

## **Week 1: The History of Man in the Sea**

Diving has been around in some form ever since people started using resources from the ocean. As diving progressed so did the technology and knowledge of diving. One of the earliest physiological problems associated with diving was decompression sickness, which showed up in laborers who were working in pressurized mines or in pressurized caissons in riverbeds. About 140 years ago physiologists first started studying decompression sickness and how to treat it. In today's lab, we will look at a few of the basic principles that play a role in diving and decompression sickness.

### **Exercise 1:**

Cartesian Diver

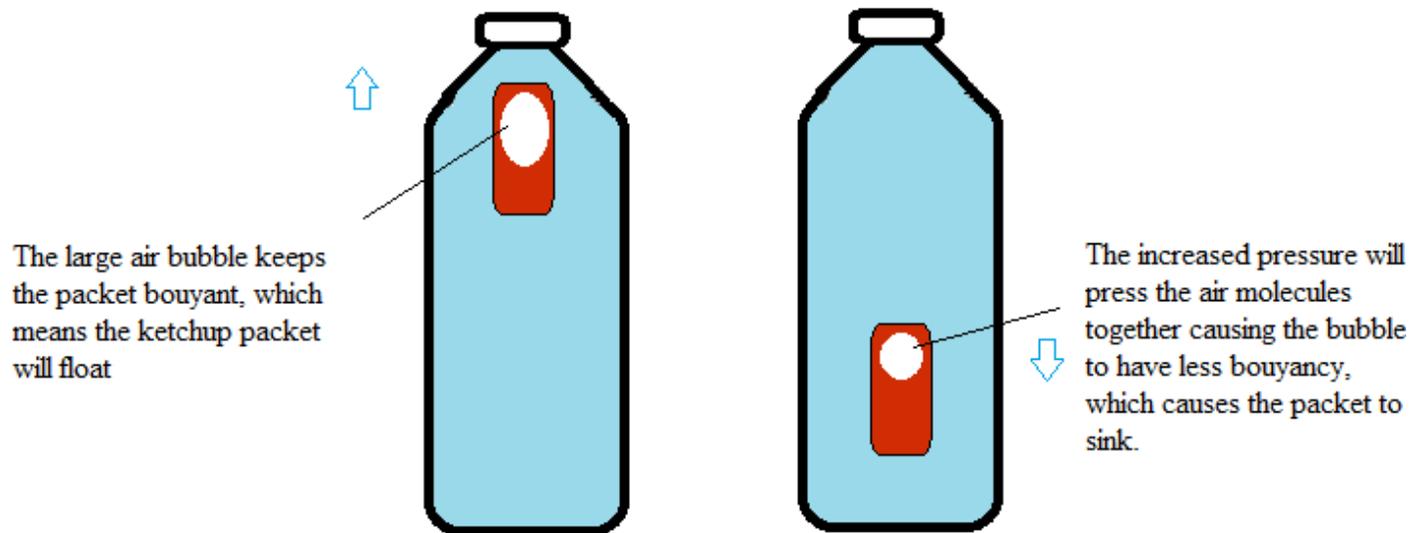
#### **Materials:**

- 1 ketchup or soy sauce packet (preferably clear packet)
- 1 clear plastic bottle (16-20 oz work fine)

Teachers Note: If the ketchup or soy sauce packet does not float initially then you need to get a new packet. You can also use a pen lid if you want another way of doing this experiment. To do this you need a ballpoint pen cap that does not have holes in it. You will also need some modeling clay. Place a small amount of modeling clay at the end of the point on the pen cap. For detailed instructions see the following link:

<http://www.sciencebob.com/experiments/cartesian.php>

First, place the soy sauce packet in the bottle of water and replace the lid. Make sure the bottle is full of water. Have the students notice where the soy sauce packet is floating. Also, take note of how big the air bubble is inside the packet (if you can see it). Squeeze the bottle of water. What happens? Now release the bottle. What happens to the packet?



### **What is happening?**

By squeezing the bottle, you are increasing the pressure inside the bottle. This increased pressure causes the ketchup or soy sauce to push against the air bubble in the packet. This causes the volume of the air bubble to decrease. As the air bubble decreases in volume the soy sauce packet will "dive" down to the bottom of the bottle. Notice that we said volume of the air, we are not changing the amount of air we have just how much space it occupies. Essentially, we are causing the air molecules to pack tightly together. When you let go of the bottle, the pressure is lessened and the bubble volume returns to normal causing the packet to float again.

### **How this relates to Aquanaut Jess and Aquanaut Bruce:**

As a diver is it important to understand the relationship, pressure has on gas. As pressure increases the volume of air decreases. When a diver descends the pressure increases every 33ft by 1 atmosphere (ATM). On land, the pressure is 1 ATM. At 33ft under water, the pressure increases to 2ATM and by 66ft the pressure is 3ATM. This is important for divers, because they have a tank of air that they are exposing to higher pressures. At 33ft, the amount of air that is in the cylinder has not changed, but the volume of air has decreased. (Remember the air molecules are being pushed together and takes up less space in the cylinder.) Imagine then that the diver is down at 66ft (3ATM) where the volume of air is 1/3 what it is normally and the diver takes a breath of air. The diver is breathing the same amount as they would at the surface. Because the air molecules are crowded together, the diver is using more air molecules than they would at less pressure. This is why divers use up the air faster at greater depths.

This is also important for Jessica and Bruce because the Habitat in which they are living is an over pressure system. This means that the air pressure inside the habitat is more than the pressure of the air at the surface. The habitat has an air pressure of

about 2ATM. This is important for two reasons. The first being that the air pressure inside the habitat is equal to the pressure of the water at that depth and so the water is kept out of the habitat because of the high air pressure. The second reason this is important is that the pressurized air means that Jessica and Bruce will be breathing in high amounts of O<sub>2</sub> and Nitrogen. This excess nitrogen is what can cause the bends if divers ascend too quickly. (More information on that in the exploding coke demo)

Teachers: If your students struggle to understand how the water does not rush inside the habitat even though there is not a door then you can show them a glass container (cup, bowl, bottle etc) flipped upside down and placed into a bowl of water. The air stays inside the glass and keeps the water out.

Depth	Pressure	Gas Volume	Density		Depth	Pressure	Gas Volume	Density	
0m / 0'	1 ATA	1	x 1		0m / 0'	1 ATA	1	x 1	
10m / 33'	2 ATA	1/2	x 2		10m / 33'	2 ATA	1/2	x 2	
20m / 66'	3 ATA	1/3	x 3		20m / 66'	3 ATA	1/3	x 3	
30m / 99'	4 ATA	1/4	x 4		30m / 99'	4 ATA	1/4	x 4	
40m / 132'	5 ATA	1/5	x 5		40m / 132'	5 ATA	1/5	x 5	

Gas density is directly proportional to the pressure on the left; the density rises as the pressure squeezes the same number of molecules into a smaller volume. On the right the volume doesn't change-much like lungs as a diver breathes with scuba gear at increasing depths - but the density rises nonetheless. Therefore, the deeper a diver is the more gas is used from the cylinder for each breath.

From the Padi encyclopedia of diving

**Definitions:**

Boyle's law: The absolute pressure exerted by a given mass of an ideal gas is inversely proportional to the volume it occupies if the temperature and amount of gas remain unchanged within a closed system.

Animation of boyles law: <http://www.grc.nasa.gov/WWW/k-12/airplane/aboyle.html>

Charles law: When the pressure on a sample of a dry gas is held constant, the Kelvin temperature and the volume will be directly related. This law describes how a gas expands as the temperature increases; conversely, a decrease in temperature will lead to a decrease in volume.

Animation of Charles law: <http://www.grc.nasa.gov/WWW/k-12/airplane/aglussac.html>

Buoyancy: The upward force exerted on any object placed in a fluid (liquid or gas). This upward force is based on how much water is displaced by the object and by how much that displaced water weighs. See Archimedes principle.

Volume: The amount of space that a substance or object occupies, or that is enclosed within a container

Pressure: a force or weight acting on some unit of area.  $P \text{ (pressure)} = \frac{N \text{ (force)}}{m^2 \text{ (area)}}$

Air pressure: Force exerted by the weight of the air

Water pressure (hydrostatic pressure): Force exerted by the weight of the water

### **Questions:**

1. Why does the ketchup packet float?
2. What are you increasing when you squeeze the bottle?
3. Why does the ketchup packet sink?
4. What happens to the volume of air when you let go of the bottle?
5. Are you changing the amount of air you have in the ketchup packet?
6. If you are not changing the amount of air then why does the ketchup packet sink?

### **Related Topics:**

How do fish stay buoyant?

Fish use a variety of swim bladders to stay buoyant when they swim. If they have problems with their swim bladder, they may float and have trouble swimming.

Do sharks have a swim bladder?

Sharks actually do not have a swim bladder like fish instead; they have a large liver that is filled with oil. Since oil is lighter than water, the liver allows the shark to stay buoyant.

How do big ships (cruise ships, aircraft carriers etc) float?

Lung pressures:

Humans rely on pressure gradients to help assist in breathing. CPAP machines also rely on pressure gradients to work.

## Exercise 2:

### Balloon Blow Up

#### **Materials:**

- balloon
- bottle of coke (any carbonated beverage)

Take the coke and without shaking it open the lid slowly. Ask the students what they see; are there any bubbles? Now take the balloon and stretch it out. Attach the balloon over the mouth of the bottle. Shake the bottle side to side and watch the balloon expand.

#### Alternate Materials:

- Balloon
- Bottle with a narrow neck (empty soda bottle)
- funnel or straw
- water
- vinegar
- baking soda

#### Alternate directions:

Take the empty bottle and pour in about an inch of a vinegar and water solution. Next, take the balloon and stretch it out. Now take the funnel or straw and fill up the balloon halfway with baking soda. Without spilling the baking soda into the bottle, place the balloon around the opening of the bottle. Pick up the balloon where the baking soda is and allow the baking soda to enter the bottle. You may want to hold onto the balloon around the bottleneck so it does not shoot off.

#### **What is happening?**

First, let us look at how the carbon dioxide got into the coke to begin with. Sodas are carbonated which means that carbon dioxide was forced into the solution using high pressure. Under pressure, the carbon dioxide will be dissolved by the syrup solution. As long as this high-pressure environment remains, the beverage will be carbonated (as long as the lid stays on). If the pressure is released, then the carbon dioxide no longer remains dissolved in the solution and it will slowly work its way out of the

solution. This is what happens when a soda is opened and left out for hours. The soda becomes flat. When the bottle is shaken, it causes the gas to escape from the high pressure (inside the coke) to the low-pressure environment. The escaping gas is then trapped inside the balloon causing the balloon to expand.

### **How this relates to Aquanaut Jess and Aquanaut Bruce:**

This is similar to what happens to scuba divers when they dive. At a depth of 33ft, the pressure is at 2ATM, which is twice the pressure that is on the surface. When the pressure of the water increases, it causes nitrogen to be absorbed into the blood stream. As long as the diver ascends to lower pressures, (shallower depths) slowly the dissolved nitrogen will slowly work its way out of the blood stream. While shaking, the bottle of soda sped up the process; the balloon will also inflate if the soda bottle was just left alone. This takes much longer to observe.

### **Questions:**

1. What makes a coke fizzy?
2. What happens if you open a coke and let it sit for a couple of hours?
3. What happens to the coke to make it flat?
4. What is causing the balloon to inflate?
5. Would the balloon still inflate if the coke was not shaken?

### **Related topics:**

How does the Nitrogen absorb into our bodies?

### **Exercise 3:**

Coke and Mentos Geyser

#### **Materials:**

- 2 liter of coke (diet is supposed to be less sticky and produce bigger reactions)
- A roll of Mentos
- a funnel or piece of paper

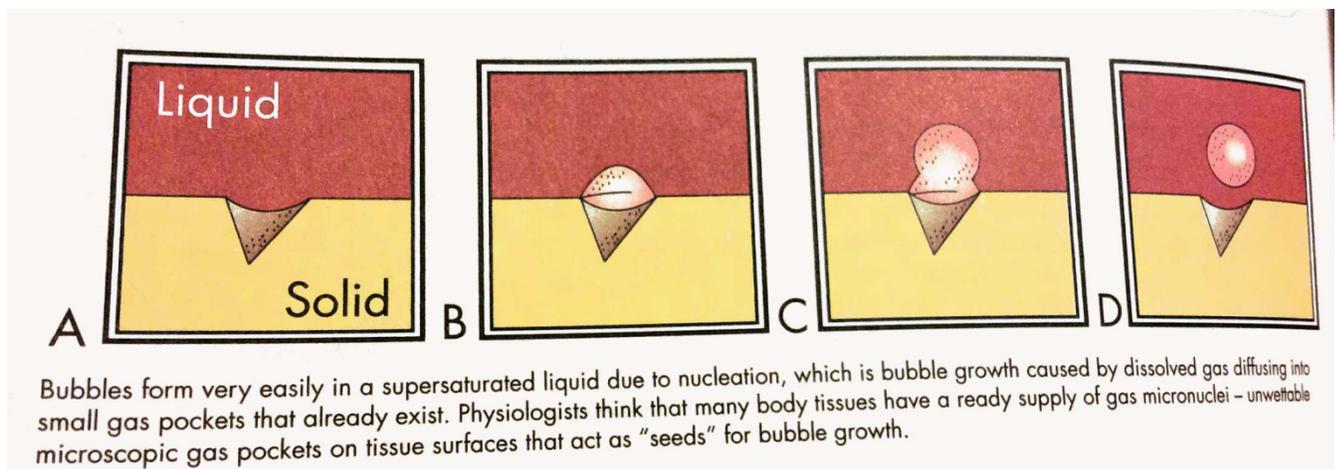
Teachers:

Make sure you do this outside!! It is extremely messy! Stress to your students to practice safe lab practices such as wearing goggles and conduct experiments with adult supervision.

Open the coke and make sure its sitting in a place where it will not tip over. You will want to drop the whole roll of Mentos into the coke at the same time so use the funnel or make a funnel with a piece of paper. Drop in all the Mentos and then run away!

#### **What is happening?**

Simply put, the carbon dioxide molecules are escaping from the coke solution very quickly causing the eruption. Exactly how this happens is a little bit more detailed. The carbon dioxide molecules are suspended into the coke solution where surface tension and pressure keeps it in the solution. Water molecules create surface tension around each carbon dioxide bubble. Essentially, the water creates a barrier around each bubble of carbon dioxide. If that carbon dioxide bubble wanted to work its way out of the solution, or join with another carbon dioxide bubble, it would first have to move that water barrier out of the way. The Mentos have a coating on the outside that will break that surface tension causing the bubbles to grow and expand using much less energy than before. The Mentos also have micronuclei, which are un-wettable microscopic gas pockets that allow gas bubbles to form. These micronuclei or nucleation sites allow bubbles to form all over the surface of the candy and they can form rapidly with little energy. The Mentos are also heavy and sink to the bottom of the coke which causes an even bigger reaction because the gas bubbles that form are forming at the bottom of the bottle and then push the liquid out with the bubbles.



### **How this relates:**

On the surface people, breathe a mixture of 21% oxygen and 79% nitrogen. When divers are at depth, the air they are breathing is denser than it is at the surface. Therefore, with each breath, a diver takes in more oxygen molecules and nitrogen molecules than they normally would at the surface. A diver will absorb nitrogen into their blood stream at higher pressures. The nitrogen will slowly work its way out of the blood stream when the diver slowly ascends to less pressure/shallower depths.

However, if the diver ascends too quickly then the diver can get decompression sickness, also known as the bends.

Two principals are at work when a diver ascends too quickly: the first is the air bubbles in the blood stream are expanding because of the lower pressure, like the air bubble in the Cartesian diver experiment. The second is that the nitrogen is rapidly coming out of the blood stream due to the lesser pressure, which is what was seen with the exploding coke. These rapidly formed air bubbles typically become trapped in the joint spaces of divers and cause severe pain. These air bubbles can cause numbness, tingling, paralysis, blocked blood flow, and even death depending on where the bubbles form. In order to avoid getting the bends divers have decompression stops. These are set depths at which the diver will stay at for a given amount of time to let any bubbles work their way out before going to a lesser pressure. For example, during a 40ft dive, a diver would stop at 15ft and do a three-minute safety stop before continuing to the surface.

### **Definitions:**

Henry's law: At a constant temperature the amount of a given gas that dissolves in a given type and volume of liquid is directly proportional to the partial pressure of that gas in equilibrium with that liquid.

### **Questions:**

1. What caused the eruption of coke?
2. If we had only dropped one Mentos into the coke would the reaction have been different?
3. Why are the Mentos important for this experiment to work?
4. So why will nitrogen cause Decompression Sickness but oxygen does not?
  - a. Because oxygen is diffused into the tissues and used metabolically.
5. If a diver gets Decompression Sickness how do you think they could get rid of the trapped bubbles?

### **Related topics:**

How do we absorb nitrogen in our bodies?

What can affect Decompression sickness susceptibility? Body fat, exercise, gender, age, dehydration, alcohol, and cold temperatures all have effects

Hyperbaric chambers

### **Links:**

Divers

<http://scifun.chem.wisc.edu/homeexpts/diver.htm>

<http://www.sciencebob.com/experiments/cartesian.php>

Balloon blow up

[https://www.youtube.com/watch?v=JK5-2X\\_GqP8](https://www.youtube.com/watch?v=JK5-2X_GqP8)

<http://ohwowkids.org/wp-content/uploads/2013/10/Balloon-Blow-Up.pdf>

<https://www.youtube.com/watch?v=I98vs-JfDPs>

Exploding coke:

<http://www.stevespanglerscience.com/lab/experiments/original-mentos-diet-coke-geyser>

Answers:

1. Why does the ketchup packet float?
    - a. The buoyancy of the air bubble inside the packet
  2. What are you increasing when you squeeze the bottle?
    - a. The pressure inside the bottle
  3. Why does the ketchup packet sink?
    - a. The increased pressure caused the air bubble to decrease in volume. The smaller air bubble is less buoyant causing the ketchup packet to sink.
  4. What happens to the volume of air when you let go of the bottle?
    - a. When the pressure is released the air bubble volume increases to normal.
  5. Are you changing the amount of air you have in the ketchup packet?
    - a. No. The volume of the air bubble is changing not the amount of air.
  6. If you are not changing the amount of air then why does the ketchup packet sink?
    - a. The smaller volume is less buoyant. The definition of buoyancy states that the upward force is based on how much water is displaced by the object and by how much that displaced water weighs. The smaller air bubble displaces less water so it is less buoyant.
- 
1. What makes a coke fizzy?
    - a. Carbonation. Carbon dioxide that is dissolved into the soda solution.
  2. What happens if you open a coke and let it sit for a couple of hours?
    - a. It becomes flat. The carbon dioxide works its way out of the soda solution.
  3. What happens to the coke to make it flat?
    - a. Due to less pressure in the air compared to what is inside the coke the carbon dioxide will work its way out of the solution.
  4. What is causing the balloon to inflate?
    - a. The carbon dioxide
  5. Would the balloon still inflate if the coke was not shaken?
    - a. Yes. It would be much slower
- 
1. What caused the eruption of coke?
    - a. The sudden release of carbon dioxide from the solution.
  2. If we had only dropped one Mentos into the coke would the reaction have been different?
    - a. Yes. It would have fizzed but not erupted the way it did in the experiment.
  3. Why are the Mentos important for this experiment to work?
    - a. It lowers the surface tension of the soda so it is easier for the carbon dioxide to come out of the solution.
  4. So why will nitrogen cause Decompression Sickness but oxygen does not?
    - a. Oxygen is diffused into the tissues and used metabolically.
  5. If a diver gets Decompression Sickness how do you think they could get rid of the trapped bubbles?

- a. Recompression. By increasing the pressure it can shrink the bubbles and allow them to slowly work their way out.

## **Tennessee Standards:**

### **Grade 6 :Embedded Inquiry**

#### Conceptual Strand

*Understandings about scientific inquiry and the ability to conduct inquiry are essential for living in the 21st century.*

#### Guiding Question

*What tools, skills, knowledge, and dispositions are needed to conduct scientific inquiry?*

### **Grade Level Expectations**

GLE 0607.Inq.1 Design and conduct open- ended scientific investigations.

GLE 0607.Inq.2 Use appropriate tools and techniques to gather, organize, analyze, and interpret data.

GLE 0607.Inq.3 Synthesize information to determine cause and effect relationships between evidence and explanations.

GLE 0607.Inq.4 Recognize possible sources of bias and error, alternative explanations, and questions for further exploration.

GLE 0607.Inq.5 Communicate scientific understanding using descriptions, explanations, and models.

### **Checks for Understanding**

0607.Inq.1 Design and conduct an open-ended scientific investigation to answer a question that includes a control and appropriate variables.

0607.Inq.2 Identify tools and techniques needed to gather, organize, analyze, and interpret data collected from a moderately complex scientific investigation.

0607.Inq.3 Use evidence from a dataset to determine cause and effect relationships that explain a phenomenon.

0607.Inq.4 Review an experimental design to determine possible sources of bias or error, state alternative explanations, and identify Questions for further investigations.

0607.Inq.S Design a method to explain the results of an investigation using descriptions, explanations, or models.

### **State Performance Indicators**

SPI 0607.Inq.1 Design a simple experimental procedure with an identified control and appropriate variables.

SPI 0607.Inq.2 Select tools and procedures needed to conduct a moderately complex experiment.

SPI 0607.Inq.3 Interpret and translate data in a table, graph, or diagram.

SPI 0607.Inq.4 Draw a conclusion that establishes a cause and effect

relationship supported by evidence.

SPI 0607.Inq.5 Identify a faulty interpretation of data that is due to bias or experimental error.

## **Grade 6 :Embedded Technology & Engineering**

Conceptual Strand

*Society benefits when engineers apply scientific discoveries to design materials and processes that develop into enabling technologies.*

Guiding Question

*How do science concepts, engineering skills, and applications of technology improve the quality of life?*

### **Grade Level Expectations**

GLE 0607.T/E.1 Explore how technology responds to social, political, and economic needs.

GLE 0607.T/E.2 Know that the engineering design process involves an ongoing series of events that incorporate design constraints, model building, testing, evaluating, modifying, and retesting.

GLE 0607.T/E.3 Compare the intended benefits with the unintended consequences of a new

GLE 0607.T/E.4 Describe and explain adaptive and assistive bioengineered products.

### **Checks for Understanding**

0607.T/E.1 Use appropriate tools to test for strength, hardness, and flexibility of materials.

0607.T/E.2 Apply the engineering design process to construct a prototype that meets certain specifications.

0607.T/E.3 Explore how the unintended consequences of new technologies can impact society.

0607.T/E.4 Research bioengineering technologies that advance health and contribute to improvements in our daily lives.

0607.T/E.5 Develop an adaptive design and test its effectiveness.

### **State Performance Indicators**

SPI 0607.T/E.1 Identify the tools and procedures needed to test the design features of a prototype.

SPI 0607.T/E.2 Evaluate a protocol to determine if the engineering design process was successfully applied.

SPI 0607.T/E.3 Distinguish between the intended benefits and the unintended consequences of a new technology.  
technology.

SPI 0607.T/E.4 Differentiate between adaptive and assistive engineered products (e.g., food, biofuels, medicines, integrated pest management).

## **Grade 7 : Embedded Inquiry**

Conceptual Strand

Understandings about scientific inquiry and the ability to conduct inquiry are essential for living in the 21st century.

Guiding Question

What tools, skills, knowledge, and dispositions are needed to conduct scientific inquiry?

### **Grade Level Expectations**

GLE 0707.Inq.1 Design and conduct open- ended scientific investigations.

GLE 0707.Inq.2 Use appropriate tools and techniques to gather, organize, analyze, and interpret data.

GLE 0707.Inq.3 Synthesize information to determine cause and effect relationships between evidence and explanations.

GLE 0707.Inq.4 Recognize possible sources of bias and error, alternative explanations, and questions for further exploration.

GLE 0707.Inq.5 Communicate scientific understanding using descriptions, explanations, and models.

### **Checks for Understanding**

0707.Inq.1 Design and conduct an open-ended scientific investigation to answer a question that includes a control and appropriate variables.

0707.Inq.2 Identify tools and techniques needed to gather, organize, analyze, and interpret data collected from a moderately complex scientific investigation.

0707.Inq.3 Use evidence from a dataset to determine cause and effect relationships that explain a phenomenon.

0707.Inq.4 Review an experimental design to determine possible sources of bias or error, state alternative explanations, and identify questions for further investigation.

0707.Inq.5 Design a method to explain the results of an investigation using descriptions, explanations, or models.

### **State Performance Indicators**

SPI 0707.Inq.1 Design a simple experimental procedure with an identified control and appropriate variables.

SPI 0707.Inq.2 Select tools and procedures needed to conduct a moderately complex experiment.

SPI 0707.Inq.3 Interpret and translate data in a table, graph, or diagram.

SPI 0707.Inq.4 Draw a conclusion that establishes a cause and effect relationship supported by evidence.

SPI 0707.Inq.5 Identify a faulty interpretation of data that is due to bias or experimental error.

## **Grade 7 : Embedded Technology & Engineering**

Conceptual Strand

Society benefits when engineers apply scientific discoveries to design materials and processes that develop into enabling technologies.

Guiding Question

How do science concepts, engineering skills, and applications of technology improve the quality of life?

### **Grade Level Expectations**

GLE 0707.T/E.1 Explore how technology responds to social, political, and economic needs.

GLE 0707.T/E.2 Know that the engineering design process involves an ongoing series of events that incorporate design constraints, model building, testing, evaluating, modifying, and retesting.

GLE 0707.T/E.3 Compare the intended benefits with the unintended consequences of a new technology.

GLE 0707.T/E.4 Describe and explain adaptive and assistive bioengineered products.

### **Checks for Understanding**

0707.T/E.1 Use appropriate tools to test for strength, hardness, and flexibility of materials.

0707.T/E.2 Apply the engineering design process to construct a prototype that meets certain specifications.

0707.T/E.3 Explore how the unintended consequences of new technologies can impact society.

0707.T/E.4 Research bioengineering technologies that advance health and contribute to improvements in our daily lives.

0707.T/E.5 Develop an adaptive design and test its effectiveness.

### **State Performance Indicators**

SPI 0707.T/E.1 Identify the tools and procedures needed to test the design features of a prototype.

SPI 0707.T/E.2 Evaluate a protocol to determine if the engineering design process was successfully applied.

SPI 0707.T/E.3 Distinguish between the intended benefits and the unintended consequences of a new technology.

SPI 0707.T/E.4 Differentiate between adaptive and assistive engineered products (e.g., food, biofuels, medicines, integrated pest management).

## **Grade 8 : Embedded Inquiry**

Conceptual Strand

Understandings about scientific inquiry and the ability to conduct inquiry are essential for living in the 21st century.

Guiding Question

What tools, skills, knowledge, and dispositions are needed to conduct scientific inquiry?

### **Grade Level Expectations**

GLE 0807.Inq.1 Design and conduct open- ended scientific investigations.

GLE 0807.Inq.2 Use appropriate tools and techniques to gather, organize, analyze, and interpret data.

GLE 0807.Inq.3 Synthesize information to determine cause and effect relationships between evidence and explanations.

GLE 0807.Inq.4 Recognize possible sources of bias and error, alternative explanations, and questions for further exploration.

GLE 0807.Inq.5 Communicate scientific understanding using descriptions, explanations, and models.

### **Checks for Understanding**

0807.Inq.1 Design and conduct an open-ended scientific investigation to answer a question that includes a control and appropriate variables.

0807.Inq.2 Identify tools and techniques needed to gather, organize, analyze, and interpret data collected from a moderately complex scientific investigation.

0807.Inq.3 Use evidence from a dataset to determine cause and effect relationships that explain a phenomenon.

0807.Inq.4 Review an experimental design to determine possible sources of bias or error, state alternative explanations, and identify questions for further investigation.

0807.Inq.5 Design a method to explain the results of an investigation using descriptions, explanations, or models.

### **State Performance Indicators**

SPI 0807.Inq.1 Design a simple experimental procedure with an identified control and appropriate variables.

SPI 0807.Inq.2 Select tools and procedures needed to conduct a moderately complex experiment.

SPI 0807.Inq.3 Interpret and translate data into a table, graph, or diagram.

SPI 0807.Inq.4 Draw a conclusion that establishes a cause and effect relationship supported by evidence.

SPI 0807.Inq.5 Identify a faulty interpretation of data that is due to bias or experimental error.

## **Grade 8 : Embedded Technology & Engineering**

Conceptual Strand

Society benefits when engineers apply scientific discoveries to design materials and processes that develop into enabling technologies.

Guiding Question

How do science concepts, engineering skills, and applications of technology improve the quality of life?

### **Grade Level Expectations**

GLE 0807.T/E.1 Explore how technology responds to social, political, and economic needs.

GLE 0807.T/E.2 Know that the engineering design process involves an ongoing series of events that incorporate design constraints, model building, testing, evaluating, modifying, and retesting.

GLE 0807.T/E.3 Compare the intended benefits with the unintended consequences of a new technology.

GLE 0807.T/E.4 Describe and explain adaptive and assistive bioengineered products.

### **Checks for Understanding**

0807.T/E.1 Use appropriate tools to test for strength, hardness, and flexibility of materials.

0807.T/E.2 Apply the engineering design process to construct a prototype that meets certain specifications.

0807.T/E.3 Explore how the unintended consequences of new technologies can impact society.

0807.T/E.4 Research bioengineering technologies that advance health and contribute to improvements in our daily lives.

0807.T/E.5 Develop an adaptive design and test its effectiveness.

### **State Performance Indicators**

SPI 0807.T/E.1 Identify the tools and procedures needed to test the design features of a prototype.

SPI 0807.T/E.2 Evaluate a protocol to determine if the engineering design process was successfully applied.

SPI 0807.T/E.3 Distinguish between the intended benefits and the unintended consequences of a new technology.

SPI 0807.T/E.4 Differentiate between adaptive and assistive engineered products (e.g., food, biofuels, medicines, integrated pest management).

## **Grade 8 - Physical Science**

### **Grade 8 : Standard 9 - Matter**

Conceptual Strand 9

The composition and structure of matter is known, and it behaves according to principles that are generally understood.

Guiding Question 9

How does the structure of matter influence its physical and chemical behavior?

### **Grade Level Expectations**

GLE 0807.9.1 Understand that all matter is made up of atoms.

GLE 0807.9.2 Explain that matter has properties that are determined by the structure and arrangement of its atoms.

GLE 0807.9.3 Interpret data from an investigation to differentiate between physical and chemical changes.

GLE 0807.9.4 Distinguish among elements, compounds, and mixtures.

GLE 0807.9.5 Apply the chemical properties of the atmosphere to illustrate a mixture of gases.

GLE 0807.9.6 Use the periodic table to determine the characteristics of an element.

GLE 0807.9.7 Explain the Law of Conservation of Mass.

GLE 0807.9.8 Interpret the events represented by a chemical equation.

GLE 0807.9.9 Explain the basic difference between acids and bases.

### **Checks for Understanding**

0807.9.1 Identify atoms as the fundamental particles that make up matter.

0807.9.2 Illustrate the particle arrangement and type of motion associated with different states of matter.

0807.9.3 Measure or calculate the mass, volume, and temperature of a given substance.

0807.9.4 Calculate the density of various objects.

0807.9.5 Distinguish between elements and compounds by their symbols and formulas.

0807.9.6 Differentiate between physical and chemical changes.

0807.9.7 Describe how the characteristics of a compound are different than the characteristics of their component parts.

0807.9.8 Determine the types of interactions between substances that result in a chemical change.

0807.9.9 Explain how the chemical makeup of the atmosphere illustrates a mixture of gases.

0807.9.10 Identify the atomic number, atomic mass, number of protons, neutrons, and electrons in an atom of an element using the periodic table.

0807.9.11 Use investigations of chemical and physical changes to describe the Law of Conservation of Mass.

0807.9.12 Differentiate between the reactants and products of a chemical equation.

0807.9.13 Determine whether a substance is an acid or a base by its reaction to an indicator.

### **State Performance Indicators**

SPI 0807.9.1 Recognize that all matter consists of atoms.

SPI 0807.9.2 Identify the common outcome of all chemical changes.

SPI 0807.9.3 Classify common substances as elements or compounds based on their symbols or formulas.

SPI 0807.9.4 Differentiate between a mixture and a compound.

SPI 0807.9.5 Describe the chemical makeup of the atmosphere.

SPI 0807.9.6 Compare the particle arrangement and type of particle motion associated with different states of matter.

SPI 0807.9.7 Apply an equation to determine the density of an object based on its mass and volume.

SPI 0807.9.8 Interpret the results of an investigation to determine whether a physical or chemical change has occurred.

SPI 0807.9.9 Use the periodic table to determine the properties of an element.

SPI 0807.9.10 Identify the reactants and products of a chemical reaction.

SPI 0807.9.11 Recognize that in a chemical reaction the mass of the reactants is equal to the mass of the products (Law of Conservation of Mass).

SPI 0807.9.12 Identify the basic properties of acids and bases.