/Gather evidence – Form a hypothesis – Test a hypothesis in an experiment – Analyze data – Interpret data and form a conclusion – Communicate results – Repeat an experiment
Content Limits	Items will address physics only.

Benchmark SC.912.N.1.5	
Body of Knowledge/ Strand	**Nature of Science**
Standard	**1: The Practice of Science**
Benchmark	**SC.912.N.1.5: Describe and provide examples of how similar investigations conducted in many parts of the world result in the same outcome.**
Common Core State Standard Connections	Indicate appropriate alignments to the Grades 9–12 CCSS Mathematics and/or Literacy Standards for Science whenever applicable. (See Appendix B.)
Benchmark Clarifications	Students will • describe or explain how scientific investigations ultimately follow the laws of the universe resulting in the same outcome regardless of the location of an investigation; and • recognize that scientific investigations are repeatable.
Content Limits	Items will address physics only. Items may not ask student to define a particular scientific law or theory. Items may reference familiar laws in physics on a conceptual level only.

Benchmark SC.912.N.1.6	
Body of Knowledge/ Strand	**Nature of Science**
Standard	**1: The Practice of Science**
Benchmark	**SC.912.N.1.6: Describe how scientific inferences are drawn from scientific observations and provide examples from the content being studied.**
Common Core State Standard Connections	Indicate appropriate alignments to the Grades 9–12 CCSS Mathematics and/or Literacy Standards for Science whenever applicable. (See Appendix B.)
Benchmark Clarifications	Students will • recognize the distinction between direct and indirect evidence when drawing a conclusion/inference; • understand that observation is the process of gathering data and that inference is the conclusion drawn about the gathered data; and • make inferences based on qualitative and quantitative observations.
Content Limits	Items will address physics only.

Benchmark SC.912.N.1.7	
Body of Knowledge/ Strand	**Nature of Science**
Standard	**1: The Practice of Science**
Benchmark	**SC.912.N.1.7: Recognize the role of creativity in constructing scientific questions, methods and explanations.**
Common Core State Standard Connections	Indicate appropriate alignments to the Grades 9–12 CCSS Mathematics and/or Literacy Standards for Science whenever applicable. (See Appendix B.)
Benchmark Clarifications	Students will • recognize that there are different ways to approach a scientific problem; and • recognize that there are different methods in conducting research.
Content Limits	Items will address physics only.

Benchmark SC.912.N.2.2	
Body of Knowledge/ Strand	**Nature of Science**
Standard	**2: The Characteristics of Scientific Knowledge**
Benchmark	**SC.912.N.2.2 : Identify which questions can be answered through science and which questions are outside the boundaries of scientific investigation, such as questions addressed by other ways of knowing, such as art, philosophy, and religion.**
Common Core State Standard Connections	Indicate appropriate alignments to the CCSS Literacy Standards for Science and Technical Subjects whenever applicable. (See Appendix B.)
Benchmark Clarifications	Students will • understand that science has limitations; • identify questions that are outside the boundaries of scientific investigation because they deal with phenomena that are not scientifically testable; and • identify valid questions to ask for scientific investigation (e.g., not valid: how happy a dog is based on the number of times the tail wags; valid: which type of dog food is preferred most?).
Content Limits	Items will assess physics-related scenarios/content only.

Benchmark SC.912.N.2.4	
Body of Knowledge/ Strand	**Nature of Science**
Standard	**2: The Characteristics of Scientific Knowledge**
Benchmark	**SC.912.N.2.4: Explain that scientific knowledge is both durable and robust and open to change. Scientific knowledge can change because it is often examined and re-examined by new investigations and scientific argumentation. Because of these frequent examinations, scientific knowledge becomes stronger, leading to its durability.**
Common Core State Standard Connections	Indicate appropriate alignments to the Grades 9–12 CCSS Mathematics and/or Literacy Standards for Science whenever applicable. (See Appendix B.)
Benchmark Clarifications	Students will construct, explain, describe, and/or compare different scientific scenarios using evidence and how thinking can change over time based on evidence.
Content Limits	Items will address physics only.

Benchmark SC.912.N.2.5	
Body of Knowledge/ Strand	**Nature of Science**
Standard	**2: The Characteristics of Scientific Knowledge**
Benchmark	**SC.912.N.2.5: Describe instances in which scientists' varied backgrounds, talents, interests, and goals influence the inferences and thus the explanations that they make about observations of natural phenomena and describe that competing interpretations (explanations) of scientists are a strength of science as they are a source of new, testable ideas that have the potential to add new evidence to support one or another of the explanations.**
Common Core State Standard Connections	Indicate appropriate alignments to the Grades 9–12 CCSS Mathematics and/or Literacy Standards for Science whenever applicable. (See Appendix B.)
Benchmark Clarifications	Students will • explain how competing interpretations from scientists create new, testable ideas and possibly new evidence supporting other scientists' explanations; and • describe that competing scientific explanations expand the knowledge of science concepts across the various fields of science.
Content Limits	Items will address physics only.

Benchmark SC.912.N.3.2	
Body of Knowledge/ Strand	Nature of Science
Standard	**3: The Role of Theories, Laws, Hypotheses, and Models**
Benchmark	**SC.912.N.3.2: Describe the role consensus plays in the historical development of a theory in any one of the disciplines of science.**
Common Core State Standard Connections	Indicate appropriate alignments to the Grades 9–12 CCSS Mathematics and/or Literacy Standards for Science whenever applicable. (See Appendix B.)
Benchmark Clarifications	Students will recognize that scientific theories (e.g. particle, relativity, conservation of energy) are supported by evidence and agreement of many scientists.
Content Limits	Items will • focus on content related to theories in physics; and • specifically focus on the role of consensus/agreement of scientists from a historical perspective. Items will not • expect the memorization of the names of scientists or specific scientific experiments associated with theories; or • include equations or calculations.

Benchmark SC.912.N.3.3	
Body of Knowledge/ Strand	Nature of Science
Standard	**3: The Role of Theories, Laws, Hypotheses, and Models**
Benchmark	**SC.912.N.3.3: Explain that scientific laws are descriptions of specific relationships under given conditions in nature, but do not offer explanations for those relationships.**
Common Core State Standard Connections	Indicate appropriate alignments to the Grades 9–12 CCSS Mathematics and/or Literacy Standards for Science whenever applicable. (See Appendix B.)
Benchmark Clarifications	Students will explain that scientific laws apply to physical relationships under given conditions, but they do not provide a specific explanation, inference, or conclusion about that relationship.
Content Limits	Items will focus on content related to laws in Physics.

Benchmark SC.912.N.3.4	
Body of Knowledge/ Strand	**Nature of Science**
Standard	**3: The Role of Theories, Laws, Hypotheses, and Models**
Benchmark	**SC.912.N.3.4: Recognize that theories do not become laws, nor do laws become theories; theories are well-supported explanations and laws are well-supported descriptions.**
Common Core State Standard Connections	Indicate appropriate alignments to the CCSS Literacy Standards for Science and Technical Subjects whenever applicable. (See Appendix B.)
Benchmark Clarifications	Students will • recognize that laws are observable fact; • recognize laws as statements that are simple, true, universal, and absolute; • recognize that scientific theories are based on laws, and not vice versa; • recognize theories are subject to change as new areas of science and technologies are developed; and • differentiate laws from theories.
Content Limits	Items will only assess laws and theories in physics for this benchmark.

Benchmark SC.912.N.3.5	
Body of Knowledge/ Strand	**Nature of Science**
Standard	**3: The Role of Theories, Laws, Hypotheses, and Models**
Benchmark	**SC.912.N.3.5: Describe the function of models in science, and identify the wide range of models used in science.**
Common Core State Standard Connections	Indicate appropriate alignments to the Grades 9–12 CCSS Mathematics and/or Literacy Standards for Science whenever applicable. (See Appendix B.)
Benchmark Clarifications	Students will • describe models as important tools to help scientists explore and explain their ideas; • recognize that there are many different types of models including physical, mathematical, illustrative, statistical, computer, theoretical, etc.; and • recognize that drawings and prototypes are other examples of models.
Content Limits	Item content should assess content related to physics at this benchmark. Items will not ask students to construct, solve, or recall mathematical or statistical equations.

Benchmark SC.912.N.4.1	
Body of Knowledge/ Strand	**Nature of Science**
Standard	**4: Science and Society**
Benchmark	**SC.912.N.4.1: Explain how scientific knowledge and reasoning provide an empirically-based perspective to inform society's decision making.**
Common Core State Standard Connections	Indicate appropriate alignments to the Grades 9–12 CCSS Mathematics and/or Literacy Standards for Science whenever applicable. (See Appendix B.)
Benchmark Clarifications	Students will distinguish between pure and applied research and how knowledge gained is used to better inform society's decision makers regarding problem solving. Given a particular decision that needs to be made, students will describe scientific research that could be done to help the decision-making process at the community, state, national, or international levels.
Content Limits	Items will not address controversial or complex issues. Items will focus on physics for this benchmark.

Benchmark SC.912.P.8.1	
Body of Knowledge/ Strand	**Physical Science**
Standard	**8: Matter**
Benchmark	**SC.912.P.8.1: Differentiate among the four states of matter.**
Common Core State Standard Connections	Indicate appropriate alignments to the Grades 9–12 CCSS Mathematics and/or Literacy Standards for Science whenever applicable. (See Appendix B.)
Benchmark Clarifications	Students will • compare and contrast the major characteristics of the four states of matter: solid, liquid, gas, plasma; and • describe/differentiate the states of matter by the general arrangement and behavior of particles (atoms, ions, molecules) and phase transitions.
Content Limit	Items will only address plasma in general terms as an ionized gas in a high-energy state. Items will not assess non-classical definitions and states of matter such as quarks, dark matter, liquid crystal, glass, and superfluids.

Benchmark SC.912.P.8.3	
Body of Knowledge/ Strand	**Physical Science**
Standard	**8: Matter**
Benchmark	**SC.912.P.8.3: Explore the scientific theory of atoms (also known as atomic theory) by describing changes in the atomic model over time and why those changes were necessitated by experimental evidence.**
Common Core State Standard Connections	Indicate appropriate alignments to the Grades 9–12 CCSS Mathematics and/or Literacy Standards for Science whenever applicable. (See Appendix B.)
Benchmark Clarifications	Students will • analyze and differentiate among the theories and associated scientists that led to the modern atomic theory; • discuss the importance of certain experiments (e.g., cathode ray tube and gold foil that led to the discovery of the particles that make up the atom); and • explain how certain experiments led to the creation of the historical and modern atom models (e.g., the plum pudding atom and the nuclear atom).
Content Limit	Items will not • address details of quantum mechanics; or • include equations or calculations.

Benchmark SC.912.P.10.1	
Body of Knowledge/ Strand	**Physical Science**
Standard	**10: Energy**
Benchmark	**SC.912.P.10.1: Differentiate among the various forms of energy and recognize that they can be transformed from one form to another.**
Common Core State Standard Connections	Indicate appropriate alignments to the Grades 9–12 CCSS Mathematics and/or Literacy Standards for Science whenever applicable. (See Appendix B.)
Benchmark Clarifications	Students will • identify different forms of energy and differentiate among them; • recognize that energy can be transformed from one form to another; and • discuss tradeoffs between potential and kinetic energy.
Content Limits	Items will not • address mass-energy transformation; or • require calculation.

Benchmark SC.912.P.10.2	
Body of Knowledge/ Strand	**Physical Science**
Standard	**10: Energy**
Benchmark	**SC.912.P.10.2: Explore the law of conservation of energy by differentiating among open, closed, and isolated systems and explain that the total energy in an isolated system is a conserved quantity.**
Common Core State Standard Connections	Indicate appropriate alignments to the Grades 9–12 CCSS Mathematics and/or Literacy Standards for Science whenever applicable. (See Appendix B.)
Benchmark Clarifications	Students will • identify and differentiate among open, closed, and isolated systems; • explain that the total energy in an isolated system is a conserved quantity; • describe the transformation of one form of energy into another (e.g., potential into kinetic); and • identify the inputs and outputs of open systems.
Content Limits	Items will not • assess mass-energy conservation; • assess entropy; or • require calculation.

Benchmark SC.912.P.10.3	
Body of Knowledge/ Strand	**Physical Science**
Standard	**10: Energy**
Benchmark	**SC.912.P.10.3: Compare and contrast work and power qualitatively and quantitatively.**
Common Core State Standard Connections	Indicate appropriate alignments to the Grades 9–12 CCSS Mathematics and/or Literacy Standards for Science whenever applicable. (See Appendix B.)
Benchmark Clarifications	Students will • calculate work done on an object; • quantitatively and qualitatively relate power to work and time; and • interpret work vs. time diagrams.
Content Limits	Items will not • require calculation of forces (e.g., gravitational, electrical); or • assess conversions of units (e.g., calories to joules). Work will be in units of joules. Power will be in units of watts. Scenarios requiring calculation of work may include the work equation.

Benchmark SC.912.P.10.4	
Body of Knowledge/ Strand	**Physical Science**
Standard	**10: Energy**
Benchmark	**SC.912.P.10.4: Describe heat as the energy transferred by convection, conduction, and radiation, and explain the connection of heat to changes in temperature or states of matter.**
Common Core State Standard Connections	Indicate appropriate alignments to the Grades 9–12 CCSS Mathematics and/or Literacy Standards for Science whenever applicable. (See Appendix B.)
Benchmark Clarifications	Students will • describe heat as a transfer of energy; • differentiate between heat and temperature; • define and differentiate among convection, conduction, and radiation; and • explore the relation between heat and changes in temperature or states of matter.
Content Limits	Phases of matter will be limited to solids, liquids, and gases. Items will not • require memorization of thermal properties (e.g., phase transition temperatures); • assess connection between temperature and average molecular kinetic energy; • assess chemical or nuclear changes; • assess changes in entropy; or • assess unit conversion. Scenarios requiring calculation of temperature change may include the equation relating temperature change to heat. Scenarios requiring the calculation of heat required for a phase transition may include the appropriate equation.

Benchmark SC.912.P.10.5	
Body of Knowledge/ Strand	Physical Science
Standard	**10: Energy**
Benchmark	**SC.912.P.10.5: Relate temperature to the average molecular kinetic energy.**
Common Core State Standard Connections	Indicate appropriate alignments to the Grades 9–12 CCSS Mathematics and/or Literacy Standards for Science whenever applicable. (See Appendix B.)
Benchmark Clarifications	Students will • describe temperature change as a change in molecular velocities; • quantitatively explore the relationship between temperature and the average molecular kinetic energy (KE); and • use the kinetic theory of gases to qualitatively describe the relationship between temperature and pressure.
Content Limits	Items will address only scenarios with a single particle mass. Items will not • assess phase transitions; • require memorization of particle masses; • require memorization of equations or physical constants; or • assess unit conversion. Temperatures may be in kelvin. Energies will be in joules. Scenarios requiring calculation of particle velocity will include the kinetic energy equation. Scenarios requiring calculation of temperature will include the equation relating temperature to average KE.

Benchmark SC.912.P.10.10	
Body of Knowledge/ Strand	Physical Science
Standard	**10: Energy**
Benchmark	**SC.912.P.10.10: Compare the magnitude and range of the four fundamental forces (gravitational, electromagnetic, weak nuclear, strong nuclear).**
Common Core State Standard Connections	Indicate appropriate alignments to the Grades 9–12 CCSS Mathematics and/or Literacy Standards for Science whenever applicable. (See Appendix B.)
Benchmark Clarifications	Students will • identify scenarios in which each of the four forces is prevalent; • qualitatively compare the magnitudes of the four fundamental forces; and • qualitatively compare the range of the four fundamental forces.
Content Limits	Items will not • require use of the formula for the law of universal gravitation; • require use of the formula for the Lorentz law of electromagnetic force; • require memorization of physical constants; • assess grand unified theories; or • assess force mediators (e.g., photons, gluons). Number lines can be used to show relative positions of the four forces (in terms of either magnitude or range). Students can be asked to rank magnitudes or ranges.

Benchmark SC.912.P.10.13	
Body of Knowledge/ Strand	**Physical Science**
Standard	**10: Energy**
Benchmark	**SC.912.P.10.13: Relate the configuration of static charges to the electric field, electric force, electric potential, and electric potential energy.**
Common Core State Standard Connections	Indicate appropriate alignments to the Grades 9–12 CCSS Mathematics and/or Literacy Standards for Science whenever applicable. (See Appendix B.)
Benchmark Clarifications	Students will • describe and relate the two types of electric charge (positive and negative); • define, compare, and contrast electric fields, electric forces, electric potentials, and electric potential energies; • describe (qualitatively and quantitatively) the field strength, force, potential, and energy for a given charge arrangement.
Content Limits	Items will not • assess moving charges; • require memorization of physical constants or equations; • assess properties of conductors, semiconductors, and insulators; • assess capacitance. Items may include diagrams of charge arrangements and/or fields. Scenarios requiring calculation of force, potential, or energy may provide the relevant equations and physical constants. Scenarios will not include more than three point charges.

Benchmark SC.912.P.10.14	
Body of Knowledge/ Strand	**Physical Science**
Standard	**10: Energy**
Benchmark	**SC.912.P.10.14: Differentiate among conductors, semiconductors, and insulators.**
Common Core State Standard Connections	Indicate appropriate alignments to the Grades 9–12 CCSS Mathematics and/or Literacy Standards for Science whenever applicable. (See Appendix B.)
Benchmark Clarifications	Students will • define and contrast properties of conductors, semiconductors, and insulators; • describe what makes a material a good conductor or insulator (e.g., stability of valence electrons); and • describe the process of doping and how it alters the conductive properties of a material.
Content Limits	Items will not require calculation (e.g., of resistivity). Items will not assess semiconductor devices (e.g., diodes, transistors).

Benchmark SC.912.P.10.15	
Body of Knowledge/ Strand	**Physical Science**
Standard	**10: Energy**
Benchmark	**SC.912.P.10.15: Investigate and explain the relationships among current, voltage, resistance, and power.**
Common Core Literacy Standard Connections	Indicate appropriate alignments to the Grades 9–12 CCSS Mathematics and/or Literacy Standards for Science whenever applicable. (See Appendix B.)
Benchmark Clarifications	Students will • define current, voltage, resistance, and power; • use Ohm's law to explain the relationship between current, voltage, and resistance; • quantitatively relate power to current, voltage, and resistance; and • explain the relationships among power, energy, and time.
Content Limits	Scenarios will be limited to direct current systems. Items will not • require memorization of formulas; • assess series vs. parallel wiring; or • assess the physiological effects of electric current. The formula for Ohm's law may be provided for items requiring calculation. Items may include a circuit diagram.

Benchmark SC.912.P.10.18	
Body of Knowledge/ Strand	**Physical Science**
Standard	**10: Energy**
Benchmark	**SC.912.P.10.18: Explore the theory of electromagnetism by comparing and contrasting the different parts of the electromagnetic spectrum in terms of wavelength, frequency, and energy, and relate them to phenomena and applications.**
Common Core State Standard Connections	Indicate appropriate alignments to the Grades 9–12 CCSS Mathematics and/or Literacy Standards for Science whenever applicable. (See Appendix B.)
Benchmark Clarifications	Students will • compare and contrast different regions of the electromagnetic spectrum; • quantitatively explore the relationships among wavelength, frequency, and energy; and • relate different regions of the spectrum to technological applications and natural phenomena.
Content Limits	Items may assess relative order of spectrum regions in terms of wavelength, frequency, or energy. Items will not require • memorization of wavelength, frequency, or energy limits of spectrum regions; or • memorization of formulae or physical constants. Items may reference labeled drawing of electromagnetic spectrum. Items requiring calculation may provide the relevant formulas and physical constants. Options may be in the form of ordered lists (e.g., listing spectrum regions in decreasing order of energy).

Benchmark SC.912.P.10.20	
Body of Knowledge/ Strand	**Physical Science**
Standard	**10: Energy**
Benchmark	**SC.912.P.10.20: Describe the measurable properties of waves, explain the relationships among them, and explain how these properties change when the wave moves from one medium to another.**
Common Core State Standard Connections	Indicate appropriate alignments to the Grades 9–12 CCSS Mathematics and/or Literacy Standards for Science whenever applicable. (See Appendix B.)
Benchmark Clarifications	Students will • describe the measurable properties of waves (e.g., amplitude, frequency, wavelength); • explore the relationships among wave velocity, frequency, and wavelength; • describe how the speed of a wave depends on the medium in which it travels; and • use Snell's law to explore how wave direction changes upon entering a new medium.
Content Limits	Items will not assess mathematical wave descriptions (e.g., sines, cosines, complex exponentials). Items may refer to • sound waves but will not assess the underlying physics; • the electromagnetic spectrum but will not assess the electromagnetic spectrum; and • labeled wave drawings. Items will not assess Doppler shifts.

Benchmark SC.912.P.10.21	
Body of Knowledge/ Strand	**Physical Science**
Standard	**10: Energy**
Benchmark	**SC.912.P.10.21: Qualitatively describe the shift in frequency in sound or electromagnetic waves due to the relative motion of a source or a receiver.**
Common Core State Standard Connections	Indicate appropriate alignments to the Grades 9–12 CCSS Mathematics and/or Literacy Standards for Science whenever applicable. (See Appendix B.)
Benchmark Clarifications	Students will • describe how sound pitch is affected by relative motion of the source; • describe how color of light is affected by relative motion of the source; and • explain how wave speed is independent of the source.
Content Limits	Items will not require calculation of frequency or wavelength shifts. Items will not assess Doppler-related technologies. Items may reference illustration of moving source and wave behavior.

Benchmark SC.912.P.10.22	
Body of Knowledge/ Strand	**Physical Science**
Standard	**10: Energy**
Benchmark	**SC.912.P.10.22: Construct ray diagrams and use thin lens and mirror equations to locate the images formed by lenses and mirrors.**
Common Core State Standard Connections	Indicate appropriate alignments to the Grades 9–12 CCSS Mathematics and/or Literacy Standards for Science whenever applicable. (See Appendix B.)
Benchmark Clarifications	Students will • identify elements of a ray diagram (e.g., focal point); • use thin lens and mirror equations to locate images formed by lenses and mirrors; • use appropriate sign conventions with thin lens equations; and • distinguish between real and virtual images.
Content Limits	Items will only assess image formation. Items will not • include wave phenomena (e.g., diffraction); • assess aberrations; or • assess chromatic (color) effects. Scenarios will be limited to three optical elements. Items may reference a labeled ray diagram. Items may provide the thin lens equation, if necessary. Options may be in the form of ray diagrams. Options may be in the form of differently oriented and/or magnified images.

Benchmark SC.912.P.12.1	
Body of Knowledge/ Strand	**Physical Science**
Standard	**12: Motion**
Benchmark	**SC.912.P.12.1: Distinguish between scalar and vector quantities and assess which should be used to describe an event.**
Common Core State Standard Connections	Indicate appropriate alignments to the Grades 9–12 CCSS Mathematics and/or Literacy Standards for Science whenever applicable. (See Appendix B.)
Benchmark Clarifications	Students will • understand that scalar quantities consist of only a magnitude, whereas vectors contain both magnitude and direction; • assess whether a scalar or vector is required in a given scenario; • use arrow diagrams to represent vector quantities; and • use graphical and component techniques to add and subtract vectors.
Content Limits	Vectors may be limited to two dimensions. Items will not assess • vector (dot and cross) multiplication; or • trigonometric identities. Items may reference a labeled vector diagram. Trigonometric identities may be provided when needed.

Benchmark SC.912.P.12.2	
Body of Knowledge/ Strand	**Physical Science**
Standard	**12: Motion**
Benchmark	**SC.912.P.12.2: Analyze the motion of an object in terms of its position, velocity, and acceleration (with respect to a frame of reference) as functions of time.**
Common Core State Standard Connections	Indicate appropriate alignments to the Grades 9–12 CCSS Mathematics and/or Literacy Standards for Science whenever applicable. (See Appendix B.)
Benchmark Clarifications	Students will • use kinematic equations to calculate an object's position, velocity, and acceleration at a given time; • qualitatively and quantitatively explore the relationships among position, velocity, and acceleration; • use graphs to describe an object's position, velocity, and acceleration as a function of time; • interpret diagrams of projectile motion in terms of the x and y components of position, velocity, and acceleration.
Content Limits	Scenarios will not assess friction or air resistance. Scenarios involving calculation may provide the kinematic equations and the acceleration due to gravity. Items may reference • labeled diagrams (e.g., an object undergoing projectile motion); and • graphs of position, velocity, or acceleration versus time.

Benchmark SC.912.P.12.3	
Body of Knowledge/ Strand	**Physical Science**
Standard	**12: Motion**
Benchmark	**SC.912.P.12.3: Interpret and apply Newton's three laws of motion.**
Common Core State Standard Connections	Indicate appropriate alignments to the Grades 9–12 CCSS Mathematics and/or Literacy Standards for Science whenever applicable. (See Appendix B.)
Benchmark Clarifications	Students will • describe Newton's three laws of motion; • use Newton's laws to qualitatively and quantitatively describe the motion of objects; • use free-body diagrams to determine the net force on an object; and • distinguish between objects in equilibrium and non-equilibrium.
Content Limits	Items may reference, but not assess, friction. Items will not assess • Newton's law of universal gravitation; or • circular motion. Scenarios will be limited to two dimensions. Items may reference illustrations or labeled free-body diagrams. Items requiring calculation of forces or acceleration may provide the formula for Newton's second law.

Benchmark SC.912.P.12.4	
Body of Knowledge/ Strand	Physical Science
Standard	**12: Motion**
Benchmark	**SC.912.P.12.4: Describe how the gravitational force between two objects depends on their masses and the distance between them.**
Common Core State Standard Connections	Indicate appropriate alignments to the Grades 9–12 CCSS Mathematics and/or Literacy Standards for Science whenever applicable. (See Appendix B.)
Benchmark Clarifications	Students will • use the law of universal gravitation to calculate the gravitational force between two objects; • describe how mass and distance affect the gravitational force between two objects; and • distinguish between weight and mass.
Content Limits	Items may provide the universal gravitation formula and gravitational constant, *G*, when needed. Items may ask students to compare relative forces at different distances or masses (e.g., how much stronger will the force be if the distance is halved?).

Benchmark SC.912.P.12.5	
Body of Knowledge/ Strand	**Physical Science**
Standard	**12: Motion**
Benchmark	**SC.912.P.12.5: Apply the law of conservation of linear momentum to interactions, such as collisions between objects.**
Common Core State Standard Connections	Indicate appropriate alignments to the Grades 9–12 CCSS Mathematics and/or Literacy Standards for Science whenever applicable. (See Appendix B.)
Benchmark Clarifications	Students will • use the impulse-momentum theorem to explore the relationships among force, momentum, and time; • use the conservation of linear momentum to describe the motion of objects before and after a collision; and • distinguish between elastic and inelastic collisions.
Content Limits	Scenarios will be limited to two dimensions. Items will not assess rotational momentum. Items may refer to illustrations of collisions. Items mayl provide the equations of momentum and impulse as needed.

Benchmark SC.912.P.12.7	
Body of Knowledge/ Strand	**Physical Science**
Standard	**12: Motion**
Benchmark	**SC.912.P.12.7: Recognize that nothing travels faster than the speed of light in a vacuum, which is the same for all observers no matter how they or the light source are moving.**
Common Core State Standard Connections	Indicate appropriate alignments to the Grades 9–12 CCSS Mathematics and/or Literacy Standards for Science whenever applicable. (See Appendix B.)
Benchmark Clarifications	Students will • recognize that nothing travels faster than the speed of light in a vacuum; • recognize that the laws of physics are the same in any inertial reference frame; • qualitatively describe the speed of light as measured by observers in different inertial frames; and • recognize that simple addition of velocities is not applicable at or near the speed of light.
Content Limits	Items will not • require calculations of relativistic velocities; or • address non-inertial (accelerating) reference frames. Items may reference an illustration of observers moving relative to one another.

Benchmark SC.912.P.12.9	
Body of Knowledge/ Strand	**Physical Science**
Standard	**12: Motion**
Benchmark	**SC.912.P.12.9: Recognize that time, length, and energy depend on the frame of reference.**
Common Core State Standard Connections	Indicate appropriate alignments to the Grades 9–12 CCSS Mathematics and/or Literacy Standards for Science whenever applicable. (See Appendix B.)
Benchmark Clarifications	Students will • explain the concepts of proper time and proper length; • describe the phenomena of time-dilation and length-contraction; • apply time-dilation and length-contraction to various situations; • describe how time, length, and energy depend on frame of reference; and • describe the rest energy of an object.
Content Limits	Items will not assess relativistic momentum. Scenarios will be limited to inertial (non-accelerating) reference frames.

Appendix A: Sample Items

Sample Item 1

Grade/Course	Item Type	DOK	NGSSS Benchmark	CCSS Benchmark	Point Value
9–12/Physics	SR	1	SC.912.P.10.14: Differentiate among conductors, semiconductors, and insulators.	N/A	1

Some materials are good conductors of electricity while other materials are not. What is the best explanation for why metals are good at conducting electricity?

A. impurities in metals introduce extra electrons

B. magnetic fields within metals attract more electrons

C. outermost electrons of each atom are easily detached*

D. positively charged nuclei of their atoms can move freely

Correct Answer: C

Rationales:

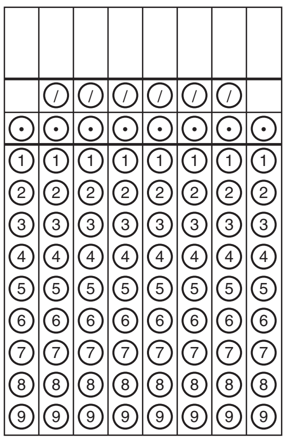
A	Incorrect. Some students may confuse the properties of conductors with semiconductors. Metals do not make use of extra electrons. The introduction of impurities is the process by which semiconductors, not metals, conduct electricity.
B	Incorrect. Some students may think that magnetic fields in metals are needed to conduct electricity. Magnetic fields can induce electric current, but they're not necessary. Metals will conduct with or without an external magnetic field. In addition, metals do not need extra electrons; they use the electrons that are already available.
C	Correct.
D	Incorrect. Some students may think that the movement of positive charges causes electric current. Current is entirely the result of moving electrons. Also, the atoms in a metal are nearly stationary.

Sample Item 2

Grade/Course	Item Type	DOK	NGSSS Benchmark	CCSS Benchmark	Point Value
9–12/Physics	GR	3	SC.912.P.12.4: Describe how the gravitational force between two objects depends on their masses and the distance between them.	N/A	1

Two planets in the solar system, Planet A and Planet B, each have about the same mass. Planet A is five times farther from the Sun than Planet B.

According to Newton's law of gravitation $F = G(m_1m_2)/r^2$, how many times stronger is the gravitational force of the Sun on Planet B than it is on Planet A?



Correct Answer: 25

Correct Answer	The gravitational force between objects is inversely proportional to the square of the distance between them. Because Planet A is five times farther than Planet B and their masses are the same, the star's gravitational pull on Planet B is 5^2, or 25, times stronger than it is on Planet A.

Sample Item 3

Grade/Course	Item Type	DOK	NGSSS Benchmark	CCSS Benchmark	Point Value
9–12/Physics	CR	2	SC.912.P.12.5: Apply the law of conservation of linear momentum to interactions, such as collisions between objects.	LACC.910.RST.2.5: Analyze the structure of the relationships among concepts in a text, including relationships among key terms (e.g., force, friction, reaction force, energy).	2

Pool is an indoor table game originating from an outdoor lawn game played by nobility. The pool table is rectangular with "pockets" at each corner and along the middle of the long sides of the table. The table is covered in a soft, felt-like, grass-colored material to mimic the outdoor lawn game. The game uses a set of 15 balls made of a smooth plastic, 7 of them a solid color, 7 of them striped, and one of them white. Players use wooden sticks, called cue sticks, to exert a force on the white ball which travels and exerts a force on a solid or striped ball. Two players oppose each other, with each player trying to "sink" either all the solid balls or all the striped balls into the pockets. The winner of the game sinks all of her or his balls in the pockets on the pool table, with the black ball being last.

Look at the picture showing balls on a pool table.

Image Source: www.clker.com (royalty free and public domain image)

Some players are participating in a game of pool. One player hits the white ball, causing it to travel across the table and strike the black ball. The white ball stops after striking the black ball. Use your knowledge of elastic collisions to explain what happens as the white ball exerts a force on the black ball. Write your answer in the space provided.

Scoring Rubric and Exemplar

Rubric	
2	A score of two indicates that the student has demonstrated a thorough understanding of the scientific concepts and/or procedures embodied in the task. The student has completed the task correctly, in a scientifically sound manner. When required, student explanations and/or interpretations are clear and complete. The response may contain minor flaws that do not detract from the demonstration of a thorough understanding.

1	A score of one indicates that the student has provided a response that is only partially correct. For example, the student may arrive at an acceptable conclusion or provide an adequate interpretation but may demonstrate some misunderstanding of the underlying scientific concepts and/or procedures. Conversely, a student may arrive at an unacceptable conclusion or provide a faulty interpretation but could have applied appropriate and scientifically sound concepts and/or procedures.
0	A score of zero indicates that the student has not provided a response or has provided a response that does not demonstrate an understanding of the scientific concepts and/or procedures embodied in the task. The student's explanation may be uninterpretable, lack sufficient information to determine the student's understanding, or contain clear misunderstandings of the underlying scientific concepts and/or procedures, or it may be incorrect.

Exemplar	
2	A completely correct student response should explain that the black ball will move forward as the white ball comes to rest. This is an elastic collision, so momentum and kinetic energy are both conserved. This is why the white ball comes to rest as all of its momentum is transferred to the black ball.

Sample Item 4

Grade/Course	Item Type	DOK	NGSSS Benchmark	CCSS Benchmark	Point Value
9–12/Physics	ER	3	SC.912.P.10.20: Describe the measurable properties of waves, explain the relationships among them, and explain how these properties change when the wave moves from one medium to another.	LACC.1112. WHST.1.2: Write informative/ explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.	4

An astronomer measures the colors of three stars and determines that one is blue, one is yellow, and one is red. Explain how the astronomer can determine the relative temperatures of the three stars and rank the stars from hottest to coolest.

Scoring Rubric and Exemplar

Rubric	
4	A score of four indicates that the student has demonstrated a thorough understanding of the scientific concepts and/or procedures embodied in the task. The student has completed the task correctly, used scientifically sound procedures, and provided clear and complete explanations and interpretations. The response may contain minor flaws that do not detract from a demonstration of a thorough understanding.
3	A score of three indicates that the student has demonstrated an understanding of the scientific concepts and/or procedures embodied in the task. The student's response to the task is essentially correct, but the scientific procedures, explanations, and/or interpretations provided are not thorough. The response may contain minor flaws that reflect inattentiveness or indicate some misunderstanding of the underlying scientific concepts and/or procedures.
2	A score of two indicates that the student has demonstrated only a partial understanding of the scientific concepts and/or procedures embodied in the task. Although the student may have arrived at an acceptable conclusion or provided an adequate interpretation of the task, the student's work lacks an essential understanding of the underlying scientific concepts and/or procedures. The response may contain errors related to misunderstanding important aspects of the task, misuse of scientific procedures/processes, or faulty interpretations of results.
1	A score of one indicates that the student has demonstrated a very limited understanding of the scientific concepts and/or procedures embodied in the task. The student's response is incomplete and exhibits many flaws. Although the student's response has addressed some of the conditions of the task, the student has reached an inadequate conclusion and/or provided reasoning that is faulty or incomplete. The response exhibits many flaws or may be incomplete.
0	A score of zero indicates that the student has not provided a response or has provided a response that does not demonstrate an understanding of the scientific concepts and/or procedures embodied in the task. The student's explanation may be uninterpretable, lack sufficient information to determine the student's understanding, or contain clear misunderstandings of the underlying scientific concepts and/or procedures, or it may be incorrect.

Exemplar	
4	**A complete student response should correctly explain the relationship between the wavelength at which a star emits most of its energy and the object's temperature AND rank the stars from hottest to coolest:** The longer the wavelength, the lower the temperature of the star, and vice versa. Stars that are blue put out most of their energy at short wavelengths. Stars that are red put out most of their energy at longer wavelengths. Yellow stars emit most of their energy at intermediate wavelengths. Therefore, the blue star is hotter than the yellow star, and the yellow star is hotter than the red one.

Sample Item 5

Grade/Course	Item Type	DOK	NGSSS Benchmark	CCSS Benchmark	Point Value
9–12/Physics	ESR	2	SC.912.P.10.18: Explore the theory of electromagnetism by comparing and contrasting the different parts of the electromagnetic spectrum in terms of wavelength, frequency, and energy, and relate them to phenomena and applications.	LACC.910. WHST.1.2: Write informative/ explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.	6

Infrared and ultraviolet light are different from visible light. Write a brief essay comparing and contrasting infrared and ultraviolet light to visible light. Consider each type of light's wavelengths, frequencies, and energies when making comparisons. Also, include in your answer situations in which each type of light can be used in everyday life.

Scoring Rubric and Exemplar

Rubric	
6	Complete and correct response is made to all parts of the prompt. Appropriate scientific terminology is used. There are no major conceptual errors, though there may be nondetracting minor errors. In-depth understanding of the scientific concepts applicable to the prompt is demonstrated. Thorough understanding of the connection between the scientific concepts and the real-life application is demonstrated.
5	Complete and correct response is made to all parts of the prompt. Appropriate scientific terminology is used correctly. There are no major conceptual errors, though there may be minor conceptual errors. Understanding of the scientific concepts applicable to the prompt is demonstrated. Connections are made between the scientific concepts and real-life application.
4	Complete and correct response is made to all parts of the prompt. There are minor errors in the use of scientific terminology. There are minor conceptual errors or omissions. The response may attempt connections between the scientific concepts and real-life application.

3	Response to two or more parts of the prompt is attempted. There is limited use of scientific terminology. Response contains some major conceptual errors or omissions. Response shows limited understanding.
2	Response to one or more parts of the prompt is attempted. The use of scientific terminology may be missing. Response contains many major conceptual errors and omissions. Response shows minimal understanding.
1	Little attempt to answer the prompt is evident. Scientific terminology is missing. Response contains many major conceptual errors and omissions. Explanation shows no understanding.
0	Response addresses an entirely different prompt or is completely unintelligible.

Exemplar	
6	**A full-credit student response should contain correct points of information that are presented in a logical flow of ideas as shown:** Infrared, visible, and ultraviolet light are all types of electromagnetic waves. The differences between them are their wavelengths and frequencies. Infrared light has a longer wavelength than visible light. Ultraviolet has a shorter one. Infrared has the lowest frequency, whereas ultraviolet has the highest. Because shorter wavelength light has higher energy, ultraviolet is the most energetic of the three. Infrared light has the lowest energy. Visible light is what we use to see. Our eyes are sensitive only to a narrow range of electromagnetic wavelengths. Infrared light is useful for detecting the heat emitted by objects. An infrared camera shows objects even when it is dark. Ultraviolet light is dangerous to humans. Ultraviolet light from the sun, because it has so much energy, is responsible for sunburns and skin cancer.

Sample Item 6

Grade/Course	Item Type	DOK	NGSSS Benchmark	CCSS Benchmark	Point Value
9–12/Physics	PT	2	SC.912.P.12.3: Interpret and apply Newton's three laws of motion.	MACC.912.N-VM.1.3: Solve problems involving velocity and other quantities that can be represented by vectors.	3

In August 2012, NASA's Curiosity rover successfully landed on the planet Mars, completing its 225 million kilometer journey from Earth. The safe landing and operation of rovers on Mars presents a challenge for NASA scientists, not only because of the vast distance from Earth, but also because of the unique physical features of Mars.

Student Instructions:

A. Use the NASA website at *http://www.nasa.gov* to explore some of the unique features of Mars. Document and record your findings in a journal or notebook.

B. Download and read the web-linked NASA "Exploration Brief" at *http://www.nasa.gov/pdf/188961main_Different_Gravity.pdf* to help you answer and calculate the weight (in Newtons) of the 899-kilogram Curiosity rover on Mars. What would the weight be on Earth? Show your work. Use gravitational accelerations rounded to two significant figures when calculating the weights on Earth and Mars.

Response Area

Show your work here:

1) Weight of the Curiosity rover on Mars:

2) Weight of the Curiosity rover on Earth:

Rubric and Exemplar:

Teacher Instructions:

The following task will require students to research Mars, perform a calculation concerning Curiosity rover's weight, and then compare the weight on Mars to the weight on Earth.

4	A 4-point student response includes complete and correct responses to part A and part B of the performance task. **A.** The student will receive a point for creating a log describing some of the unique features of Mars, which may include, but are not limited to, the following: • Polar caps • Dry ice/Carbon dioxide that falls as snow • Volcanoes • Extreme temperature ranges • Wind erosion • Large canyons • Dust storms • Mountain ranges • Thin atmosphere composed mainly of carbon dioxide • Lower gravitational acceleration (compared to Earth) **B.** Students will receive one point for correctly showing their work, and one point for determining the correct weight on Mars and on Earth. **1) Work for solving the weight of the Curiosity Rover on Mars:** • $W_{(\text{Mars})} = ma_{(\text{Mars})}$ • $W_{(\text{Mars})} = (899\text{ kg})(3.7\text{ m/s}^2)$ • Correct answer: $W_{(\text{Mars})} = 3300$ newtons **2) Work for solving Weight of the Curiosity Rover on Earth:** • $W_{(\text{Earth})} = mg$ • $W_{(\text{Earth})} = (899\text{ kg})(9.8\text{ m/s}^2)$ • Correct answer: $W_{(\text{Earth})} = 8800$ newtons

Appendix B: Common Core State Standard Connections

A. Reading Standards for Literacy in Science and Technical Subjects—Physics

LACC.910.RST.1.1	Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.
LACC.1112.RST.1.1	Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
LACC.910.RST.1.3	Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.
LACC.1112.RST.1.3	Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.
LACC.910.RST.2.4	Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9–10 texts and topics.
LACC.1112.RST.2.4	Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11–12 texts and topics.
LACC.910.RST.2.5	Analyze the structure of the relationships among concepts in a text, including relationships among key terms (e.g., force, friction, reaction force, energy).
LACC.910.RST.3.7	Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.
LACC.1112.RST.3.7	Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.
LACC.910.RST.4.10	By the end of grade 10, read and comprehend science/technical texts in the grades 9–10 text complexity band independently and proficiently.
LACC.1112.RST.4.10	By the end of grade 12, read and comprehend science/technical texts in the grades 11–12 text complexity band independently and proficiently.

B. Writing Standards for Literacy in Science and Technical Subjects—Physics

LACC.910.WHST.1.2	Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes. a. Introduce a topic and organize ideas, concepts, and information to make important connections and distinctions; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension. b. Develop the topic with well-chosen, relevant, and sufficient facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience's knowledge of the topic. c. Use varied transitions and sentence structures to link the major sections of the text, create cohesion, and clarify the relationships among ideas and concepts. d. Use precise language and domain-specific vocabulary to manage the complexity of the topic and convey a style appropriate to the discipline and context as well as to the expertise of likely readers. e. Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing. f. Provide a concluding statement or section that follows from and supports the information or explanation presented (e.g., articulating implications or the significance of the topic).

LACC.1112.WHST.1.2	Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes. a. Introduce a topic and organize complex ideas, concepts, and information so that each new element builds on that which precedes it to create a unified whole; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension. b. Develop the topic thoroughly by selecting the most significant and relevant facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience's knowledge of the topic. c. Use varied transitions and sentence structures to link the major sections of the text, create cohesion, and clarify the relationships among complex ideas and concepts. d. Use precise language, domain-specific vocabulary and techniques such as metaphor, simile, and analogy to manage the complexity of the topic; convey a knowledgeable stance in a style that responds to the discipline and context as well as to the expertise of likely readers. e. Provide a concluding statement or section that follows from and supports the information or explanation provided (e.g., articulating implications or the significance of the topic).
LACC.910.WHST.3.9	Draw evidence from informational texts to support analysis, reflection, and research.
LACC.1112.WHST.3.9	Draw evidence from informational texts to support analysis, reflection, and research.

C. Mathematics Standards in Science and Technical Subjects—Physics

MACC.912.N-Q.1.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
MACC.912.N-Q.1.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
MACC.912.N-VM.1.3	Solve problems involving velocity and other quantities that can be represented by vectors.

MACC.912.F-IF.3.7	Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases. a. Graph linear and quadratic functions and show intercepts, maxima, and minima. b. Graph square root, cube root, and piecewise-defined functions, including step functions and absolute value functions. c. Graph polynomial functions, identifying zeros when suitable factorizations are available, and showing end behavior. d. Graph rational functions, identifying zeros and asymptotes when suitable factorizations are available, and showing end behavior. e. Graph exponential and logarithmic functions, showing intercepts and end behavior, and trigonometric functions, showing period, midline, and amplitude.