Guidance on Student Use:
Below are writing prompts related to content learned in this unit as well as recommended assessment probes. Not every student will have explored each indicator; it depends upon the solutions students selected. The assessment probes can be found in a series of books titled “Uncovering Student Ideas”. One copy of each of these books has been provided to each school’s science department. The names of each book and the shorthand used to denote the books follow.

- Uncovering Students Ideas in Science: 25 Formative Assessment Probes, Volume 1 (Vol. 1)
- Uncovering Students Ideas in Science: 25 More Formative Assessment Probes, Volume 2 (Vol. 2)
- Uncovering Students Ideas in Science: Another 25 Formative Assessment Probes, Volume 3 (Vol. 3)
- Uncovering Students Ideas in Science: 25 New Formative Assessment Probes, Volume 4 (Vol. 4)
- Uncovering Students Ideas in Physical Science: 45 New Force and Motion Assessment Probes, Volume 1 (PS)

Indicators with Related Writing Prompts and Assessment Probes:

**3E.1: How can a simple machine be incorporated into the design of the playground?**

**Writing Prompt:** Simple Machine

**5.1.1** The student will use analytical techniques appropriate to the study of physics.
- symbolically represent vector quantities (angle for direction, length for magnitude)
- add vectors (same and opposite directions and at right angles)

**Writing Prompt:** Swinging in the Trees

**Assessment Probes:** Assessment Probe: Apple in a Plane (PS, p. 107)

**5.1.3** The student will analyze and explain how Newton’s Laws describe changes in an object’s motion.
- the effect of balanced forces (fnet = 0) (quantitative and qualitative)
- the effect of unbalanced forces (fnet ≠ 0) (quantitative and qualitative)

**Writing Prompt:** Swinging in the Trees, Runaway Truck Ramp I

**Assessment Probes:** Pulling on a Spool (PS, p. 119), Apple on a Desk (Vol. 3, p. 63)

**5.1.3** The student will analyze and explain how Newton’s Laws describe changes in an object’s motion.
- relationship among force, mass and acceleration (describe qualitative relationships and calculate)

**Writing Prompt:** Sledding
Assessment Probes: Lifting Buckets (PS, p. 123)

5.1.4 The student will analyze the behavior of forces.
   - friction (qualitative description of its nature and behavior)

Writing Prompt: Hot Blade
Assessment Probes: Just Rolling Along (PS, p. 43), Friction (PS, p. 83), World without Friction (PS, p. 87)

5.1.4 The student will analyze the behavior of forces.
   - relation to work and power (qualitative and quantitative)

Writing Prompt: Sledding I
Assessment Probes: Bicycle Gears (PS, p. 205)

3E.2: How can an interactive educational component be incorporated into the design of the playground?
Writing Prompt: Interactive Educational Component

4.1.1 The student will analyze the structure of the atom and describe the characteristics of the particles found there.
   - subatomic particles (protons, neutrons, & electrons –not to include quantum mechanical details of electron configurations)
   - nucleus & electron cloud (definition; no orbitals included)

Writing Prompt: Models of Atoms
Assessment Probes:

4.3.2 The student will describe observed changes in pressure, volume, or temperature of a sample in terms of macroscopic changes and the behavior of particles.
   - constant temperature (effect of pressure or volume change to sample of solid, liquid, or gas)
   - constant volume (effect of pressure or temperature change to sample of solid, liquid, or gas)
   - constant pressure (effect of temperature or volume change to sample of solid, liquid, or gas)

Writing Prompt: Scuba Diving

5.1.2 The student will use algebraic and geometric concepts to qualitatively and quantitatively describe an object’s motion.
   - projectile motion (mathematical solutions limited to initial horizontal velocity only; conceptual questions not restricted)

Writing Prompt: Pumpkin Chunkin
Assessment Probes:
5.2.2 The student will describe the sources and effects of electric and magnetic fields.
   - Qualitative description of magnetic field created by moving charges
   **Writing Prompt:** Magnetic Money
   **Assessment Probes:** Batteries, Bulbs, and Wires (Vol. 3, p. 57), Magnet in Water (Vol. 4, p. 67)

5.4.3 The student will qualitatively describe the physical behaviors of waves.
   - Reflection (apply the law of reflection, represent image formation for plane and concave surfaces using a ray diagram)
   - Refraction (causes and resultant behavior, which may include ray diagrams for behavior at a plane boundary and for double convex lenses)
   - Diffraction (causes and relationship between wavelength and size of opening)
   - Interference (constructive and destructive)
   - Polarization (relation to type of wave, effect on intensity of light)
   - Doppler effect (examples and explanation including frequency shift)
   **Writing Prompt:** Highway Noise
   **Assessment Probes:** Mirror on the Wall (Vol. 3, p. 51)

**3E.3:** *What surfaces are the most appropriate in the design of the assigned area of the playground?*

**Writing Prompt:** Surface Material

4.2.2 The student will explain why organic compounds are so numerous and diverse.
   - Inorganic and organic compounds (define in terms of carbon content; do not include CO, CO2, or carbonates as organic compounds; definition of hydrocarbons)
   - Ability of carbon to form chains and make rings (recognize, but not produce structural formulas)
   **Writing Prompt:** Plastic
   **Assessment Probes:**

5.1.3 The student will analyze and explain how Newton’s Laws describe changes in an object’s motion.
   - Action/reaction (application)
   **Writing Prompt:** Space Shuttle Launch
   **Assessment Probes:** Finger Strength Contest (PS, p. 127), Equal and Opposite (PS, p. 131)

5.3.1 The student will relate thermodynamics to the balance of energy in a system.
   - Specific heat (both describe and calculate)
   **Writing Prompt:** Pool Party I
   **Assessment Probes:**

**3E.4:** *How can reused and recycled materials be used in the design of the playground?*

**Writing Prompt:** Reused and Recycled Materials
4.1.3 The student will explain how atoms interact with other atoms through the transfer and sharing of electrons in the formation of chemical bonds.
   - bond (definition)
   - metallic bond (definition)
   - metallic, ionic, and molecular substances (melting point)

**Writing Prompt:** Baseball Bats
**Assessment Probes:** Is it Made of Molecules? (Vol. 1, p. 85), Chemical Bonds (Vol. 2, p. 71)

4.2.2 The student will explain why organic compounds are so numerous and diverse.
   - inorganic and organic compounds (define in terms of carbon content; do not include CO, CO2, or carbonates as organic compounds; definition of hydrocarbons)
   - ability of carbon to form chains and make rings (recognize, but not produce structural formulas)

**Writing Prompt:** Plastic
**Assessment Probes:**

4.2.3 The student will describe the properties of solutions and explain how they form.
   - solute, solvent, and solubility
   - suspensions and colloids

**Writing Prompt:** Paintball
**Assessment Probes:** Sugar Wheel (Vol. 4, p. 11)

4.3.3 The student will explain why the interactions among particles involve a change in the energy system.
   - endothermic change (bond breaking; dissociation; thermal energy absorbed)

**Writing Prompt:** Recycling Energy
**Assessment Probes:** Burning Paper (Vol. 4, p. 23), Nails in a Jar (Vol. 4, p. 31), Salt Crystals (Vol. 4, p. 39)
How can a simple machine be incorporated into the design of a playground? In your response, be sure to do the following:

- a possible plan for incorporating a simple machine.
- possible strengths and weaknesses of this plan for incorporating a simple machine that should be considered.
- a detailed explanation of how a chemistry or physics concept relates to this plan for incorporating a simple machine.
- a visual representation (picture, diagram, graph, table, etc.), with labels, to support the physics or chemistry concept.

Be sure to consider the completeness of your response, supporting details, and accurate use of terms.
Two monkeys are swinging on vines together. One monkey gets stuck hanging from a branch unable to move. The other monkey, who is very smart, knows that to move he needs to have a net force in the direction he wants to go.

Identify the forces acting on the two monkeys and how those forces impact their ability to swing. In your response, be sure to include:

- labels of the forces acting on the two monkeys using arrows and appropriate terms.
- identification of the balanced and unbalanced forces.
- how unbalanced and balanced forces affect the motion of the monkeys.

Be sure to consider the completeness of your response, supporting details, and accurate use of terms.
On roads that go downhill at a steep angle or for a long distance, runaway truck ramps are placed periodically. If the brakes on a truck fail, the truck can pull off on the ramp to slow down. The picture below shows where a truck’s brake failed (point A), where the truck pulled onto the ramp (point B) and where the truck stopped (point C).

Describe the forces that acted on the truck in order to make it stop. In your response, be sure to include:

- A description of and/or drawing of the forces acting on the truck at all three points (A, B and C).
- Definitions of balanced and unbalanced forces.
- Identification of whether the forces acting on the truck at each point are balanced or unbalance.
- How balanced and unbalanced forces affect motion.

Be sure to consider the completeness of your response, supporting details, and accurate use of terms.
**Unit 3E: Playground (3E.1) Sledding**

**Indicator(s)**

5.1.2 The student will use algebraic and geometric concepts to qualitatively and quantitatively describe an object’s motion.

5.1.3 The student will analyze and explain how Newton’s Laws describe changes in an object’s motion.

A student comes up with an idea to make some extra money during a snow day. All the neighborhood kids are outside sledding. The student offers to pull the students to the top of the hill for one dollar per ride. The student notices that it was taking more time to pull some student to the top then it was other students even though he was pulling with the same force. He decides to start timing how long it takes to pull each kid and see if there was a pattern based on their age.

![Image of a student pulling a sled]

Explain why some kids too longer to pull to the top of the hill then other kids despite pulling with the same force. In your response, be sure to include:

- the pattern of the data including any exceptions to the trend.
- the role of Newton’s second law in it taking longer to pull some kids.
- a prediction of how long it would take to pull the ten and twelve year olds if they were on the same sled.

Be sure to consider the completeness of your response, supporting details, and accurate use of terms.
A student comes up with an idea to make some extra money during a snow day. All the neighborhood children are outside sledding. He offers to pull the children to the top of the 10 meter long hill for one dollar per ride. The student notices that it takes more time to pull some children to the top then it does for others even though he pulls with the same force. He decides to start timing how many seconds it takes to pull each kid. When he went home, the student showed his dad a graph he made and says “look at how much work I did pulling children on sleds”.

<table>
<thead>
<tr>
<th>Age of Sled Ridder</th>
<th>Amount of Time vs. Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>20</td>
</tr>
<tr>
<td>8</td>
<td>30</td>
</tr>
<tr>
<td>9</td>
<td>40</td>
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<td>10</td>
<td>50</td>
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<tr>
<td>11</td>
<td>60</td>
</tr>
<tr>
<td>12</td>
<td>70</td>
</tr>
</tbody>
</table>

Evaluate the student’s statements for scientific accuracy. In your response, be sure to include:

- A definition of work.
- An explanation of which would take more work, pulling the 8 or 10 year old to the top of the hill.

Be sure to consider the completeness of your response, supporting details, and accurate use of terms.
While working on some home repairs with his uncle, a student helps cut the wood. After the cut is made, she blows off the dust and feels the heat coming up from the wood onto his face. She also smells a slight burning smell. The student asks her uncle, “why did it get so hot?” and her uncle responds with one word: friction.

Explain why the blade and wood became so hot while cutting. In your response, be sure to include:

- A definition of friction.
- How friction changes the temperature of substances.
- How the width of the blade and depth of the cut would affect the amount of heat produced and why.

Be sure to consider the completeness of your response, supporting details, and accurate use of terms.
How can an interactive educational component be incorporated into the design of a playground? In your response, be sure to include:

- a possible plan for incorporating an interactive educational component.
- possible strengths and weaknesses of this plan for incorporating an interactive educational component that should be considered.
- a detailed explanation of how a chemistry or physics concept relates to this plan for incorporating an interactive educational component.
- a visual representation (picture, diagram, graph, table, etc.), with labels, to support the physics or chemistry concept.

Be sure to consider the completeness of your response, supporting details, and accurate use of terms.
| Indicator(s) | 4.1.1 The student will analyze the structure of the atom and describe the characteristics of the particles found there. |

A Bohr model is one way to represent an atom. Like every model, it can help scientists to better explain the behavior of atoms but it is also inaccurate in ways.

Explain how models can be helpful while also being inaccurate. In your response, be sure to include:
- Labels of what the Bohr model is showing.
- How a Bohr model is used to better understand the behavior of atoms.
- The ways in which a Bohr model is inaccurate.
- An example of another way to model an atom.

Be sure to consider the completeness of your response, supporting details, and accurate use of terms.
Scuba diving tanks are filled with a mixture of oxygen and nitrogen gas. The gas is under a very high pressure (3,000 psi) inside of the tank. When it leaves the tank and goes to the regulator, the pressure is much less (14.7 psi) resulting in a change in both volume of the gas and temperature.

Explain how the change in pressure affects the gas as it leaves the scuba tank. In your response, be sure to include:
- How the change in pressure affects the volume of the gas.
- How this change in the volume affect the temperature of the gas.
- A description of what is happening on the molecular level.

Be sure to consider the completeness of your response, supporting details, and accurate use of terms.
Pumpkin chunkin is a competition where teams launch pumpkins using machines that they have created, such as large slingshots and cannons. The goal of most competitions is to get the pumpkin to go further than the other teams. A new competition decided to focus on accuracy. Teams have to get their pumpkin to land as close to a target as possible. The first team’s pumpkin went too far.

Explain how the team should change their launch to get closer to the target. In your response, be sure to include:
- How the speed of the launch will affect the pumpkin’s motion.
- How the angle of the launch will affect the pumpkin’s motion.
- Drawings to support the explanations.

Be sure to consider the completeness of your response, supporting details, and accurate use of terms.
<table>
<thead>
<tr>
<th>Unit 3E: Playground (3E.2)</th>
<th>Magnetic Money</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indicator(s)</td>
<td>5.2.2 The student will describe the sources and effects of electric and magnetic fields.</td>
</tr>
</tbody>
</table>

A credit card is actually just a plastic card with a magnetic strip on the back. This magnetic strip contains the bank and owner’s information in a series of alternating north and south poles. Because the information is magnetically stored, the magnet must be moved in order to induce electrical fields that allow a computer to “read” the information on the card. Credit card information has been known to be erased by exposure to strong magnets.

![Credit Card Image]

Explain how the magnetic field from a strong magnet can affect a credit card. In your response, be sure to include:

- Draw the magnetic field that forms around a bar magnet.
- Explain how weak magnets are affected by strong magnetic fields.

Be sure to consider the completeness of your response, supporting details, and accurate use of terms.
As the world is increasing in population density, the sound from traffic a significant issue. The U.S. Department of Transportation recognizes that noise from highways is a large issue, particularly for those who live close to the highway. Engineers have come up with several solutions to the problem. One solution is noise barriers which can be dirt mounds between a highway and homes or high vertical walls. A second solution is planting vegetation such as trees. A third solution is having a large buffer zone or open space between the highway and homes.

Explain how vegetation, noise barriers and buffer zones reduce the noise from a highway that is heard at a nearby home. In your response, be sure to include:

- the accurate use of terms to explain how the acoustics of the traffic noise are impacted by each of the three methods.
- how the noise heard by someone in the home would be impacted by each of the three methods.
- how the noise heard by someone driving on the highway would be impacted by each of the three methods.

Be sure to consider the completeness of your response, supporting details, and accurate use of terms.
### Unit 3E: Playground (3E.3) Surface Material

<table>
<thead>
<tr>
<th>Indicator(s)</th>
<th>Surface Material</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>The response should address one of the indicators.</strong></td>
<td>4.2.2 The student will explain why organic compounds are so numerous and diverse.</td>
</tr>
<tr>
<td></td>
<td>5.1.3 The student will analyze and explain how Newton’s Laws describe changes in an object’s motion.</td>
</tr>
<tr>
<td></td>
<td>5.3.1 The student will relate thermodynamics to the balance of energy in a system.</td>
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</tbody>
</table>

What surfaces are the most appropriate in a specific area of a playground? In your response, be sure to include:
- a possible plan for the surface.
- possible strengths and weaknesses of this plan for the surface that should be considered.
- a detailed explanation of how a chemistry or physics concept relates to this plan for the surface.
- a visual representation (picture, diagram, graph, table, etc.), with labels, to support the physics or chemistry concept.

Be sure to consider the completeness of your response, supporting details, and accurate use of terms.
Plastic is one of the most used inventions of the 20th century. Some of the many benefits of plastic include that it is lightweight, unreactive, durable, inexpensive and moldable. Many things today are made from plastic including computer parts, bottles, eating utensils and chairs. Plastics are made of polymers, typically made from fossil fuels. One of the biggest concerns about plastic is how long it lasts in a garbage dump. In addition to recycling plastic to keep it out of dumps, another approach is to make plastic from plants, which allows the plastic to be broken down more easily. Two polymers are shown below that are made from plants.

Describe the diversity that exists in plastics. In your response, be sure to include:

- What makes the above compounds organic.
- How the two compounds above are similar to each other.
- How the two compounds above are different from each other.
- Why plastics can be made from fossil fuels and plants.

Be sure to consider the completeness of your response, supporting details, and accurate use of terms.
The motion of space shuttles is caused differently than that of most modes of transportation. As the fuel is burned, the hot gasses produced rush out of the bottom of the craft. This causes the space shuttle to launch into the air.

Describe how hot gasses rushing out of the bottom of a space shuttle cause it to launch. In your response, be sure to include:

- labels of the forces acting on the space shuttle using arrows and appropriate terms.
- how Newton’s third law allows the space shuttle to launch.
- why there is a delay between when the fuel starts to burn and when the space shuttle launches.

Be sure to consider the completeness of your response, supporting details, and accurate use of terms.
A local pool was getting ready for a night time pool party. They heated the water to 85°F. When the party started the water felt very warm, but as the night went on it felt cooler and cooler. An employee of the pool decided to record the temperature every half an hour.

![Temperature of Pool Water over Time](image)

Explain why the temperature of the pool was changing. In your response, be sure to include:

- what happened to the heat that was leaving the pool.
- what must be true of the air temperature based on the recorded pool temperatures.
- why you would or would not expect the graph to look the same if the pool were filled with something other than water, such as mud.

Be sure to consider the completeness of your response, supporting details, and accurate use of terms.
How can reused and recycled materials be used in the design of a playground? In your response, be sure to include:

- a possible plan for using reused and recycled materials.
- possible strengths and weaknesses of this plan for using reused and recycled materials that should be considered.
- a detailed explanation of how a chemistry or physics concept relates to this plan for using reused and recycled materials.
- a visual representation (picture, diagram, graph, table, etc.), with labels, to support the physics or chemistry concept.

Be sure to consider the completeness of your response, supporting details, and accurate use of terms.
A student notices that his little brother plays with a metal bat in his Little-League games, but only wooden bats are used at the professional level. He asks the coach what the difference is between a metal bat and a wooden one. The coach explains that the type of bat used in baseball games can determine how fast a ball is hit, and therefore how far the ball will fly. In professional baseball, wooden bats are required because they do not give anyone an unfair advantage. In Little-League, the aluminum bats are still used in order to save money.

Explain how a metal bat is chemically different than a wooden bat. In your response, be sure to include:

- The type of bonds in a metal bat (aluminum atoms).
- The type of bonds in a wooden bat (carbon, hydrogen, and oxygen atoms).
- How electrons are involved in the two types of bonds.
- Why a metal bat is more durable than a wooden bat.

Be sure to consider the completeness of your response, supporting details, and accurate use of terms.
Plastic is one of the most used inventions of the 20th century. Some of the many benefits of plastic include that it is lightweight, unreactive, durable, inexpensive and moldable. Many things today are made from plastic including computer parts, bottles, eating utensils and chairs. Plastics are made of polymers, typically made from fossil fuels. One of the biggest concerns about plastic is how long it lasts in a garbage dump. In addition to recycling plastic to keep it out of dumps, another approach is to make plastic from plants, which allows the plastic to be broken down more easily. Two polymers are shown below that are made from plants.

Describe the diversity that exists in plastics. In your response, be sure to include:

- What makes the above compounds organic.
- How the two compounds above are similar to each other.
- How the two compounds above are different from each other.
- Why plastics can be made from fossil fuels and plants.

Be sure to consider the completeness of your response, supporting details, and accurate use of terms.
For his birthday party, a student wants to play paintball with his friends. Some of his friends' parents won’t let them play because they don’t want clothes to get ruined with paint. The student decides to send an e-mail to all the parents explaining that a paintball doesn’t actually contain paint, but a mixture that will wash off clothing. The main component is polyethylene glycol (PEG) that is tasteless, colorless and dissolves in water. The other parts of the mixture are food dye and starch.

Compose an e-mail to the parents explaining that paintball will not ruin clothes. In your response, be sure to include:

- Definition of a solution, solute and solvent.
- The identity of the solvent(s) and solute(s).
- The difference between a solution, suspension, and a colloid.
- Whether paintballs are filled with a solution, suspension or colloid based on the ingredients and why.

Be sure to consider the completeness of your response, supporting details, and accurate use of terms.
Recycling has many benefits. One benefit is that there is less trash when more waste is recycled. Another benefit is that less energy is needed to make products if old products are recycled rather than using raw materials. This is especially true for metals such as aluminum, where 95% of the energy used to make a new aluminum can is saved by recycling an old one. Below is a tale showing the amount of energy needed to manufacture products.

<table>
<thead>
<tr>
<th>Material</th>
<th>Raw Energy required to manufacture product from raw materials (Million BTU)</th>
<th>Recycled Energy required to manufacture product from recycled materials (Million BTU)</th>
<th>Energy Saved Energy saved by using recycled materials (Million BTU) Raw – Recycled</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glass</td>
<td>7.49</td>
<td>2.13</td>
<td></td>
</tr>
<tr>
<td>Plastic (HDPE)</td>
<td>67.15</td>
<td>50.37</td>
<td></td>
</tr>
<tr>
<td>Paper</td>
<td>37.28</td>
<td>10.08</td>
<td></td>
</tr>
</tbody>
</table>

Use the table above to identify which product saves the greatest amount of energy if recycled. In your response, be sure to include:
- Definition of an endothermic process.
- How endothermic processes apply to recycling energy.
- The energy saved by using recycled materials for glass, plastic and paper.
- An explanation of why production from raw products requires more energy than production from recycled products.

Be sure to consider the completeness of your response, supporting details, and accurate use of terms.