Science

Module 4

Physical Science: Forces and Motion

Module Goal

The goal of this module is to provide information that will help educators increase their knowledge of grade-appropriate science concepts, knowledge, and skills to support effective planning or modification of their existing science instructional units for students with significant cognitive disabilities. The module includes important concepts, knowledge, and skills for the following instruction:

- Motion and Stability: Forces and Interactions (elementary)—Interactions occur between objects and can be explained using the concept of forces (e.g., magnetic force, gravitational force, balanced forces, and unbalanced forces). Electric, magnetic, and gravitational forces between a pair of objects do not require that the objects be in contact—for example, magnets push or pull at a distance. The gravitational force of Earth acting on an object near Earth's surface pulls that object toward the planet's center. All forces have both magnitude and direction. Technical terms, such as magnitude, velocity, momentum, and vector quantity, are not introduced at this level, but the concept that some quantities need both size and direction to be described is developed.
- Motion and Stability: Forces and Interactions (middle)—Motion of an object can be described by its position, force, and direction. A change in an object's motion depends on the sum of forces on the object. The greater the mass of the object, the greater the force needed to cause movement. For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first but in the opposite direction (Newton's third law).

Module Objectives

The content module supports educators' planning and implementation of instructional units in science by:

- Developing an understanding of the concepts and vocabulary that interconnect with information in the module units.
- Learning instructional strategies that support teaching students the concepts, knowledge, and skills related to the module units.
- Discovering ways to transfer and generalize the content, knowledge, and skills to future school, community, and work environments.

The module provides an overview of the science concepts, content, and vocabulary related to Physical Science: Forces and Motion and provides suggested teaching strategies and ways to support transference and generalization of the concepts, knowledge, and skills. The module does not include lesson plans and is not a comprehensive instructional unit. Rather, the module provides information for educators to use when developing instructional units and lesson plans.

The module organizes the information using the following sections:

I. Tennessee Academic Standards for Science and Related Knowledge and Skills Statements and Underlying Concepts;
II. Scientific Inquiry and Engineering Design;
III. Crosscutting Concepts;
IV. Vocabulary and Background Knowledge information, including ideas to teach vocabulary;
V. Overview of Units' Content;
VI. Universal Design for Learning (UDL) Suggestions;

VII. Transference and Generalization of Concepts, Knowledge, and Skills; and
VIII. Tactile Maps and Graphics.

Section I

Tennessee Academic Standards for Science and Related Knowledge and Skills Statements and Underlying Concepts

It is important to know the expectations for each unit when planning for instruction. The first step in the planning process is to become familiar with the identified academic standards and the Knowledge and Skills Statements (KSSs) and Underlying Concepts (UCs) covered in the module. The KSSs are specific statements of knowledge and skills linked to the grade-specific science academic standards. The UCs are entry-level knowledge and skills that build toward a more complex understanding of the knowledge and skills represented in the KSSs and should not be taught in isolation. It is important to provide instruction on the KSSs along with the UCs to move toward acquisition of the same knowledge and skills.

Table 1 includes the academic standards and related KSSs and UCs for Physical Science: Forces and Motion. While only the academic standards targeted for the Tennessee Comprehensive Assessment Program/Alternate (TCAP/Alt) are included, instruction on additional standards will aid in student understanding. Standards that are not included still represent important content for students to master. Therefore, the KSSs and UCs included in the table do not cover all the concepts that can be taught to support progress and understanding aligned to the standards.

Table 1. Tennessee Academic Standards for Science and Related KSSs and UCs [1]

Academic Standards	Knowledge and Skills Statement (KSS)	Underlying Concept (UC) of the Academic Standard
Motion and Stability: Forces and Interactions		
3.PS2.1: Explain the cause and effect relationship of magnets.	**3.PS2.1.a:** Ability to recognize cause and effect relationships of magnetic interactions between two objects	**3.PS2.1.UC:** Match materials with similar physical properties (i.e., attracted to magnets).
5.PS2.1: Test the effects of balanced and unbalanced forces on the speed and direction of motion of objects.	**5.PS2.1.a:** Ability to identify that an object is at rest unless it is pushed or pulled	**5.PS2.1.UC:** Identify a push or a pull on an object.
5.PS2.3: Use evidence to support that the gravitational force exerted by Earth on objects is directed toward the Earth's center.	**5.PS2.3.a:** Ability to identify that the gravitational force exerted by Earth on objects is directed down	**5.PS2.3.UC:** Identify the direction an object will go when dropped.
5.PS2.4: Explain the cause and effect relationship of two factors (mass and distance) that affect gravity.	**5.PS2.4.a:** Ability to identify that more mass and less distance result in greater forces of gravity	**5.PS2.4.UC:** Recognize that the force of gravity does not require the interacting objects to be in contact with one another.
Motion and Stability: Forces and Interactions		
8.PS2.3: Create a demonstration of an object in motion and describe the position, force, and direction of the object.	**8.PS2.3.a:** Ability to describe an object's position in terms of its relationship to another object	**8.PS2.3.UC:** Recognize a change in an object's motion using graphical or visual displays.
	8.PS2.3.b: Ability to describe the effect of a force (i.e., strength or direction) on an object	
8.PS2.4: Plan and conduct an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.	**8.PS2.4.a:** Ability to recognize that a change in an object's motion is due to the mass of an object and the forces acting on that object, using data on the motion of the object **8.PS2.4.b:** Ability to recognize that an object with more mass takes more force acting on the object in order to cause movement	**8.PS2.4.UC:** Recognize that a larger force causes a larger change in the motion of an object.
8.PS2.5: Evaluate and interpret that for every force exerted on an object there is an equal force exerted in the opposite direction.	**8.PS2.5.a:** Ability to describe the relationship of forces given a model or scenario (e.g., a person's body is propelled forward as their foot pushes backwards against a surface)	**8.PS2.5.UC:** Recognize that an object being acted on by a force exerts an equal force back, (i.e. if you push on a wall, the wall pushes back.).

[1] Instruction is not intended to be limited to the concepts, knowledge, and skills represented by the KSSs and UCs listed in Table 1.

Section II

Scientific Inquiry and Engineering Design

It is important for students with significant cognitive disabilities to have the opportunity to explore the world around them and learn to problem solve during science instruction. This approach to science instruction does not involve rote memorization of facts; instead it involves scientific inquiry. A Framework for K-12 Science Education (2012) unpacks scientific inquiry, providing eight practices for learning science and engineering in grades K–12. These practices provide students an opportunity to learn science in a meaningful manner. Students should combine the science and engineering practices as appropriate to conduct scientific investigations instead of using a practice in isolation or sequentially moving through each practice. Support should be provided as necessary for students with significant cognitive disabilities to actively use the practices. A link to *Safety in the Elementary Science Classroom* is in the resources of this section. See Section VI. Universal Design for Learning Suggestions for support ideas. Following are the science and engineering practices (National Research Council, 2012) associated with the content of this module. Examples are provided for each practice.

- Asking questions (for science) and defining problems (for engineering).
  Examples: How does the orientation of the magnet affect the direction of the magnetic force? What causes the motion of an object to change? What would happen if there were no force of gravity? Work in small groups to make suggestions for a device that can be improved with the incorporation of a magnet or identify problems that can be solved by integrating magnets into the solutions. Create, with peers, a device that demonstrates the properties of magnetism, magnetic fields, and polarity. Ask questions about the impact of collisions between two cars, between a car and stationary objects, and between a meteor and a space vehicle.

- Developing and using models.
  Examples: Use a model to demonstrate balanced and unbalanced forces. Label a model of forces exerted on an object and make a prediction of future motion of the object (e.g., applying these forces to a ball or a toy car). Design a model to test a design that will lessen the impact of two cars colliding. A demonstration of how increased speed or mass contributes to increased kinetic energy could include two objects of different masses (e.g., balls) rolling into targets (e.g., plastic bowling pins, wooden blocks, etc.).

- Planning and carrying out investigations.
  Examples: Through planning and conducting investigations, come to understand that groups of forces that result in changes in an object's speed or direction of motion are unbalanced. Identify the cause and effect relationships at work and identify the objects that are exerting forces on one another. In a developed investigation plan, describe how the motion of the object will be observed and recorded. Plan investigations that control variables and provide evidence to support explanations or design solutions related to unbalanced forces acting upon an object, in later grades applying Newton's second law to such instances. Identify the phenomenon under investigation, which includes the change in motion of an object.

- Analyzing and interpreting data.
  Examples: Analyze and interpret data to identify patterns of change in the motion of objects and to make predictions about an object's future motion. Use graphical displays to organize data such as mass of the object, speed of the object, and direction of the object. Using the analyzed data, describe the relationship between kinetic energy and mass as a linear proportional relationship and/or the relationship between kinetic energy and speed as a nonlinear (square) proportional relationship.

- Constructing explanations (for science) and designing solutions (for engineering).
  Examples:. Explain why magnetic forces are sometimes repulsive. Given a problem to solve involving a collision of two objects, design a solution (e.g., an object, tool, process, or system). Use knowledge of Newton's third law to systematically determine how well the design solution meets the criteria and constraints.
- Engaging in argument from evidence.
  Examples: Use reasoning to connect the relevant and appropriate evidence to support the claim with argumentation. For example, since an object that is stationary when held moves downward when released, there must be a force (gravity) acting on the object that pulls the object toward the center of Earth.
- Obtaining, evaluating, and communicating information.
  Examples: Communicate the idea that depending on the direction of the force relative to the direction of motion, the object may change its speed, direction of motion, or both (e.g., a fly ball). Evaluate and describe the given evidence, data, and/or models and describe how it supports the claim that larger objects are harder to move, which leads to the conclusion that gravity must apply a greater force on more massive objects since all objects fall at the same rate.

Science Practices Resources[2]

- Safety in the Elementary Science Classroom provides safety information for teachers and students.
  https://www.acs.org/content/dam/acsorg/about/governance/committees/chemicalsafety/safetypractices/safety-in-the-elementary-school-science-classroom.pdf
- This site categorizes inquiry into three types: structured inquiry, guided inquiry, and open inquiry. Each type provides a wide range of example lessons grouped by elementary and middle school.
  http://www.justsciencenow.com/inquiry/
- Education.com provides a variety of physical science activities and experiments.
  https://www.education.com/activity/physical-science/
- This site provides information on introducing models to elementary students.
  http://seplessons.ucsf.edu/node/1760

Section III

Crosscutting Concepts

Grade-level science content includes Crosscutting Concepts, which are concepts that connect information between different science strands and grade levels. The Crosscutting Concepts are intended to work together with the science inquiry and engineering practices, in addition to core content, to enable students to reason with evidence, make sense of phenomena, and design solutions to problems. Helping students make connections between these types of concepts and new content information supports comprehension of the concepts, knowledge, and skills as well as transference and generalization (see Section VII for more information). Crosscutting Concepts that are specific to this module connect to content across the units within the module as well as across modules.

Crosscutting Concepts are a common link between multiple standards and units of study. The Crosscutting Concepts, by being revisited and linked to multiple units of study, become a strong foundation of understanding and support the students in learning new concepts. Physical science focuses on physical and chemical principles that explain mechanisms of cause and effect in systems and processes. For example, understanding that cause and effect relationships may cause change is a Crosscutting Concept that applies to the effect of wind and water movements on Earth's surface, competition of organisms within an environment, and applied force on the motion of an object. Crosscutting Concepts may apply across multiple content areas and instructional emphases (e.g., cause and effect in reading science texts). The Crosscutting Concepts of cause and effect and stability and change provide a framework for understanding forces and motion.

This content module, Physical Science: Forces and Motion, addresses the effect of unbalanced forces on an object resulting in a change of motion. It addresses the fact that some forces act through contact and some forces act even when the objects are not in contact.

Teaching Crosscutting Concepts

The following strategies pulled from the principles of UDL (CAST, 2011) are ways in which to teach Crosscutting Concepts to help students understand the concepts and make connections between different curricular content. During instruction, highlight:

- patterns (e.g., point out patterns in the shape of a graph or repeating pattern on a chart),
- critical features (e.g., provide explicit cues or prompts, such as highlighting, that help students to attend to important features),
- big ideas (e.g., present and reinforce the "big ideas" that students should take and apply to the students' lives.), and
- relationships (e.g., make the connection between the unit concepts and how they apply to the students' lives).

Following are **Crosscutting Concepts** for this Content Module—Physical Science: Forces and Motion. According to *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* (2012), these concepts help provide students with an organizational framework for connecting knowledge from the various disciplines into a coherent and scientifically based view of the world.

Patterns

Patterns

- Patterns of change can be used to make predictions (e.g., Scientists and engineers analyze patterns to make predictions, develop questions, and create solutions. As students have opportunities to observe forces interacting with objects, they will ask questions and analyze and interpret data to identify patterns of change in the motion of objects and to make predictions about an object's future motion.).

Causality

Cause and Effect

- Cause and effect relationships are routinely identified (e.g., When equal forces are pulling on two ends of a rope, the rope remains at rest.).
- Cause and effect relationships are routinely identified, tested, and used to explain change (e.g., As students interact with objects, such as pushing a door closed, bouncing a ball, or rolling a ball down a ramp, they may ask, "What caused the changes that I observed? How can I change the way in which the object moved?").

Systems

Systems and System Models

- Models can be used to represent systems and their interactions—such as inputs, processes, and outputs—and energy and matter flows within systems (e.g., Two balls colliding with each other models the principle that an object being acted on by a force exerts an equal force back.).

Stability and Change

- Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales (e.g., The change in the motion of an object subjected to unbalanced forces depends on the mass of the object.).

Crosscutting Concept Resources

- Grant Wiggins talks about "big ideas" in this article. http://www.authenticeducation.org/ae_bigideas/article.lasso?artid=99
- A Framework for K-12 Science Education, Appendix G explains the crosscutting concepts and how the concepts help students deepen their understanding of the information. http://www.nextgenscience.org/sites/default/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf
- Teacher Vision provides ten science graphic organizers that are free and printable. https://www.teachervision.com/graphic-organizers/science/52539.html
- Utah Education Network provides a variety of student interactives for:
  - grades three through six. http://www.uen.org/3-6interactives/science.shtml
  - grades seven through twelve. http://www.uen.org/7-12interactives/science.shtml

Section IV

Vocabulary and Background Knowledge

Vocabulary is critical to building an understanding of science concepts, knowledge, and skills. The vocabulary words that students gain through experiences provide ways for students to comprehend new information (Sprenger, 2013). Students can better understand new vocabulary when they have some background knowledge to which they can make connections. In addition, learning new vocabulary increases students' background knowledge. Therefore, it is important to teach vocabulary purposely when introducing new concepts, knowledge, or skills (e.g., magnetism) and in the context of the specific content (e.g., Teach the terms "magnetic," "force," "attract," and "repel" when experimenting with magnets.).

This module includes two types of vocabulary words, both equally important to teach. The first type, **general vocabulary words,** labels groups of words that generalize to a variety of animals, plants, organisms, and activities. For example, understanding the meaning of the words "push" and "pull" helps students understand "balanced and unbalanced forces." The second type, **specific content words,** represents groups of words that are associated with an organism, system, process, or phenomena. For example, the specific words "gravitational force" connect to the general words "force," "distance," and "direction" when learning about gravity. Providing exposure and instruction on general words provides background knowledge when introducing corresponding or related specific words.

Key Vocabulary for Instructional Units

Table 2 and Table 3 contain lists of key general vocabulary words and specific content words that are important to the units in this module. The vocabulary words span across grades three, five, and eight. Refer to the Tennessee Academic Standards for Science for grade specific words. Teach general vocabulary words to the student using a student-friendly description of the word meaning (e.g., Distance is the amount of space between two objects.) and an example of the word (e.g., The ball traveled a long distance after being kicked.). Teach the specific content vocabulary using a student-friendly description of the word meaning (e.g., Unbalanced force is when more force is applied on one side of an object than the opposite side. This causes the object to change its motion.) and a possible connection to a general vocabulary word (e.g., When one team pulls harder than the other in a game of tug of war, the motion of the rope will change.).

Do not teach memorization of vocabulary words; instead, place emphasis on understanding the word as a result of observation, investigation, viewing a model, etc. For example, a student should identify an object in motion rather than defining the term.

Table 2. General Vocabulary Words

General Vocabulary—words that generalize to different animals, plants, organisms, and activities. Describe the word and provide examples (e.g., Force is a push or pull on an object. *Example: Pushing a ball is applying a force to the ball that causes the ball to move away.).*		
• action	• magnet	• repel
• attract/attraction	• mass	• rest
• collide	• moving/motion	• speed
• direction	• physical properties	• strength
• distance	• position	• time
• energy	• pull	• transfer
• force	• push	
• friction	• reaction	

Table 3. Specific Content Words

Specific Content Words—words that specify a particular thing (e.g., sedimentary rock) or phenomena (e.g., forces and motions). Describe the word and when possible make the connection to a Crosscutting Concept (e.g., A magnetic field is the force around a magnet. The magnetic force can cause other magnets or other magnetic materials to move.).		
• acceleration	• magnetic force	• Newton's third law of motion
• balanced forces	• magnetic poles	• north pole
• gravitational force	• mass	• south pole
• gravity	• Newton's first law of motion	• unbalanced forces
• magnetic field	• Newton's second law of motion	

Ideas to Support Vocabulary Learning

Table 4 includes ideas and examples for teaching vocabulary in ways to build conceptual understanding of the words. The examples include ideas on how to provide individualization, indicated in brackets, for unique student needs. These individualization ideas are provided to guide educators in ways to create access to vocabulary instruction for individual students.

Table 4. Ideas to Teach Vocabulary Effectively (Marzano, 2004)[1]

Ideas	Examples
Explain, describe, and/or give examples of the vocabulary word rather than formal definitions.	• Provide a description and an example of gravity (e.g., Gravity is the force that causes objects to fall toward Earth. Gravity causes my pencil to fall to the ground when I drop it.)
Have students restate the vocabulary word in their own words. Take this opportunity to help students connect new vocabulary, especially general vocabulary, to prior knowledge.	• Have students state in their own words or give an example of "attract" and "repel." Help students make the connection when experimenting with magnets. [Individualization idea: Record and label two voice output switches, one with "attract" and one with "repel." Have students select the correct switch when observing objects that are being attracted and repelled.]
Have students represent vocabulary words in a variety of ways (e.g., pictures, symbols, graphic organizers, or models).	• Have students complete a graphic organizer by testing objects and sorting them into those attracted to magnets and those that are not. (see Figure 1).
Provide multiple exposure to vocabulary words in a variety of ways. This does not suggest mass trials, but rather distributed trials in different ways or contexts. Reference http://projectlearnet.org/tutorials/learning_trials.html for information on learning trials.	• Read books or watch videos related to the vocabulary and concepts. (e.g., gravity, force, and work: https://www.youtube.com/watch?v=LEs9J2IQIZY; balanced and unbalanced forces: https://www.youtube.com/watch?v=L_TXu8ih668). • Have students access online texts about magnets (e.g., http://bookbuilder.cast.org/view.php?op=view&book=44306&page=1). • Have students complete activities such as pushing and pulling objects with different strengths and in different directions. [Individualization idea: Have students use an adapted switch to activate a battery-operated fan to push different lightweight objects.]

Ideas	Examples
Ask students to discuss the vocabulary words with each other.	• Have students share a favorite word and explain why it is their favorite. [Individualization idea: Place descriptions of a few vocabulary words on a voice output device and have the student choose which one to share with a classmate using an adapted switch.] • Have students share their representations (e.g., drawings or pictures) of a vocabulary word with each other.
Play vocabulary word games with students.	• Have students, with help as needed, complete interactive software on gravity (e.g., http://sciencenetlinks.com/media/filer/2011/10/13/gravity_launch26.swf). • Have students practice vocabulary with online study sets that read the word and definition (e.g., https://quizlet.com/222924778/motion-flash-cards/).
Have students watch a dramatization or have them act out the vocabulary term.	• Have students act out vocabulary such as "push," "pull," "motion," and "direction." [Individualization idea: Have students choose the appropriate word while a peer or teacher acts out the vocabulary word.]

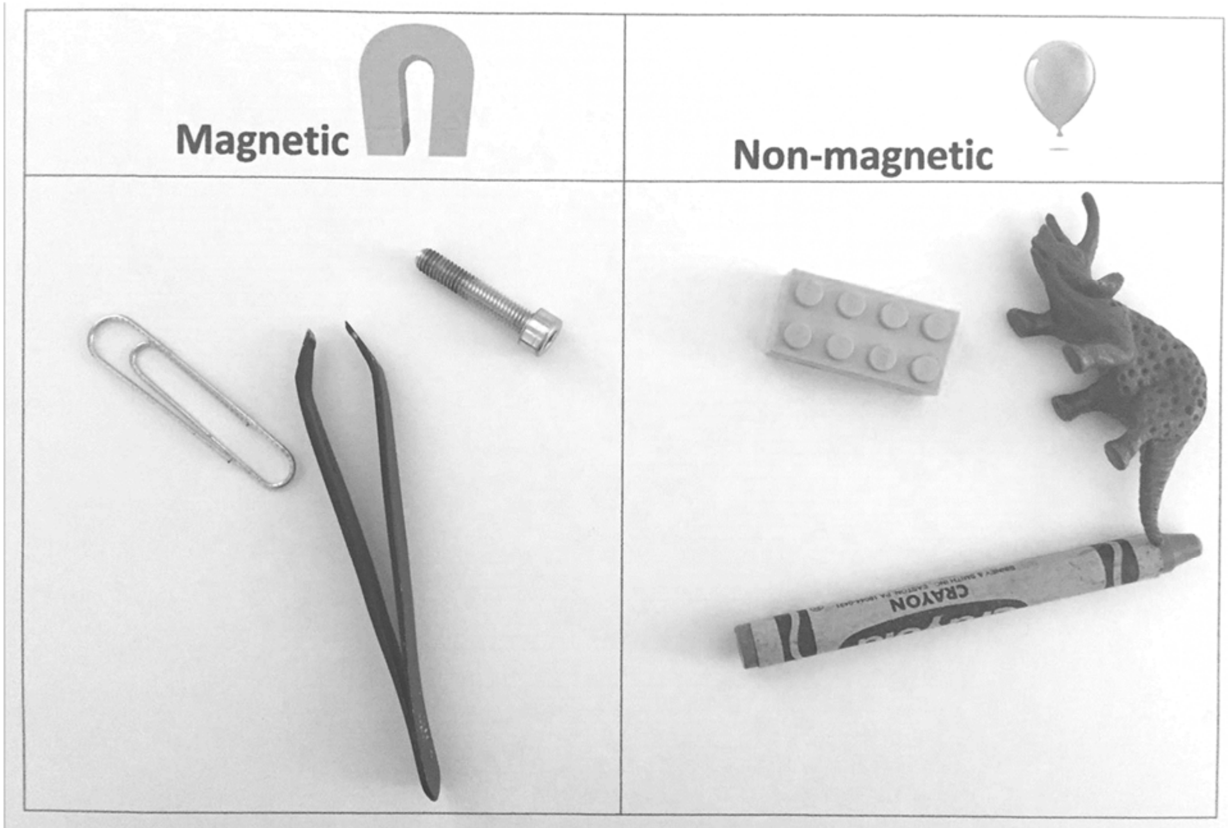
[1] Refer to Section VI, Universal Design for Learning (UDL) Suggestions for additional instructional strategies.

Vocabulary Example

Have students build an understanding of what a magnet is by testing small objects to see if they are attracted to a magnet and sort the objects onto a graphic organizer (see **Error! Reference source not found.**). Educators may need to support, modify, or adapt steps as needed for individual students. [Individualization ideas: Provide a magnet with a handle, provide the correct terminology on the student's AAC system, etc.] National Center and State Collaborative (NCSC) resources are available and may prove helpful:

- Use systematic instruction as described in the NCSC Instructional Guide. https://wiki.ncscpartners.org
- Reference ideas in the NCSC Vocabulary and Acquisition Content Module. https://wiki.ncscpartners.org

Figure 1. Example Magnet Graphic Organizer



Vocabulary Resources

- Vocabulary.com provides explanations of words using real-world examples. Once signed in, an educator can create word lists for students. http://www.vocabulary.com/
- TextProject provides Word Pictures that are free for educators to use. Their site includes word pictures for core vocabulary and various content areas including science and social studies. This link will take you to the Word Pictures page where you can select the category of words you want to use. http://textproject.org/classroom-materials/textproject-word-pictures/
- The Science Penguin site provides ideas to teach science vocabulary. The vocabulary demonstration activity uses real objects to teach vocabulary terms. http://thesciencepenguin.com/2013/12/science-solutions-vocabulary.html

Section V

Overview of Units' Content

This section of the module contains additional content and references to support educators' understanding and instruction of the instructional units. The information reflects important content to address the KSSs and to build students' knowledge, skills, and abilities; however, it is not exhaustive and should be expanded upon as appropriate.

Motion and Stability: Forces (elementary)

Content

Magnets

- Magnets attract or repel other magnets and some metals.
- Magnets can move objects without touching them (i.e., acts at a distance).
- A magnet has two sides: a north pole and a south pole.
- Like poles (north/north or south/south) repel; unlike poles (north/south) attract.
- A magnet creates an invisible area of magnetism all around it called a magnetic field.
- Magnets attract some, but not all, metals.
- Earth has a magnetic field.
- The strength between a magnet and an object depends on the distance between them.

Motion

- Objects are at rest or in motion.
- Objects in contact exert forces on each other.
- Pushing or pulling an object can change its motion.
- The strength of a push or pull affects the speed or direction of an object.
- Balanced forces on an object will cause it to remain at rest or remain in motion.
- Unbalanced forces on an object can cause changes in the object's speed or direction of motion.

Gravity

- Gravity is a fundamental force that pulls objects vertically downward toward the center of Earth.
- Earth's gravity pulls on any object on or near Earth, without touching it.
- The force of gravity is a type of pull.
- Gravitational forces are always attractive.
- The more distance between objects, the less gravitational attraction.
- Gravitational force is stronger for more massive objects.

Motion and Stability: Forces (middle)

Content

- The position of an object is its location relative to another object (e.g., above, below, in front of, or behind). Relative position is quantitative and can be represented on a number line.
- When objects collide, energy can be transferred from one object to another, changing its direction.

- Objects in contact exert forces on each other.
- Force, when applied to an object, affects the object (i.e., speed, or direction).
- The more mass an object has, the more force required to change its motion.
- The larger the force, the larger the change in the motion of an object.
- Every force exerted on an object has an equal force exerted in the opposite direction.
- For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first, but in the opposite direction (Newton's third law).
- The motion of an object is determined by the sum of the forces acting on it.

Unit Content Resources

- Interactive Sites for Education provides a wide variety of topics that include interactive animations. http://interactivesites.weebly.com/science.html

Magnets

- Better Lesson has a series of lesson plans to explore magnets. https://betterlesson.com/next_gen_science/browse/2113/ngss-3-ps2-3-ask-questions-to-determine-cause-and-effect-relationships-of-electric-or-magnetic-interactions-between-two-objects
- MnStep provides a lesson plan on the magnetic pull of a magnet by varying distances. http://serc.carleton.edu/sp/mnstep/activities/26850.html
- Science Matters has lessons and investigations about magnetism and electricity. http://sbsciencematters.com/lesson-units/4th-grade/4physical-magnetism-electricity/
- SRP has introductory information and lessons about magnets. https://www.srpnet.com/education/pdfx/magnetism.pdf
- This site provides a lesson plan on magnets. https://www.teachengineering.org/activities/view/cub_mag_lesson1_activity1
- Science NetLinks provides an activity-based lesson plan on magnets. http://sciencenetlinks.com/lessons/magnets-1-magnetic-pick-ups/

Motion

- This site has a lesson on factors that affect the motion of an object. http://safersim.nads-sc.uiowa.edu/uploads/article_29/14.%20Lesson%201%20Factors%20That%20Affect%20Motion.pdf
- eSchoolToday has information and diagrams on balanced and unbalanced forces. http://eschooltoday.com/science/forces/balanced-forces.html
- This site has an activity on balanced and unbalanced forces. http://www.morethanaworksheet.com/2015/06/20/teaching-balanced-and-unbalanced-forces/
- This site has information with animated diagrams on Newton's laws of motion. http://teachertech.rice.edu/Participants/louviere/Newton/law1.html
- Physics4Kids has information on Newton's laws of motion. http://www.physics4kids.com/files/motion_laws.html
- This site provides a lesson on designing a solution to lessen the impact of collisions. http://twobitcircus.org/wp-content/uploads/2017/03/MS-FORCES-Scramble-Car-lesson-plans.pdf

Gravity

- PBS has a lesson plan on gravity and falling objects that includes videos and hands on activities. http://www.pbslearningmedia.org/resource/phy03.sci.phys.mfe.lp_gravity/gravity-and-falling-objects/
- Science NetLinks provides a lesson on gravity. http://sciencenetlinks.com/afterschool-resources/falling-gravity/
- This site includes a lesson plan on gravity. https://betterlesson.com/lesson/645727/what-does-gravity-have-to-do-with-weight-and-mass#

Section VI

Universal Design for Learning (UDL) Suggestions

Three principles of the UDL—multiple means of representation, multiple means of action and expression, and multiple means of engagement—guide development of instruction, instructional materials, and assessments to provide access to learning to the widest range of students. A well-designed lesson using the principles of UDL reduces the need to make accommodations and modifications. However, some students with significant cognitive disabilities, especially students with visual and/or hearing impairments, physical disabilities, and students with complex communication needs, may require additional scaffolds, adaptations, and modifications to access content and support learning. UDL's three guiding principles guide educators in creating instructional materials and activities in a flexible manner to address the needs of different types of learners. Utilizing the three principles of UDL as a framework when designing instruction allows for individualization when needed. Table 5 provides strategies and examples for the UDL Principle I, **Multiple Means of Representation**: presenting information in a variety of ways to address the needs of different types of learners. Table 6 provides strategies and examples for the UDL Principle II, **Multiple Means of Action and Expression**: providing a variety of ways for students to interact with the instructional materials and to demonstrate understanding. Table 7 provides strategies and examples for the UDL Principle III, **Multiple Means of Engagement**: providing a variety of ways to engage and motivate students to learn.

The strategies and examples provided in Tables 5 through 7 are based on UDL principles and can assist all students in understanding the basic concepts. The strategies and examples, as well as individualization ideas, should serve as a catalyst for ideas that can be individualized to meet the needs of each student. Some of the examples include activities that work exceptionally well for students with vision, hearing, and/or physical limitations as well as for all students. Each example has a code to indicate when it includes specific ideas or activities that meet these needs:

V = visually impaired (low vision, blind, or deaf-blind)
H = hearing impaired (deaf, hard of hearing, or deaf-blind)
P = physical disability (limited use of hands)

Table 5. Instructional strategy ideas using the UDL Principle: Multiple Means of Representation

Multiple Means of Representation	
Strategies	**Examples**
Introduce information through a multi-sensory approach (e.g., auditory, visual, tactile).	Have students predict which objects will be attracted to magnets. Then have students test their predictions using magnets. [Individualization idea: Provide wand magnets, attach a magnet to a wrist cuff, etc.]. **P** Conduct an experiment on motion and forces (e.g., Newton's second law of motion: http://www.perkinselearning.org/accessible-science/motion-and-forces-newtons-second-law-motion). **V** Have students explore the concepts of push/pull, incline, change in motion, etc., using playground equipment, balls, or classroom materials.
Model content through pictures, dramatization, videos, etc.	Demonstrate magnets attracting and repelling each other based on orientation. [Individualization idea: Add north and south labels to the magnets.] Watch an animated video explaining: • magnetism (e.g., https://www.youtube.com/watch?v=D3e47M_AsyA), • inertia and gravity (e.g., http://studyjams.scholastic.com/studyjams/jams/science/forces-and-motion/fgravity-and-inertia.htm), • balanced and unbalanced forces (e.g., https://www.youtube.com/watch?v=L_TXu8ih668), and • equal and opposite forces (e.g., https://www.youtube.com/watch?v=y61_VPKH2B4 or https://www.youtube.com/watch?v=dCF--YOjiOw).
Present information using graphic organizers and models.	Use an extended version of the KWHL: What do I **K**now? What do I **W**ant to know about or wonder about (e.g., a phenomena)? **H**ow will I find out (e.g., determine how to organize investigations)? What have I **L**earned? What **A**ction will I take (e.g., share with others, apply to daily life, etc.)? What new **Q**uestions do I have? More information can be found at http://langwitches.org/blog/2015/06/12/an-update-to-the-upgraded-kwl-for-the-21st-century/. [Individualization idea: Use strategies for the KWHL chart for accessibility ideas: https://nceo.umn.edu/docs/Teleconferences/tele14/CourtadeFlowers.pdf.] Present a diagram of a magnetic field (e.g., http://www.coolmagnetman.com/maggallery.htm). [Individualization idea: Provide a tactile version of the diagram (see Section VIII: Tactile Maps and Graphics for guidance).] **V** Show diagrams of balanced and unbalanced forces (e.g., http://eschooltoday.com/science/forces/balanced-forces.html).
Provide appropriate and accessible text on the	Provide articles online about force and motion (e.g., https://online.kidsdiscover.com/unit/force-and-

Multiple Means of Representation	
Strategies	**Examples**
content for students to listen to or read.	motion?ReturnUrl=/unit/force-and-motion – *requires free account*). [Individualization idea: Have students use a screen reader or pair with a partner to read aloud the articles.] Provide online books that have an embedded text reader (e.g., http://bookbuilder.cast.org/view.php?op=view&book=44306&page=1 – *requires free account*) or create book(s) on the unit topics (e.g., http://bookbuilder.cast.org/). [Individualization idea: Have students use an adapted mouse to turn the pages of the online book.] **P**
Teach information using songs, poems, or rhymes.	Sing songs about: • motion (e.g., http://www.learninggamesforkids.com/science-games/science-songs/motion-song-2.html), • push and pull (e.g., https://www.youtube.com/watch?v=FOcY37oGhj8), and • magnetism (e.g., https://www.youtube.com/watch?v=RWf01NNx_bA). [Individualization idea: Teach American Sign Language signs to the songs.] **H**

Table 6. Instructional strategy ideas using the UDL Principle: Multiple Means of Action and Expression

Multiple Means of Action and Expression	
Strategies	**Examples**
Use technology/assistive technology to optimize student access and interaction with the instructional materials and content.	Have students interact with an online simulation about magnetism (e.g., http://www.scholastic.com/play/flash/gamejunk.swf). [Individualization ideas: Use an adapted mouse. **P** Preview the items in the simulation and remind the student the material each are made of.] Have students record data in a spreadsheet. [Individualization idea: Use accessibility features included in the spreadsheet program to turn on text to speech, create high-contrast, increase font, etc.] **V**
Allow for instructional materials that can be modified to provide access.	Provide steps for completing a science investigation. [Individualization idea: Create steps with simple text paired with photographs of someone completing each step.] Measure the distance a marble or ball rolls using photocopies of rulers and help students attach each measurement onto a chart on the wall to graph the data. [Individualization idea: Have students use three-dimensional blocks to graph the distance.] **P** Provide a choice of graphic organizers for students to use for a topic. [Individualization idea: Provide three-dimensional objects with hook and loop tape or magnets to complete the graphic organizer. **V/P**
Provide multiple means for students to make choices and select answers.	Have student dictate answers. [Individualization idea: Place answer options in the student's AAC device or on multi-select voice output switch.] **P** Provide answer choices. [Individualization idea: Have students use three switches with generic labels (e.g., a, b, c; red, blue, green; or three different textures) to which they listen, and then choose their answer.] **V/P** Ask questions that can be answered with yes/no or with answer choices.
Provide simulation activities.	Have students interact with a simulation about forces and motion (e.g., http://phet.colorado.edu/en/simulation/forces-and-motion-basics and https://phet.colorado.edu/en/simulation/forces-and-motion). [Individualization idea: Have students use their AAC device to communicate values (e.g., higher/lower) to change in the simulation.]
Provide graphic organizers and templates.	Sort pictures depicting push and pull in daily activities into the correct section of a graphic organizer. [Individualization idea: Provide a digital graphic organizer and have student drag and drop the pictures to the correct section.] **P**

Table 7. Instructional strategy ideas using the UDL Principle: Multiple Means of Engagement

Multiple Means of Engagement	
Strategies	**Examples**
Provide a schedule.	Provide personal schedules with tangible symbols. Have students select the next activity on the schedule and set the visual timer to indicate how long the student has before a break. Use a first/then schedule (e.g., https://www.autismclassroomresources.com/visual-schedule-series-first-then/). Modify a planner or assignment notebook similar to those used by other students by adding graphics.
Vary the challenge and amount of information presented at a time.	Begin with having students identify which objects are attracted to magnets, and then discuss the reason some objects are attracted to magnets and others are not.
Make connections to topics or activities that are motivating.	Show "funny" videos of tug of war when learning about balanced and unbalanced forces (e.g., https://www.youtube.com/watch?v=LbPlzCqR3Mw). Demonstrate force and motion using objects students are motivated by (e.g., superhero figure, sports equipment, etc.).
Allow choices as possible.	Allow students to choose where to sit and options of types of seats (e.g., stool, exercise ball, etc.). Provide students with choices for how they will present information (e.g., slide show, oral presentation, etc.) Allow students to choose whether to look at/listen to a book or watch a video about gravity during independent work time.
Provide opportunities to work collaboratively with peers.	Have students work in cooperative groups with mixed abilities. [Individualization ideas: Present instructions and group expectations using a task checklist and group rules. Develop and read a social story about working in a group to the student. Provide the student with the necessary communication tools to participate in the group activity. Assign specific pieces of the task to each student.] Have students work with a general education peer to research information on force and motion.
Teach student self-regulation skills.	Provide communication symbols to request a break or express feelings and model how to use them appropriately. Provide students with stress balls, finger fidgets, etc. Provide students with stress balls, finger fidgets, etc.

UDL Resources

- The National Center on Universal Design for Learning has a plethora of information on UDL along with examples and resources. www.udlcenter.org

- The UDL Curriculum Toolkit provides two applications for science. http://udl-toolkit.cast.org/p/applications/l1
- Perkins School for the Blind provides life science activities for students who are blind or have low vision. http://www.perkinselearning.org/accessible-science/activities/life-science
- This Perkins School for the Blind 20-minute video describes the techniques used to make science accessible for students who are blind and deaf-blind. https://www.youtube.com/watch?v=tpAejot1-Ec
- Symbaloo is a free online tool that allows an educator to create bookmarks using icons. It is easy to create and allows an educator to provide students links to sources of information that can be used for specific instructional units. www.symbaloo.com
- This site provides a brief description of Symbaloo and multiple ways to use the online tool. https://www.theedublogger.com/2014/04/09/11-ways-to-use-symbaloo-in-the-classroom/
- Perkins School for the Blind provides information on using tangible symbols to increase communication, create personal schedules, and provide choices. http://www.perkinselearning.org/videos/webcast/tangible-symbols

Section VII

Transference and Generalization of Concepts, Knowledge, and Skills

For learning to be meaningful for all students, including students with significant cognitive disabilities, it is important to intentionally make connections to future content, real-world application, and college and career readiness skills. For example, students can learn that the way they discover information through observation and investigation can also be used to problem solve daily living tasks. Additionally, the instruction of science concepts, knowledge, and skills may be the catalyst to developing other areas such as needed communication skills, reading/listening comprehension, mathematics skills, age-appropriate social skills, independent work behaviors, and skills in accessing support systems. Table 8 provides instructional ideas to help transfer and generalize concepts, knowledge, and skills and suggested opportunities to embed other skills into instruction.

Table 8. Transfer and Generalization Ideas

Area	Instruction	Opportunity to Embed Skills
Communication	When students are engaging in Scientific Inquiry and Engineering Design practices (see Section II), help students make the connections between constructing explanations and explaining their wants and needs to their friends or coworkers. Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings.	Use the context of the content area instruction to increase language skills, work on articulation, or access alternative and augmentative communication (AAC) systems.
Reading and Listening Comprehension	Provide content information through reading books and articles on science concepts (e.g., biodiversity) while working on reading comprehension.	Provide practice on communication skills when students are answering questions about information in the book or article. Work on use of assistive technology to independently read online text using a screen reader.
Mathematics	Teach measuring when observing how far a ball will travel after going down a ramp.	Provide practice on identifying numbers and understanding the relative value of each.
Age-Appropriate Social Skills	Make connections between the Crosscutting Concepts in Section III (e.g., cause and effect relationships) and the student's behavior (e.g., Student's behavior caused negative or positive effect).	Provide opportunities to work alongside same-age peers to practice age-appropriate social skills and serve a vital role in the group. Structure the learning around explaining or solving a social or community-based issue.
Independent Work Behaviors	Encourage and reinforce independent completion of tasks to build independent work skills.	Use this time to have the student work on following task completion checklists independently.
Skills in Accessing Support Systems	Encourage students to ask appropriately for assistance from peers or adults when conducting an investigation.	Use this time to have the student work on behavior and communication skills.

Section VIII

Tactile Maps and Graphics

The maps and graphics guidelines will help create tactile versions of instructional maps, diagrams, models, and timelines to use with students who are blind or deaf-blind. The tactile maps and graphics may be beneficial to other students as well. A tactile graphic is a representation of a graphic (e.g., picture, drawing, diagram, map, etc.) in a form that provides access through touch. It is not an exact copy of the graphic. The section provides basic guidance and links to more comprehensive resources.

Importance of Tactile Maps and Graphics

It is important to provide tactile graphics for young readers (BANA, 2010). It helps students understand and gain information when presented with science concepts, knowledge, and skills. Science instruction often presents diagrams (e.g., water cycle) and two-dimensional models of living and nonliving things (e.g., model of cell) to teach the related concepts. The following guidance includes information to build upon when creating tactile graphics.

Tactile Graphic Guidance

1. **Determine need for graphic:** When encountering graphics in instructional materials, determine if the graphic is essential to understanding the concept. The Braille Authority of North America (2010) provides a decision tree to help in this determination. It can be accessed online at http://www.brailleauthority.org/tg/web-manual/index.html by selecting "Unit 1 Criteria for Including a Tactile Graphic."
2. **Consult with the local educator trained to work with students with visual impairments.**
3. **Determine the essential information in the graphic.** Read the surrounding information and the caption to determine which information in the graphic to exclude. For example, a model to illustrate the cell wall, nucleus, chloroplast, and vacuole would not need to include the nuclear membrane, Golgi body, and ribosomes.
4. **Reduce unnecessary detail in the graphic.** Identify details that are not necessary for interpreting the information in the graphic. For example, a model of the water cycle may show crevices on the mountains, leaves on a tree, and waves in an ocean. Eliminate unnecessary details, as they are difficult to interpret tactilely.
5. **Remove frames or image outlines if they serve no purpose.** Ensure that all lines are necessary (e.g., the lines showing the river), and remove any that are not (e.g., ripples in the water).
6. **Modify the size of the graphic.** Modify the graphic as needed to reduce clutter and allow a blank space between adjacent textures. Additionally, consider the size of the student's hand.
7. **Use solid shapes as feasible.** When solid shapes do not clearly represent the information, use clear solid lines.
8. **Systematically teach exploration and interpretation of tactile graphics.** Systematic instruction and repetition are important when teaching a student to understand a tactile graphic. Pairing the tactile graphic with a 3-dimensional object may help (e.g., pair a raised line drawing of a plant, an example of plants and their parts, with a real plant).

Specific Graphic Type Guidance

Following is information for specific types of graphics that may support instruction in science.

Graphic Organizers/Concept Maps

- It is best to present information to compare or make connections using a tactile graphic. A tactile graphic presents the information in a spatial display and aids in comparison better than a list.

Diagrams/Models

- Limit the number of areas, lines, and labels. Having more than five makes interpretation difficult.
- Consider pairing a tactile graphic with a 3-dimensional model.

Timelines

- Present timelines in the same direction every time (i.e., horizontal or vertical).

Maps

- Distinguish water from land using a consistent background texture for the water.
- Align the direction of the compass rose arrows with the lines of longitude and latitude on the map.

Creating Tactile Graphics

Following are some ways to create tactile graphics. Additional information can be found at www.tactilegraphics.org.

Commercial products:

- Capsule paper or swell paper for printing, and
- Thermoform.

Textured shapes can be made from:

- Sticky back textured papers found at craft stores,
- Corrugated cardboard,
- Fabric with texture (e.g., corduroy, denim),
- Silk leaves,
- Cork,
- Felt,
- Vinyl,
- Mesh tape (used for drywall), and
- Sandpaper.

Raised lines can be made from:

- Glue (best not to use water-based glue), and
- Wax pipe cleaners.

Resources

- The American Foundation for the Blind provides basic principles for preparing tactile graphics. http://www.afb.org/info/solutions-forum/electronic-files-and-research-work-group/tactile-graphics/345
- The Texas School for the Blind and Visually Impaired provides basic principles for preparing tactile graphics, element arrangement on a tactile graphic, resources for preparing quality graphics, etc. http://www.tsbvi.edu/graphics-items/1465-basic-principles-for-preparing-tactile-graphics
- Perkins School for the Blind has tips for reading tactile graphics in science with a focus on state assessment. http://www.perkinselearning.org/accessible-science/blog/tips-reading-tactile-graphics-science-focus-state-assessment

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Picture Citations

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