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NM STEM Ready! Science Standards Implementation Guide

Overview

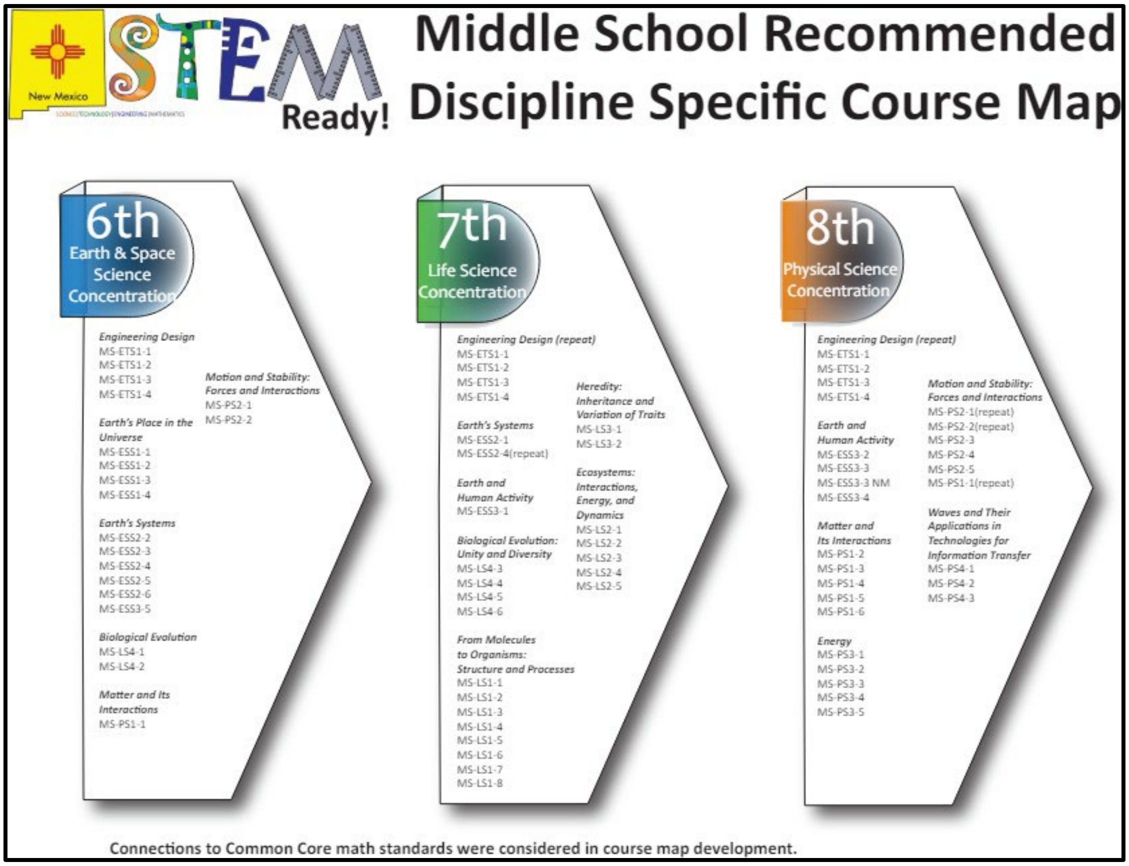
A Framework for K–12 Science Education marks a leap forward in how we think about science education and captures the advancements made in understanding how students best learn science that have been made over the last 30 years. The New Mexico Public Education Department (PED) and New Mexico public school teachers worked together over the course of spring 2024 to construct an updated Instructional Scope 2.0 document for the New Mexico STEM Ready! Science Standards.

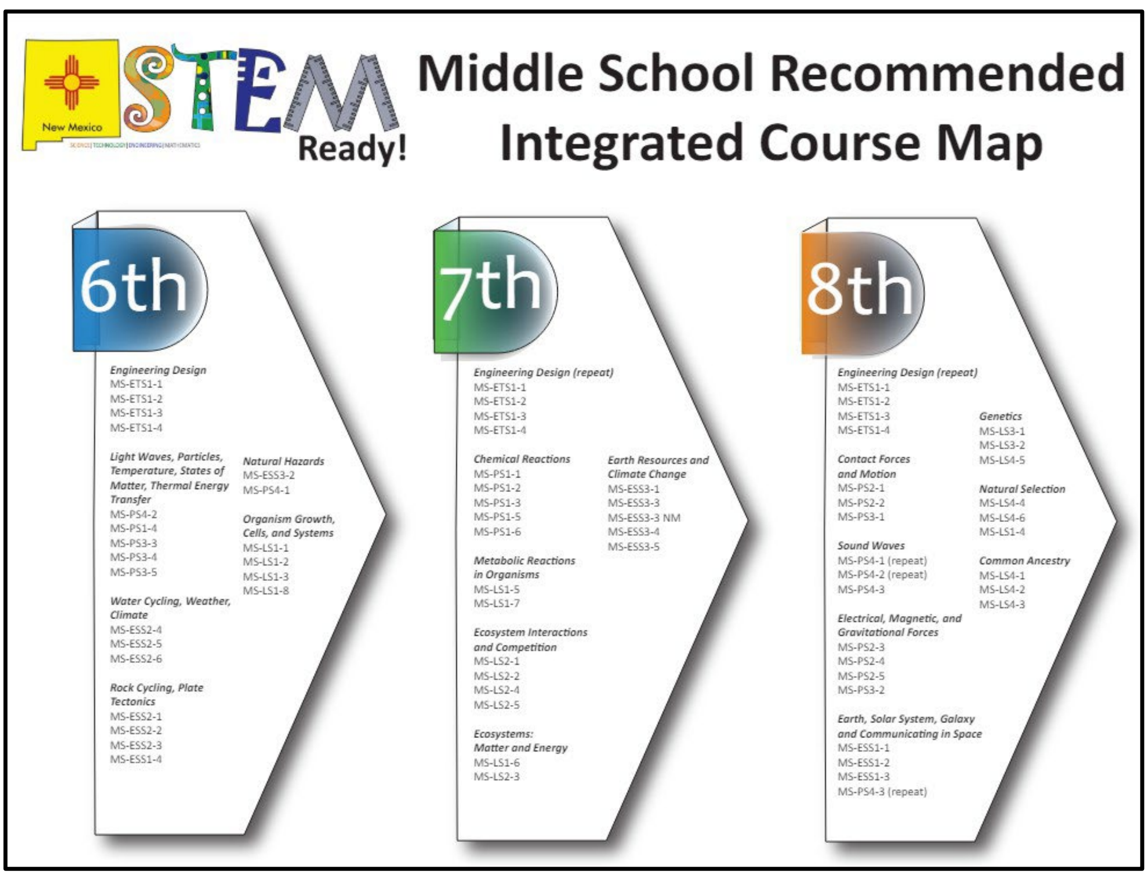
There are many public schools where high-quality instructional materials (HQIM) are present, and these should be used in the teaching of science. The updated 2.0 Instructional Scope includes some reference to the high-quality instructional materials (HQIM) used in the state, but also has updated sections that may be beneficial if they are not included with HQIM, like New Mexico relevant science phenomena and New Mexico's Multi-Layered Systems of Support (MLSS) section. It is recommended that schools with adopted HQIM continue to use their materials, but also reference the updated 2.0 Instructional Scope for context to better support New Mexico students.

New Mexico science teachers worked collaboratively to identify and construct an updated template, common misconceptions, sample phenomena, classroom assessment items, culturally and linguistically responsive (CLR) instructional strategies, Universal Design for Learning (UDL) strategies, MLSS, and cross-curricular connections for each performance expectation in the New Mexico STEM Ready! Science Standards.

The best practice of bundling related standards together to capture multiple aspects of a single phenomenon was not done, as local educational agencies (LEAs) should determine how best to bundle New Mexico STEM Ready! Science Standards based on their needs.

The standards are separated into their different disciplines and provided in a sequential format (EX: MS-PS1-1, MS-PS2-3, MS-ETS1-1), however, these standards are not meant to be taught individually on their own but bundled with other standards. Bundles are groups of standards arranged together to create endpoints for instruction and helps students see connections between concepts and allow more efficient use of instructional time. Work with your local school, or district, on creating bundles for your science courses or you can utilize resources and guidance from PED, such as the recommended discipline specific or integrated course maps (see images below).


New Mexico
STEM Ready!
Middle School Recommended
Discipline Specific Course Map
6th
Earth & Space Science Concentration
Engineering Design
MS-ETS1-1
MS-ETS1-2
MS-ETS1-3
MS-ETS1-4
Earth's Place in the Universe
MS-ESS1-1
MS-ESS1-2
MS-ESS1-3
MS-ESS1-4
Earth's Systems
MS-ESS2-2
MS-ESS2-3
MS-ESS2-4
MS-ESS2-5
MS-ESS2-6
MS-ESS3-5
Biological Evolution
MS-LS4-1
MS-LS4-2
Matter and Its Interactions
MS-PS1-1
Motion and Stability: Forces and Interactions
MS-PS2-1
MS-PS2-2
7th
Life Science Concentration
Engineering Design (repeat)
MS-ETS1-1
MS-ETS1-2
MS-ETS1-3
MS-ETS1-4
Earth's Systems
MS-ESS2-1
MS-ESS2-4(repeat)
Earth and Human Activity
MS-ESS3-1
Biological Evolution: Unity and Diversity
MS-LS4-3
MS-LS4-4
MS-LS4-5
MS-LS4-6
From Molecules to Organisms: Structure and Processes
MS-LS1-1
MS-LS1-2
MS-LS1-3
MS-LS1-4
MS-LS1-5
MS-LS1-6
MS-LS1-7
MS-LS1-8
Heredity: Inheritance and Variation of Traits
MS-LS3-1
MS-LS3-2
Ecosystems: Interactions, Energy, and Dynamics
MS-LS2-1
MS-LS2-2
MS-LS2-3
MS-LS2-4
MS-LS2-5
8th
Physical Science Concentration
Engineering Design (repeat)
MS-ETS1-1
MS-ETS1-2
MS-ETS1-3
MS-ETS1-4
Earth and Human Activity
MS-ESS3-2
MS-ESS3-3
MS-ESS3-3 NM
MS-ESS3-4
Matter and Its Interactions
MS-PS1-2
MS-PS1-3
MS-PS1-4
MS-PS1-5
MS-PS1-6
Energy
MS-PS3-1
MS-PS3-2
MS-PS3-3
MS-PS3-4
MS-PS3-5
Motion and Stability: Forces and Interactions
MS-PS2-1(repeat)
MS-PS2-2(repeat)
MS-PS2-3
MS-PS2-4
MS-PS2-5
MS-PS1-1(repeat)
Waves and Their Applications in Technologies for Information Transfer
MS-PS4-1
MS-PS4-2
MS-PS4-3
Connections to Common Core math standards were considered in course map development.


New Mexico
STEM Ready!
Middle School Recommended
Integrated Course Map
6th
Engineering Design
MS-ETS1-1
MS-ETS1-2
MS-ETS1-3
MS-ETS1-4
Light Waves, Particles, Temperature, States of Matter, Thermal Energy Transfer
MS-PS4-2
MS-PS1-4
MS-PS3-3
MS-PS3-4
MS-PS3-5
Water Cycling, Weather, Climate
MS-ESS2-4
MS-ESS2-5
MS-ESS2-6
Rock Cycling, Plate Tectonics
MS-ESS2-1
MS-ESS2-2
MS-ESS2-3
MS-ESS1-4
Natural Hazards
MS-ESS3-2
MS-PS4-1
Organism Growth, Cells, and Systems
MS-LS1-1
MS-LS1-2
MS-LS1-3
MS-LS1-8
7th
Engineering Design (repeat)
MS-ETS1-1
MS-ETS1-2
MS-ETS1-3
MS-ETS1-4
Chemical Reactions
MS-PS1-1
MS-PS1-2
MS-PS1-3
MS-PS1-5
MS-PS1-6
Metabolic Reactions in Organisms
MS-LS1-5
MS-LS1-7
Ecosystem Interactions and Competition
MS-LS2-1
MS-LS2-2
MS-LS2-4
MS-LS2-5
Ecosystems: Matter and Energy
MS-LS1-6
MS-LS2-3
Earth Resources and Climate Change
MS-ESS3-1
MS-ESS3-3
MS-ESS3-3 NM
MS-ESS3-4
MS-ESS3-5
8th
Engineering Design (repeat)
MS-ETS1-1
MS-ETS1-2
MS-ETS1-3
MS-ETS1-4
Contact Forces and Motion
MS-PS2-1
MS-PS2-2
MS-PS3-1
Sound Waves
MS-PS4-1 (repeat)
MS-PS4-2 (repeat)
MS-PS4-3
Electrical, Magnetic, and Gravitational Forces
MS-PS2-3
MS-PS2-4
MS-PS2-5
MS-PS3-2
Earth, Solar System, Galaxy and Communicating in Space
MS-ESS1-1
MS-ESS1-2
MS-ESS1-3
MS-PS4-3 (repeat)
Genetics
MS-LS3-1
MS-LS3-2
MS-LS4-5
Natural Selection
MS-LS4-4
MS-LS4-6
MS-LS1-4
Common Ancestry
MS-LS4-1
MS-LS4-2
MS-LS4-3

The Standards

Each performance expectation (PE) begins with links to the *Next Generation Science Standards* and a snapshot of the performance expectation with the relevant Science and Engineering Practices (SEP), Disciplinary Core Ideas (DCI), and Cross Cutting Concepts (CCC). Also captured are the connections across the grade level or band (horizontal), connections across grade levels or bands (vertical), and connections to the *Common Core State Standards* (CCSS) in math and English language arts.

The Performance Expectation (PE) describes what a student is expected to be able to do at the completion of instruction. They are intended to guide the development of assessments, but they are not the assessment as such. They are not instructional strategies or instructional objectives, but they should influence and guide instruction. Most performance expectations contain a clarification statement and an assessment boundary statement to provide clarity to the performance expectation and guidance to the scope of the expectation, respectively.[1]

The foundation box, which is located below the PE, contains the learning goals that students should achieve and that will be assessed using the PED. The three parts to the foundation box are the science and engineering practices, the disciplinary core ideas, and the crosscutting concepts. The information contained in the foundation box is taken directly from *A Framework for K–12 Science Education*. Also included in the foundation box, where appropriate, are connections to engineering, technology, and applications of science as well as connections to the nature of science. These supplemental goals are related to the other material in the foundation box and are intended to guide instructions, but the outcomes are not included in the performance expectation.

The connections box identifies connections to other disciplinary core ideas at this grade level that are relevant to the standard, identifies the articulation of disciplinary core ideas across grade levels, and identifies connections to the CCSS in mathematics and in English language arts and literacy that align to this standard. The connections box helps support instruction and development of instructional materials.

[1] Pratt, Harold (2013) *The NSTA Reader's Guide to the Next Generation Science Standards*

Common Misconceptions

What: This planning support identifies some of the common misconceptions students develop about a scientific topic.

Why: Our brains are highly advanced cause and effect reasoning machines. From birth, we begin to analyze effects to determine causes and provide some sort of reasoning for the whole event. The more events that support our reasoning, the stronger that learning becomes. So, every student in your classroom brings their own unique background knowledge into your classroom. Some of this is aligned to scientific understanding and some of this is misaligned to scientific understanding but aligned to that student's personal experiences. As science educators, we must always create space for students to bring their current understanding about a topic into our classroom so that we can begin to address understandings that are misaligned to scientific understanding. Some of these misunderstandings are not unique to a single student; rather, they are common to many students.

How: When planning with your HQIM look for ways to directly address with students some common misconceptions. The planning supports in this document provide some possible misconceptions and your HQIM might include additional ones. The goal is not to avoid misconceptions, they are a natural part of the learning process, but we want to support students in exploring the misconception and modifying incorrect or partial understandings.

Sample Phenomena and New Mexico Relevant Phenomena

Located directly under the standards and misconceptions are the suggested sample phenomena. This section was constructed specifically for New Mexico with suggestions for phenomena that are relevant to New Mexico or relatable by New Mexico students..

What: Natural phenomena are observable events that occur in the universe and that we can use our science knowledge to explain or predict. The goal of building knowledge in science is to develop general ideas, based on evidence, that can explain and predict phenomena. Engineering involves designing solutions to problems that arise from phenomena and using explanations of phenomena to design solutions. In this way, phenomena are the context for the work of both the scientist and the engineer.

Why: Despite their centrality in science and engineering, phenomena have traditionally been a missing piece in science education. Anchoring learning in explaining phenomena supports student agency for wanting to build science and engineering knowledge. Students are able to identify an answer to "why do I need to learn this?" before they even know what "this" is. By centering science education on phenomena that students are motivated to explain, the focus of learning shifts from learning about a topic to figuring out why or how something happens. Explaining phenomena and designing solutions to problems allow students to build general science knowledge in the context of their application to understanding phenomena in the real world, leading to deeper and more transferable knowledge. Students who come to see how science ideas can help explain and model phenomena related to compelling real-world situations learn to appreciate the social relevance of science. They get interested in and identify with science as a way of understanding and improving real-world contexts.

Learning to explain phenomena and solve problems is the central reason students engage in the three dimensions of the *NGSS*. Students explain phenomena by developing and applying the DCI and CCC through use of the SEPs. Phenomena-centered classrooms also give students and teachers a context in which to monitor ongoing progress toward understanding all three dimensions. As students are working toward being able to explain phenomena, three-dimensional formative assessment becomes more easily embedded and coherent throughout instruction.

<u>How:</u> We use phenomena to drive instruction to help students engage in practices to develop the knowledge necessary to explain or predict the phenomena. Therefore, the focus is not just on the phenomenon itself. It is the phenomenon plus the student-generated questions about the phenomenon that guides the learning and teaching. The practice of asking questions or identifying problems becomes a critical part of trying to figure something out.

There could potentially be many different lines of inquiry about the same phenomenon. Teachers should help students identify different aspects of the same phenomenon as the focus of their questions. Students also might ask questions about a phenomenon that motivates a line of investigation that isn't grade appropriate or might not be effective at using or building important disciplinary ideas. Teacher guidance may be needed to help students reformulate questions so they can lead to grade appropriate investigations of important science ideas.

It is important that all students—including English Learners and students from cultural groups underrepresented in STEM—are supported in working with phenomena that are engaging and meaningful to them. Not all students will have the same background or relate to a particular phenomenon in the same way. Educators should consider student perspectives when choosing phenomena and should prepare to support student engagement in different ways. When starting with one phenomenon in your classroom, it is always a good idea to help students identify related phenomena from their lives and their communities to expand the phenomena under consideration.

Not all phenomena need to be used for the same amount of instructional time. Teachers could use an anchoring phenomenon as the overall focus for a unit, along with other investigative phenomena along the way as the focus of an instructional sequence or lesson. They may also highlight everyday phenomena that relate investigative or anchoring phenomena to personally experienced situations. A single phenomenon doesn't have to cover an entire unit, and different phenomena will take different amounts of time to figure out.

The most powerful phenomena are culturally or personally relevant or consequential to students. Such phenomena highlight how science ideas help us explain aspects of real-world contexts or design solutions to science-related problems that matter to students, their communities, and society. An appropriate phenomenon for instruction should help engage all students in working toward the learning goals of instruction as described by the DCIs, SEPs, and CCCs in the foundation box of the standard.

The process of developing an explanation for a phenomenon should advance students' understanding. If students already need to know the target knowledge before they can inquire about the phenomenon, then the phenomenon is not appropriate for initial instruction. Students should be able to make sense of anchoring or investigative phenomena, but not immediately, and not without investigating it using sequences of the science and engineering practices. Phenomena do not need to be flashy or unexpected. Students might not be intrigued by an everyday phenomenon right away because they believe they already know how or why it happens. With careful teacher facilitation, students can become dissatisfied with what they believe they already know and strive to understand it in the context of the DCI that the teacher is targeting.[2]

Classroom Assessment Items

To align with the phenomena section above, this includes New Mexico based assessment items that directly relate, or comparatively, to the suggested New Mexico phenomena when available.

What: Classroom assessments (sometimes referred to as internal assessments) is used to refer to assessments designed or selected by teachers and given as an integral part of classroom instruction. This category of assessment may include teacher-student interactions in the classroom, observations of students, student products that result directly from ongoing instructional activities, quizzes tied to instructional activities, formal classroom exams that cover material from one or more instructional units, or assessments created by curriculum developers and embedded in instructional materials for teacher use.[3]

Classroom assessments can be designed to guide instruction (formative purposes) or to support decisions made beyond the classroom (summative purposes). Assessments used for formative purposes occur during the course of a unit of instruction and may involve both formal tests and informal activities conducted as part of a lesson. They may be used to identify students' strengths and weaknesses, assist students in guiding their own learning, and foster students' sense of autonomy and responsibility for their own learning. Assessments for summative purposes may be administered at the end of a unit of instruction. They are designed to provide evidence of achievement that can be used in decision making, such as assigning grades, making promotion or retention decisions, and classifying test takers according to defined performance categories. The results of all these assessments are evaluated by the teacher or sometimes by groups of teachers. These assessments play an integral role in students' learning experiences while also providing evidence of progress in that learning.

Why: In *Developing Assessments for the Next Generation Science Standards*, the National Research Council shared the following conclusions regarding assessing three-dimensional learning[4]:

- Measuring the three-dimensional science learning called for in the framework and the NGSS requires assessment tasks that examine students' performance of scientific and engineering practices in the context of crosscutting concepts and disciplinary core ideas. To adequately cover the three dimensions, assessment tasks will generally need to contain multiple

[2] Penuel, W. R., Bell, P., Neill, T., Morrison, D., & Tesoriero, G. (2018). *Selecting Anchoring Phenomena for Equitable 3D Teaching*. [OER Professional Development Session from the ACESSE Project] Retrieved from http://stemteachingtools.org/pd/sessione

[3] National Resource Council. (2014). *Developing Assessments for the Next Generation Science Standards.* Committee on Developing Assessments of Science Proficiency in K-12. Board on Testing and Assessments and Board on Science Education, J.W. Pellegrino, M.R. Wilson, J.A. Koenig, and A.S. Beatty, *Editors*. Division of Social Sciences and Education. Washington, DC: The National Academies Press.

[4] National Research Council. (2014). *Developing Assessments for the Next Generation Science Standards.* Committee on Developing Assessments of Science Proficiency in K-12. Board on Testing and Assessment and Board on Science Education. J.W. Pellegrino, M.R. Wilson, J.A. Koenig, and A.S. Beatty, *Editors*. Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press.

[5] STEM Teaching Tools (n.d.), http://stemteachingtools.org/tools accessed on July 7, 2021

components. It may be useful to focus on individual practices, core ideas, or crosscutting concepts in the various components of an assessment task, but, together, the components need to support inferences about students' three-dimensional science learning as described in a given performance expectation.

- The Next Generation Science Standards require that assessment tasks be designed so they can accurately locate students along a sequence of progressively more complex understandings of a core idea and successively more sophisticated applications of practices and crosscutting concepts.

- The NGSS places significant demands on science learning at every grade level. It will not be feasible to assess all the performance expectations for a given grade level with any one assessment. Students will need multiple – and varied – assessment opportunities to demonstrate their competence on the performance expectations for a given grade level.

- Effective evaluation of three-dimensional science learning requires more than a one-to-one mapping between the NGSS performance expectations and assessment tasks. More than one assessment task may be needed to adequately assess students' mastery of some performance expectations, and any given assessment task may assess aspects of more than one performance expectations. In addition, to assess both understanding of core knowledge and facility with a practice, assessments may need to probe students' use of a given practice in more than one disciplinary context. Assessment tasks that attempt to test practices in strict isolation from one another may not be meaningful as assessments of the three-dimensional science learning called for by the NGSS. (Developing assessments for NGSS, NRC, pp.44-46)

How: The amount of information that has been generated around designing and creating three-dimensional assessment tasks to meet the conclusions laid out above by the National Research Council has been overwhelming. The following free resources are available through STEM teaching tools to help you navigate this flood of information and translate it into your classroom. You should start by familiarizing yourself with the STEM Teaching Tools[5]: http://stemteachingtools.org/tools

- Practice Brief 18 on how teachers can develop formative assessments that fit a three-dimensional view of science learning.
- Practice Brief 26 on how to design formative assessments that engage students in three-dimensional learning.
- Practice Brief 30 on integrating science practices into assessment tasks
- Practice Brief 41 on integrating cross cutting concepts into assessment and instruction
- Practice Brief 33 on designing assessments for emerging bilingual students

Culturally and Linguistically Responsive Instruction

What: Culturally and Linguistically Responsive Instruction (CLRI), or the practice of situational appropriateness, requires educators to contribute to a positive school climate by validating and affirming students' home languages and cultures. Validation is making the home culture and

[5] STEM Teaching Tools (n.d.), http://stemteachingtools.org/tools accessed on July 7, 2021

language legitimate, while affirmation is affirming or making clear that the home culture and language are positive assets. It is also the intentional effort to reverse negative stereotypes of non-dominant cultures and languages and must be intentional and purposeful, consistent and authentic, and proactive and reactive. Building and bridging is the extension of validation and affirmation. By building and bridging students learning to toggle between home culture and linguistic behaviors and expectations and the school culture and linguistic behaviors and expectations. The building component focuses on creating connections between the home culture and language and the expectations of school culture and language for success in school. The bridging component focuses on creating opportunities to practice situational appropriateness or utilizing appropriate cultural and linguistic behaviors. It is essential to recognize the impact of language in accessing the learning and guidance for linguistic vocabulary support are provided.

Why: Student understanding of science is shaped by their interactions with phenomena throughout their lives. Science educators must intentionally and purposefully legitimize the home culture and languages of students and validate their ways of knowing and understanding. In addition, create connections between the cultural and linguistic behaviors of the students' home culture and language and the culture and language of scientific understanding.

How: When planning instruction it is critical to consider ways to validate/affirm and build/bridge from your students' cultural and linguistic assets. There has been an overwhelming amount of guidance within STEM education about CLRI. The following STEM Teaching Tools can be a good place to start wrapping your mind around this topic[6].

- Practice Brief 15: Promoting equity in science education
- Practice Brief 47: Promoting equitable sensemaking
- Practice Brief 54: Building equitable learning communities
- Practice Brief 11: Indigenous ways of knowing and STEM
- Practice Brief 27: Engaging English language learners in science and engineering practices
- Practice Brief 71: Advancing equity and justice in science education
- Practice Brief 53: Avoiding pitfalls associated with CLRI

The planning supports for each performance expectation provide an example of how to support equity-based teaching practices. Look for additional ways within your HQIM to ensure all students are included in the pursuit of scientific understanding in your classroom.

Multi Layered System of Supports (MLSS)

The Multi-Layered Systems of Support (MLSS) has been updated to include instructional, social-emotional, and behavioral supports for layers 1, 2, and 3. While not all supports can be listed to meet the needs of all students, general suggestions are provided for guidance. Work within your local control to best meet the needs of your students.

What: The Multi-Layered Systems of Support (MLSS) is designed to support teachers in planning instruction for the needs of all students. Each section identifies general supports (layer 1) for supporting pedagogically sound whole class science instruction, targeted supports (layer 2) for supporting those scholars that teachers identify as not understanding the topic, and students needing intensive support (layer 3) for those students needing longer duration or otherwise more

[6] STEM Teaching Tools (n.d.), http://stemteachingtools.org/tools accessed on July 7, 2021

intense support through small group instruction.

Why: MLSS is a holistic framework that guides educators, those closest to the student, to intervene quickly when students need additional support. The framework moves away from the "wait to fail" model and empowers teachers to use their professional judgement to make data-informed decisions regarding the students in their classroom to ensure academic success with grade level expectations of the New Mexico Science Standards.

How: When planning with your high-quality instructional materials (HQIM) use the suggested universal supports embedded in the sequence of instruction. If you do not have access to HQIM in your school, the universal (layer 1) support in this document can be used in planning your instruction.

Cross-Curricular Connections

The very last section of the Instructional Scope is the cross-curricular connections. These include math and literacy standards that are supplied for the performance expectation of each standard, as well as career connections for relevant job connections.

What: In order to provide guidance on cross-curricular instruction, the standards are identified for common core English language arts (ELA) and mathematics. When reading the CCSS in mathematics and English language arts (ELA), consider the following questions:

- Should students have achieved these mathematics and ELA standards to engage in the learning of science, or could they be learned together?
- In what ways do the referenced mathematics and ELA standards help clarify the science performance expectations?
- Can any of the science core ideas be included as examples in the mathematics or ELA instruction?

Why: The cross-curricular connections utilizes common core ELA and mathematics standards identified in NGSS and provides suggestions for use within instruction so teachers are better able to see how these connections might live within their instruction.

How: When planning with your high-quality instructional materials (HQIM) use the suggested cross-curricular connections embedded in the sequence of instruction. If you do not have access to HQIM in your school, utilize the suggestions in this document that can be used in planning your instruction.

STANDARDS BREAKDOWN

[Physical Science: Motion and Stability: Forces and Interactions]
[MS-PS2-1]
[MS-PS2-2]
[MS-PS2-3]
[MS-PS2-4]
[MS-PS2-5]

Grade	NGSS Discipline Overview
MS	Physical Science
Click to find the standards breakdown.	**Teacher Background by Performance Expectation (PE)**
PS2-1	In a design challenge, students will leverage scientific knowledge of Newton’s Third Law to create solutions for problems involving collisions between two objects. This solution could be an object itself, a tool, a specific process, or even an entire system. Students will dissect the collision, identifying the objects and the forces acting upon them. They'll then apply Newton's Third Law to guide their design, selecting appropriate technologies (materials or devices) that fit within the problem's constraints. These constraints can include factors like cost, object mass and speed, available time, and materials. Students will not only define the desired outcomes (criteria) but also explain why these criteria are relevant to the problem. Finally, using Newton's Law, they'll evaluate how effectively their design meets these criteria while respecting the limitations. Newton's Third Law of Motion states that for every action, there is an equal and opposite reaction. In simpler terms, whenever two objects collide, they exert forces on each other that are equal in strength but opposite in direction like: ● When two cars crash, each car exerts a force on the other. Car A pushes on Car B with a certain amount of force, and according to Newton's Third Law, Car B pushes back on Car A with an equal force in the opposite direction. This explains why both cars experience a jolt during the collision, with the severity depending on their mass and speed (more on that later). ● When a car hits a stationary object like a pole, the same principle applies. The car hits the pole with a force, and the pole pushes back on the car with an equal but opposite force.. ● In space, where there's no friction, Newton's Third Law plays a crucial role in spacecraft movement. If a meteor collides with a spacecraft, the meteor exerts a force on the spacecraft, but due to the meteor's smaller mass compared to the spacecraft, its own change in direction might be negligible. However, the force exerted by the meteor pushes the spacecraft in the opposite direction, potentially altering its course. The forces always act on different objects. The magnitude (strength) of the forces is equal. The directions of the forces are opposite. The effect of the force depends on the mass of the objects involved. A more massive object experiences a smaller change in motion compared to a less massive object when subjected to the same force. This evaluation will also consider the solution's societal value and how both constraints and the boundaries of current technology influence their chosen technologies.

Standards Breakdown				
MS	Physical Science 2-1			
PS2-1	*The performance expectation below was developed using the following elements from the NRC document, A Framework for K-12 Science Education*			
	MS-PS2-1: Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects. **Clarification Statement:** Examples of practical problems could include the impact of collisions between two cars, between a car and stationary objects, and between a meteor and a space vehicle. **Assessment Boundary:** Assessment is limited to vertical or horizontal interactions in one dimension.	**SEP** **Constructing Explanations and Designing Solutions** 6-8 builds on K-5 experiences and progresses to including constructing explanations and designing solutions supported by multiple sources of evidence. • Apply scientific ideas or principles to design an object, tool, process, or system	**DCI** **PS2.A: Forces and Motion** • 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).	**CCC** **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. ***Connections to Engineering, Technology and Applications of Science*** **Influence of Science, Engineering, and Technology on Society and the Natural World** • The uses of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions.
	These standards are not meant to be taught individually on their own, but bundled with other standards. Bundles are groups of standards arranged together to create endpoints for instruction and it helps students see connections between concepts and allow more efficient use of instructional time. Work with your local school, or district, on creating bundles for your middle school science courses or you can utilize resources and guidance from NMPED.			
	Common Misconceptions			
	• If an object is at rest, no forces are acting on the object. • Only animated objects can exert a force. Thus, if an object is at rest on a table, no forces are acting upon it. • Force is a property of an object. An object has force and when it runs out of force it stops moving. • Large objects exert a greater force than small objects. • Action-reaction forces cancel each other.			
	New Mexico Relevant Phenomena			
	When available, you should use your locally selected or created high quality instructional materials. However, the following is an example phenomenon you can use if you don't have local high quality instructional materials available.			
	Why do things sometimes get damaged when they hit each other?	*How do rodeo riders use forces to stay in the saddle as long as possible while being bucked by a bronco or bull?*		

Oh, no! I've dropped my phone! Most of us have experienced the panic of watching our phones slip out of our hands and fall to the floor. We'v experienced the relief of picking up an undamaged phone and the frustration of the shattered screen. This common experience anchors learning in the Contact Forces unit as students explore a variety of phenomena to figure out, "Why do things sometimes get damaged when they hit each other?" Student questions about the factors that result in a shattered cell phone screen lead them to investigate what is really happening to any object during a collision.

Sourced from Open Sci Ed [8.1 Contact Forces - 8th Grade Physical Science]

What is the impact of various forces and how do they affect us?

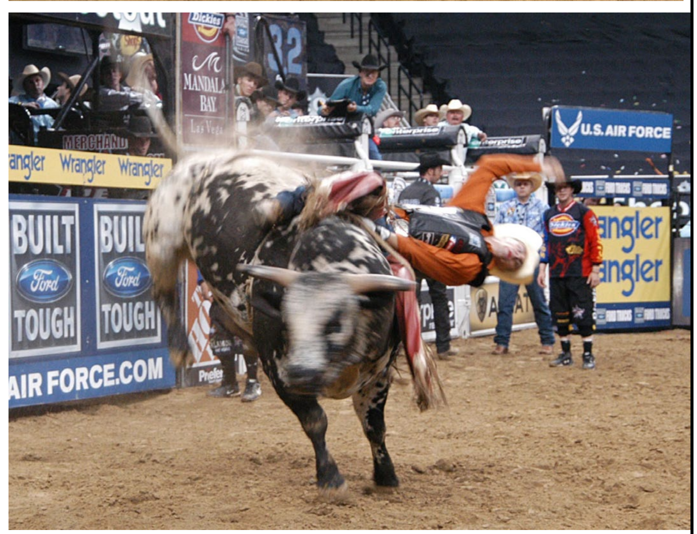
A Bed of Nails

thewonderofscience.com

Special caution should be taken when sitting down or getting up from a bed of nails. In this video, Steve Spangler used a motor to lift the entire bed of nails up and down safely. Each of the nails is pushing on the participant but since there are so many nails the force is distributed safely between all of the nails. This demonstration could be used in any physics unit discussing forces and pressure.

For example, when you jump, your legs apply a force to the ground, and the ground applies an equal and opposite reaction force that propels you into the air.

Pose the images below, or show the video [Mutton Busting: Kids Riding Sheep at The Clovis Rodeo | Localish], and ask students to share experiences with the rodeo or events shown here



In a rodeo, Newton's Third Law of motion comes into play during events such as bull riding or bronc riding (and the famous kids' event known as Mutton Busting). When a rider rides a bull or bronco, they apply force with their legs and body to stay balanced and in control.

As the bull or bronco bucks and twists, it exerts an equal and opposite reaction force on the rider. For example, when the bull's hind legs push off the ground to buck, it creates a force that propels the rider upwards and forwards. In response, the rider must counteract this force by tightening their grip and shifting their weight to maintain balance and control. In the case of Mutton

Consider the flying motion of birds. A bird flies by using its wings. The wings of a bird push air downwards. Since forces result from mutual interactions, the air must also be pushing the bird upwards. The size of the force on the air equals the size of the force on the bird; the direction of the force on the air (downwards) is opposite the direction of the force on the bird (upwards). For every action, there is an equal (in size) and opposite (in direction) reaction. Action-reaction force pairs make it possible for birds to fly.

Consider the motion of a car on the way to school. A car is equipped with wheels that spin. As the wheels spin, they grip the road and push the road backwards. Since forces result from mutual interactions, the road must also be pushing the wheels forward. The size of the force on the road equals the size of the force on the wheels (or car); the direction of the force on the road (backwards) is opposite the direction of the force on the wheels (forwards). For every action, there is an equal (in size) and opposite (in direction) reaction. Action-reaction force pairs make it possible for cars to move along a roadway surface.
[Watch this link to get more ideas about Newton's third law]

Students could draw free-body diagrams representing some of the examples above, and indicating force vectors on the object (man on bed of nails, bird flying, car on the road). Students should be able to see whether these forces are balanced (object in constant acceleration like bird flying, or object lying still like the man on the bed of nails.) or unbalanced (object changing position, direction of motion, or change in acceleration.)

Sourced from Wonder of Science [A Bed of Nails — The Wonder of Science]

Busting, the kids must hold onto the wool with the same amount of force as that of the sheep's motion, in order to stay on!

Similarly, when the rider leans back or leans to one side to counteract the bull's movements, they exert force against the animal. This action results in an equal and opposite reaction force from the bull, which continues to try to lose the rider through its bucking or twisting motion.

Students can design rodeo equipment (perhaps additions to saddles or harnesses, or even special clothing or head gear) that will mitigate some of the impact of the bull or bronco's forces on the rider. Their designs should include drawings and discussion of how their new equipment helps to balance the unbalanced forces.

When a meteorite lands on Earth, does it have any effect on the Earth? Or is only the smaller object (meteorite) affected?

A meteorite traveling through space eventually collides with Earth, demonstrating a dramatic real-world application of Newton's Third Law of Motion. When the meteorite hits Earth's surface, both objects exert equal and opposite forces on each other. This collision causes the meteorite to decelerate rapidly and often results in the formation of a crater, while Earth experiences an impact force that can lead to various geological and atmospheric changes.

Ask students to draw the moment a meteorite impacts Earth, showing the forces acting on both the meteorite and the Earth's surface. Have them describe what happens during the collision in terms of force, motion, and energy transfer. Create a discussion board or group activity where students design a solution to minimize the damage caused by a meteorite impact. Possible solutions could involve deflecting the meteorite before it reaches Earth or designing structures that can withstand the impact force.

Classroom Assessment Items

When available, you should use your locally selected or created high quality instructional materials. However, the following is an example assessment item you can use if you don't have local high quality instructional materials available.

	Newton's Third Law Performance Task The Tesla Company is designing a reclining bike targeting teenage riders. You have been selected to join a team of scientists asked to create a solution for improving safety during a head-on collision. The goal is to protect the rider from the interaction between the bike and a wall. The design solution must prevent the body from crashing into the wall and it cannot block the rider's view. Sourced from Newton's Third Law 8th Grade Newton's Third Law BC.pdf Cell Phone Damage People drop their phones all the time! It's estimated that 95 million people drop their phone every year. A cost effective case that meets certain criteria is needed to protect a phone.	New Mexico Bull Riding Sam went to a local rodeo event with his family. One of the events he saw was the bull and bronc riding where the riders try to stay on as the animal bucks. He is trying to figure out why the rider moves forward when the animal pushes backwards with their legs as shown in the video short here. Consider the components in the system, construct a scientific explanation to help Sam understand the motion in riding a bucking bull or bronc. Make sure to include: ● A claim that states how each component is shown interacting in the system. ● Evidence from observing the video to support your claim. ● Reasoning that uses what you know about the ideas of force and motion, for example, Newton's Third Law. ● Create a diagram representation of the system using arrows and description. Adapted from Learning to Swim from Next Generation Science Assessment Headgear Assessment Part I Protecting Athlete's Heads and Brains Many sports require or recommend helmets for protecting athletes' heads and brains. There are helmets for biking and skateboarding, helmets for baseball and football, helmets for rock climbing, and some people are even recommending headgear for soccer players. All of these are intended to prevent damage to the head or brain in the event of a collision.

Name: ____ Date: ________

Stimulus

People drop their phones all the time! It's estimated that 95 million people drop their phone every year. A cost effective case that meets certain criteria is needed to protect a phone.

Graph 1: Percentage of Respondents Who Dropped Their Phones in Different Ways

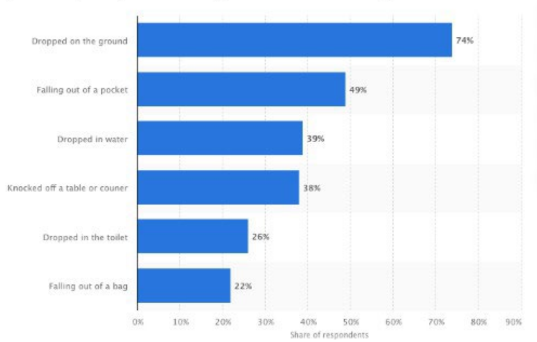


Table 1: Features of Cell Phones Cases and Drop Distance Rating and Price of Phone Case Models

Case brand	Screen Protector	Weight	Special Features	Drop Distance	Price
 Brand A	No	1 Ounce	Shock spread material helps absorb the impact of the drops	11 feet	$24.99
 Brand B	Yes	3 Ounces	Three layers of protection. 50% of materials are recycled.	24 feet	$39.96
 Brand C	Yes	6.4 Ounces	Four layer impact protection	10-15 feet	$39.99
 Brand D	No	0.81 Ounces	Lightweight, clear protection that comes with impact-absorbing AiroShock Technology	6 feet	$49.99

Your Task
In the questions that follow, you will design a solution that both protects a phone from colliding with the ground and is inexpensive based on Newton's Third Law.
Question 1
Part A: List all of the forces acting on each other when we drop a smartphone on the ground.

There are sports people participate in like basketball, soccer, and rodeo where helmets or headgear are not required even though concussions and other head injuries happen often. In rodeo, concussions are very common. How could rodeo riders protect their heads during competition?

Part 1: Evaluating headgear
Here are three different headgear devices that are currently being marketed as protection from potential concussions in cheerleading, another sport that doesn't require head protection, that could be considered for rodeo.

1a. If you were a protective headgear device designer evaluating the materials being used in another company's design, what properties or materials would you expect to see in a good protective device if it were cut open?

1b. Draw a model of the material structure you would expect to see in the design described in 1a. In your model, label each design feature. For each design

Part B: Draw a model illustrating all the forces acting on the phone and the ground. Draw arrows to show the direction and relative sizes of the forces acting on each other.

Question 2
What percentage increase occurred in cases where individuals accidentally dropped their phones into toilets compared to incidents of phones being dropped on the ground?

Question 3
Based on the information in Table 1 about the structure and function of each phone case. Write a claim about the case that you believe is the most protective. Provide reasoning and support with evidence from the table to support your claim.

Question 4
Compare and contrast the Price and Drop Distance data of the different phone cases found in Table 2.

- Part A: Rank each brand from the best protection to worst protection by putting a 1, 2, 3, or 4 in the protection column. Where a 1 protects the phone from the highest height.
- Part B: Rank each brand from the best price to worst price by putting a 1, 2, 3, or 4 in the price column. Where a 1 is the lowest price.

Question 5
You are looking for a phone case that is inexpensive and provides a significant amount of protection. Based on the information in Question 4, write a claim stating which phone case is the best for your budget, reasoning and supporting your claim with evidence from Table 1 and Table 2, including your rationale on screen protectors, weight, special features, drop distance and price.

Question 6

Redesign your case to make it more protective and/or a lower price. You can take two cases and combine features to make a new, updated case, or suggest new modifications that are not included.
Part A: Describe your new smartphone case.
Part B: Draw a model of your new case and show the forces acting on the phone when you drop it.
Part C: Explain how your updated design optimized phone protection and applied knowledge about feature you label, explain in words how the structural properties help it function as a protective material.

2a. When any of the three designs shown above are worn on a person's head, the person's head is in contact with the headgear. When a person falls to the floor and hits their head, the headgear makes contact with the ground.

Draw and label a diagram that shows all three of these objects (head, headgear, ground) in contact with each other at the point in time when the collision with the ground first starts.

2b. Draw three free body diagrams, one for each object in your system in 2a. Include the following details in each diagram:
Show the strength of the forces applied to each object in the system.

- Label what is applying this force to that object.
- Show the direction of these forces.
- Label the surface they are applied to.

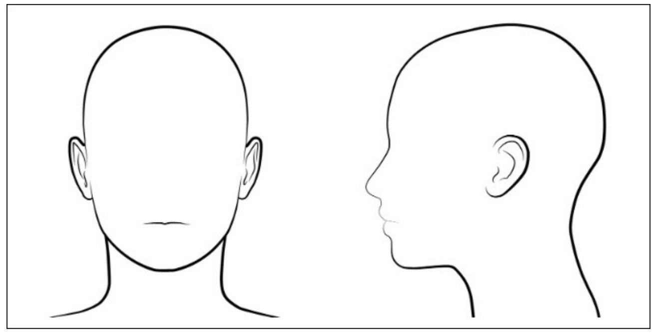
3a. During practice, a rider does not want to wear their headgear. Another member of the rodeo asks the rider to wear their headgear because it will not only protect the rider, but it will also further protect the base if they fall off instead of riding for the full 8 seconds and dismounting. Do you agree or disagree with this claim?

3b. Support or refute this claim by citing evidence from investigations we did and using any related science ideas we developed to defend your argument.

Headgear Assessment Part II
Your task is to create an optimal headgear design for a rider to wear in a competition. Complete the prompts on the next page to describe your design choices.

1. What is the purpose of the design? What criteria does the headgear you design need to meet?

2. Pick one stakeholder who will be affected by your design and design with that person in mind.
   - Who is the stakeholder you are designing for?
   - What constraints do you anticipate your stakeholder will bring to your design? List at least 3 constraints that you think a helmet designer would have to consider.

	Newton's Third Law. Sourced from SEEd [SEEd 7.1.2 Formative Assessment]	3. Use words and pictures to show the structure of your design solution. In your design solution, make sure to label the different parts and materials used in the structure. Draw the proposed design on, over, and around the 2 views of the head shown below.  4. Write an argument for why your design solution is optimal and meets the needs of your stakeholder. If you made trade-offs, discuss what trade-offs you made and why. [As an alternative to writing your argument, you can use this space to prepare to present your explanation orally instead. Think about any imagery (diagrams, pictures, drawings) you want to include in your presentation and how you will convey all the components of your design solution (why it is optimal and meets the stakeholder needs). If you choose this route, make a plan with your teacher for when you can present your explanation.] Adapted from Open Sci Ed Lesson 15 [8.1 Contact Forces - 8th Grade Physical Science]

Culturally and Linguistically Responsive Instruction		
Validate and Affirm	*Build and Bridge*	*Linguistic Vocabulary Support*
What knowledge and experiences have you might help us as a class explain what's happening when objects collide? (Example: Have you seen the car collision?)	Why would it be important for you or your community to understand what happens when objects collide ? (Example: What happens when the car hits the person or the telephone pole? What happens when the ball hits the wall?)	Build a driving question board where students can stick questions and re-address their learning through time. Include vocabulary words with written and illustrated definitions. Revisit this board often to help students make sense of their science learning. Bring those questions to group discussion. When appropriate, allow students to play charades with vocabulary words.

Planning for Multi-Layer System of Support (MLSS) & Universal Design Learning		
Layer 1 ***Core Instruction + Universal***	***Layer 2*** ***Core + Targeted***	***Layer 3*** ***Core + Targeted + Intensive***
Instructional/Academic Supports		
Recruiting Interest: Consistently reference to the given phenomenon provided at the start of instruction to engage students with relevance and value to them. **Perception:** Students should understand the concepts of force through the use of diagramming and force diagrams.Provide different ways for students to use or observe forces like captions, charts, manipulatives, and diagrams, but ensure that arrows and other variables are used. **Language & Symbols:** Provide clarity for representation of forces and symbols with multiple pictures and examples of action and reaction forces. **Universal Design for Learning** Representation Engagement Action and Expression STEM Ready UDL Supports	**Executive Functions:** Manage information and how students understand action and reaction forces through the use of graphic organizers. Additionally, provide graphic organizers for students to organize design thinking processes and their learning from testing since this standard focuses on applying knowledge to a design solution.	Consider the misconceptions in content and skills needed within the PE and identify students for small group intervention. EX:If an object is at rest, no forces are acting on the object. Students will need various examples of how action and reaction forces can be applied to an object at rest. EX: A book sitting on a table. Provide multiple opportunities for small-groups to respond, both verbally and in writing, as they process through scale and representation. Provide immediate, specific, and corrective feedback.
Social Emotional Supports		

	Integrate CASEL Playbook Strategies into your whole class routines or instruction. Some emphasized strategies/suggested activities are: **Self/Social Awareness:** After introducing the phenomenon, utilize the Optimistic Closure-Human Bar Graph (p.39) for their current understanding of the phenomenon or questions.	Provide small-group support for students in need of focused skill instruction related to self-awareness, self-management, social awareness, relationship skills, and responsible decision making. Increase positive reinforcement within the classroom for positive behavior.	Ensure that all learning environments allow students to thrive by considering the PBIS Sensory Tools. Develop consistent Behavior Meetings to help build consistency and support for the students. Additional student stakeholders may offer additional support through Counselor Referral or Collaboration with a student's physician or mental health provider.
	Behavioral Supports		
	For all students, the use of Clear, consistent, and predictable consequences helps build a productive learning environment.	Ensure the use of a PBIS Behavior Contract during lab investigations and hands-on learning to ensure Layer 1 routines are supported.	Utilize the PBIS Check In Check Out (CICO) to engage all student stakeholders in creating a consistent learning environment.

	Ensure the use of a PBIS Behavior Contract during lab investigations and hands-on learning to ensure Layer 1 routines are supported.	With challenging academic learning, utilize PBIS Structured Breaks throughout the learning cycle to support the multi-sensory environment of phenomena-based science.	
	Cross-Curricular Connections		
	ELA/Literacy	*Mathematics*	
	RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions. (MS-PS2-1) **RST.6-8.3** Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks. (MS-PS2-1)	**MP.2** Reason abstractly and quantitatively. (MS-PS2-1) **6.NS.C.5** Understand that positive and negative numbers are used together to describe quantities having opposite directions or values; use positive and negative numbers to represent quantities in real-world contexts, explaining the meaning of 0 in each situation. (MS-PS2-1) **6.EE.A.2** Write, read, and evaluate expressions in which letters stand for numbers. (MS-PS2-1)	

	WHST.6-8.7 Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration. (MS-PS2-1)	**7.EE.B.3** Solve multi-step real-life and mathematical problems posed with positive and negative rational numbers in any form, using tools strategically. Apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies. (MS-PS2-1) **7.EE.B.4** Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities. (MS-PS2-1)
	Give students a design challenge (such as which material makes the best phone case) that requires them to research materials, follow steps to experiment and use their research and results to share what they learned.	Have students analyze Newton's Law of Gravitation equation and solve given the masses of different objects.
	Career & Skill Connections	
	Atmospheric science Biology Chemistry Conservation science Engineering	Farming Landscape architecture & design Mechanical engineering Meteorology Urban planning

Grade	NGSS Discipline Overview
MS	Physical Science
Click to find the standards breakdown.	**Teacher Background by Performance Expectation (PE)**
PS2-2	Students identify the phenomenon under investigation, which includes the change in motion of an object. Students will need to identify the purpose of the investigation, which includes providing evidence that the change in an object's motion is due to the following factors: balanced or unbalanced forces acting on the object and the mass of the object. Balanced forces occur when two or more forces acting on an object are equal in strength and opposite in direction. These forces cancel each other out, resulting in no net force acting on the object. Consequently, the object remains at rest or continues moving at a constant speed in a straight line (maintaining its current motion). ● Two or more forces: There must be at least two forces acting on the object. ● Equal in strength: The magnitude (strength or size) of each force needs to be the same. ● Opposite in direction: The forces must point in opposite directions. ● Net force equals zero: When these opposing forces balance each other out, the net force acting on the object becomes zero. ● Effect on motion: Due to the net force being zero, the object's state of motion doesn't change. It stays still if it was already at rest, or it keeps moving at the same speed and in the same direction if it was already moving. Here are some everyday examples of balanced forces: ● A book resting on a table: The weight of the book pulling downwards is balanced by the normal force (support force) exerted by the table pushing upwards. ● A person tugging on a rope in one direction while another person pulls with the same force in the opposite direction. The rope remains stationary because the forces acting on it are balanced. Students develop a plan for the investigation individually or collaboratively. In the plan, students describe that the following data will be collected: data on the motion of the object, data on the total forces acting on the object, and data on the mass of the object. Students will also need to describe which data are needed to provide evidence for each of the following: an object subjected to balanced forces does not change its motion (sum of $F=0$) and an object subjected to unbalanced forces changes its motion over time (sum of $F \neq 0$).

Standards Breakdown				
MS	**Physical Science 2-2**			
	The performance expectation below was developed using the following elements from the NRC document, A Framework for K-12 Science Education			
PS2-2	**MS-PS2-2:** Plan 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. **Clarification Statement:** Emphasis is on balanced (Newton's First Law) and unbalanced forces in a system, qualitative comparisons of forces, mass and changes in motion (Newton's Second Law), frame of reference, and specification of units. **Assessment Boundary:** Assessment is limited to forces and changes in motion in one-dimension in an inertial reference frame and to change in one variable at a time. Assessment does not include the use of trigonometry.	**SEP** **Constructing Explanations and Designing Solutions** 6–8 builds on K–5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or design solutions. • Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim. **Scientific Knowledge is Based on Empirical Evidence** • Science knowledge is based upon logical and conceptual connections between evidence and explanations.	**DCI** **PS2.A: Forces and Motion** • The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion. • All positions of objects and the directions of forces and motions must be described in an arbitrarily chosen reference frame and arbitrarily chosen units of size. In order to share information with other people, these choices must also be shared.	**CCC** **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.
	These standards are not meant to be taught individually on their own, but bundled with other standards. Bundles are groups of standards arranged together to create endpoints for instruction and it helps students see connections between concepts and allow more efficient use of instructional time. Work with your local school, or district, on creating bundles for your middle school science courses or you can utilize resources and guidance from NMPED.			
	Common Misconceptions			

- If the sum of all forces adds to zero, then the object cannot move.
- An object can have a force within it that keeps it moving.
- If speed increases, then acceleration must be increasing as well.
- Forces must be exerted on a system in order for the system to maintain motion.
- Any force on an object must be in the direction of movement.
- Individual forces, not their sum, determine the motion of an object.
- If an object is moving, the sum of all forces cannot equal zero.
- Constant speed, not constant acceleration, results from constant force.

New Mexico Relevant Phenomena

When available, you should use your locally selected or created high quality instructional materials. However, the following is an example phenomenon you can use if you don't have local high quality instructional materials available.

Why is it easier to keep a block tower standing when cards are pulled from between the blocks compared to when lighter objects like paper cups are used?	*How do the forces acting on a hot air balloon change its motion? What happens when the forces on the balloon are unbalanced? How about when they are balanced?*

This HQIM phenomenon is also used in PS2-1 and provides an example of bundling standards for students to see connections between concepts.

Oh, no! I've dropped my phone! Most of us have experienced the panic of watching our phones slip out of our hands and fall to the floor. We've experienced the relief of picking up an undamaged phone and the frustration of the shattered screen. This common experience anchors learning in the Contact Forces unit as students explore a variety of phenomena to figure out, "Why do things sometimes get damaged when they hit each other?" Student questions about the factors that result in a shattered cell phone screen lead them to investigate what is really happening to any object during a collision.

Sourced from Open Sci Ed 8.1 Contact Forces - 8th Grade Physical Science

Why is it easier to keep a block tower standing when cards are pulled from between the blocks compared to when lighter objects like paper cups are used?

The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion. Remembering your trips to the supermarket. It is easier to push an empty shopping cart or a full shopping cart .

In New Mexico, the annual tradition of the Albuquerque International Balloon Fiesta fills the skies with colorful hot air balloons. As these massive balloons rise into the air, their motion depends on the interaction of forces acting upon them. How Do Hot Air Balloons Work? | Best Learning Videos For Kids | Thinking Captain

The change in the balloon's motion, whether ascending, descending, or maintaining altitude, is influenced by a combination of factors, including the mass of the balloon, the downward force of gravity, and the upward force exerted by the hot air inside the balloon. The wind also exerts a force on the balloon, which can change its direction of travel.

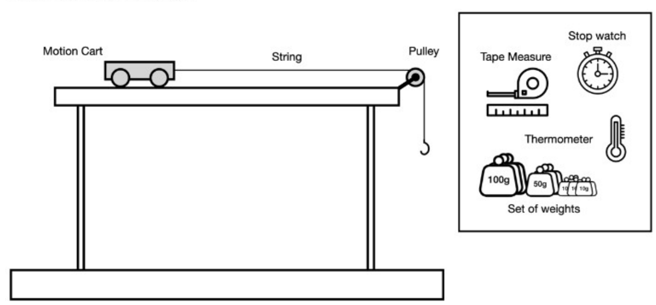
When the forces are unbalanced, the balloon travels in the direction of the greatest force. When the forces are balanced, the balloon maintains its current position. How Do Hot Air Balloons Work?

Create a discussion board for students to share their ideas. Guiding questions could include: What happens to the balloon's motion when the forces are balanced? When they are unbalanced? How does increasing the mass of the balloon affect its motion? How does wind (a horizontal force) influence the direction of the

In these activities, students explore the concept of inertia. They try to keep a block tower standing when cards are pulled from between the blocks, then compare with what happens when they try the same activity with lighter objects such as paper cups. A variation is included in which students pull a large cardboard box a certain distance while being timed, then try again as people of different masses sit inside the box.

Sourced from Wonder of Science Inertia Tower

balloon's travel? Though they may not have access to a helium tank, students can use regular balloons to see how balanced and unbalanced forces affect them as well.

Classroom Assessment Items	
When available, you should use your locally selected or created high quality instructional materials. However, the following is an example assessment item you can use if you don't have local high quality instructional materials available.	
Dog's Puller Toy Annie has two dogs and they often scramble for the same toy. One day Annie saw the two dogs bite the same toy and pull in opposite directions, but the toy never moved toward either dog, it just kept still. Draw a model to explain why the toy never moved toward either dog, but just kept still when the two dogs bite and pull it in opposite directions. Make sure your model includes: a. Forces exerted on the toy and the movement of the toy. b. Text or symbols that clarify the relationship between forces and movement of the toy. Describe how your model explains the phenomenon of the toy never moving toward either dog while the dogs bite and pull in opposite directions. **Sourced from Next Generation Science Assessment*	Coaster Launcher Roller coasters are similar to some of the forces that are at play with hot air balloons. The Formula Rossa is the fastest roller coaster in the world. The coaster reaches a top speed of 240 km/hour in 4.9 seconds using a hydraulic launch system. The weight of the roller coaster when fully loaded is 3864 kg. You will be designing an investigation to study the effect of either mass or unbalanced force on the motion of a scaled-down version of the coaster as shown below: Figure 1: Available Lab Material  What is the purpose of this investigation?

Sightseeing elevator
Henry and his mother take a sightseeing elevator so that they can go up from the 1st to 100th floor directly without stopping. When they take the elevator, Henry finds it interesting that once it gets going the elevator moves upward evenly, taking about three seconds per floor. His mother tells him that a lifting device is pulling the elevator up at a constant speed that makes them feel comfortable and safe. Henry wonders why the elevator can move upward at such a constant speed.

Draw a model to explain why the elevator can move upward at a constant speed. Make sure your model includes:
a. Forces exerted on the sightseeing elevator and the movement of the sightseeing elevator.
b. Text or symbols that clarify the relationship between forces and movement of the sightseeing elevator.

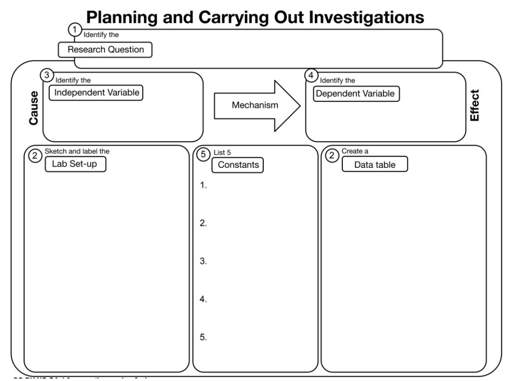
Describe how your model explains the phenomenon of the sightseeing elevator moving upward at a constant speed.

Sourced from [Next Generation Science Assessment]

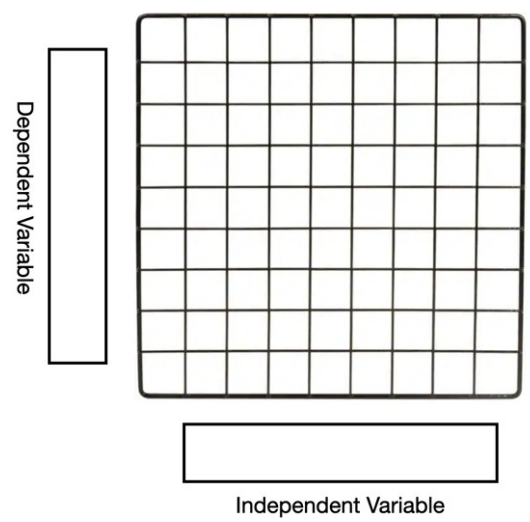
Which of the following questions would you like to investigate? (Circle one)

- How does the mass of the rollercoaster affect the motion of the rollercoaster?
- How does the unbalanced force affect the motion of the rollercoaster?

Fill out the investigation plan below to help you plan your investigation. You will be able to use any of the equipment shown in Figure 1.



Label and the graph below using your variables. Sketch out the expected relationship between these two variables.



Riders on the Formula Rossa will experience different forces depending on the number of riders and the mass of the riders. How could you modify the roller coaster so that all rides will be identical no matter how many riders are on the coaster.

Source from Wonder of Science [MS-PS2-2 Assessment- Coaster Launcher]

Culturally and Linguistically Responsive Instruction		
Validate and Affirm	*Build and Bridge*	*Linguistic Vocabulary Support*
What knowledge and experiences have you had that might help us as class understand the relationship between an object mass and how much force you have to exert to move it ?	Why does it matter to you or your community to understand the relationship between an object's mass and the forces needed to change its motion?	Throughout the standard, students will be asked to gather and make sense of information to describe forces acting on an object. Create the routine for physical science, to allow students to preview any learning material for unknown words. Provide the meaning with no judgment or reference to other learning material. **Best practice when this happens is for the teacher to keep a running record of the words and frequency.* Build a driving question board where students can stick questions and re-address their learning over time. Revisit this board often to help students make sense of their science learning. Bring those questions to group discussion. Encourage students to work with vocabulary in meaningful ways. As students engage in sensemaking, students discuss complex ideas with everyday vocabulary and use many different verbal and non-verbal strategies to community their ideas. A common practice is to create an interactive “word wall” with students, with all the terms they have used when thinking and talking about the phenomena over the course of the unit. Overtime, teachers support, encourage, and/or require students to use proper terms as they ask questions, design experiments, and argue with evidence. Some vocabulary include: balanced, unbalanced, Newton’s First Law, inertia, mass, change in motion, object, frame of reference, stability and change

Planning for Multi-Layer System of Support (MLSS) & Universal Design Learning		
Layer 1 ***Core Instruction + Universal***	***Layer 2*** ***Core + Targeted***	***Layer 3*** ***Core + Targeted + Intensive***
Instructional/Academic Supports		

	Comprehension: Provide multiple real world, local community application of science investigations like local sports or attractions in the area for students to explore the forces that act on objects. **Clarify language:** Force diagrams, or free body diagrams, will be new and unfamiliar language to students. Students should work through drawing multiple models of scenarios with forces acting on an object free body diagram. **Universal Design for Learning** Representation Engagement	**Use multiple tools for construction and composition:** Somes students need additional support on collecting and addressing the sum of factors how gravity and normal force act each other through the use of calculators, math manipulatives, or pre-completed examples. **Facilitate managing information and resources:** Use *prepared* data sets (data tables, graphs, etc) to discuss the differences between examples of Newton's 1st and 2nd Law of Motion. Some students need more time to analyze and interpret the data.	Students may struggle with developing a plan for an investigation on their own. Utilize smaller groups to collaborate and develop an investigation together. Have some of the tools and data tables ready for students to use as manipulatives.

	Action and Expression STEM Ready UDL Supports		
	Social Emotional Supports		
	Integrate CASEL Playbook Strategies into your whole class routines or instruction. Some emphasized strategies/suggested activities are: **Self/Social Awareness:** After introducing the phenomenon, utilize the Optimistic Closure-Human Bar Graph (p.39) for their current understanding of the phenomenon or questions.	Provide small-group support for students in need of focused skill instruction related to self-awareness, self-management, social awareness, relationship skills, and responsible decision making. Increase positive reinforcement within the classroom for positive behavior.	Ensure that all learning environments allow students to thrive by considering the PBIS Sensory Tools. Develop consistent Behavior Meetings to help build consistency and support for the students. Additional student stakeholders may offer additional support through Counselor Referral or Collaboration with a student's physician or mental health provider.
	Behavioral Supports		

For all students, the use of Clear, consistent, and predictable consequences helps build a productive learning environment. Ensure the use of a PBIS Behavior Contract during lab investigations and hands-on learning to ensure Layer 1 routines are supported.	Ensure the use of a PBIS Behavior Contract during lab investigations and hands-on learning to ensure Layer 1 routines are supported. With challenging academic learning, utilize PBIS Structured Breaks throughout the learning cycle to support the multi-sensory environment of phenomena-based science.	Utilize the PBIS Check In Check Out (CICO) to engage all student stakeholders in creating a consistent learning environment.

Cross-Curricular Connections

ELA/Literacy	*Mathematics*
RST.6-8.3 - Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks. **WHST.6-8.1** - Cite specific textual evidence to support analysis of science and technical texts.	**6.EE.A.2** - Write, read, and evaluate expressions in which letters stand for numbers. **7.EE.B.3** - Solve multi-step real-life and mathematical problems posed with positive and negative rational numbers in any form (whole numbers, fractions, and decimals), using tools strategically. Apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies. **7.EE.B.4** - Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities. **MP.2** - Reason abstractly and quantitatively.
During their block tower experiment students can follow the steps, keep track of their data and do research to help support their conclusion.	Students will use equations to help them adjust their roller coaster in the New Mexico specific activity above.

Career & Skill Connections

Animal training Atmospheric science Biology Chemistry Conservation science Engineering	Farming Landscape architecture & design Mechanical engineering Meteorology Solar energy systems engineering Transportation management

Grade	NGSS Discipline Overview
MS	**Physical Science**
Click to find the standards breakdown.	**Teacher Background by Performance Expectation (PE)**
PS2-3	Students formulate questions that arise from examining given data of objects (which can include particles) interacting through electric and magnetic forces. The answers to these questions should clarify the cause-and-effect relationships that affect magnetic forces due to the magnitude of any electric current present in the interaction, or other factors related to the effect of the electric current (e.g., number of turns of wire in a coil), the distance between the interacting objects, the relative orientation of the interacting objects, the magnitude of the magnetic strength of the interacting objects. They should also clarify the cause-and-effect relationship that affect electric forces due to the magnitude and signs of the electric charges on the interacting objects, the distances between the interacting objects and magnetic forces. Based on scientific principles and given data, students frame hypotheses that can be used to predict the strength of electric and magnetic forces due to cause-and-effect relationships and can be used to distinguish between possible outcomes, based on an understanding of the cause-and-effect relationships driving the system. Students' questions can be investigated scientifically within the scope of a classroom, outdoor environment, museum, or other public facility.

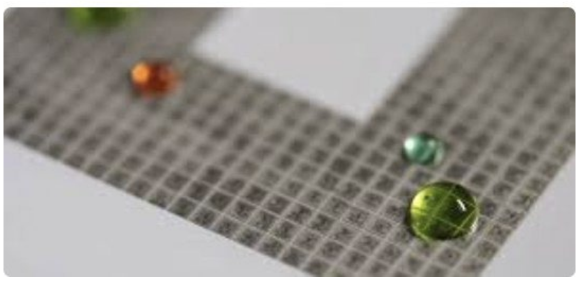
Standards Breakdown				
MS	Physical Science 2-3			
PS2-3	*The performance expectation below was developed using the following elements from the NRC document, A Framework for K-12 Science Education*			
	MS-PS2-3: Ask questions about data to determine the factors that affect the strength of electric and magnetic forces. **Clarification Statement:** Examples of devices that use electric and magnetic forces could include electromagnets, electric motors, or generators. Examples of data could include the effect of the number of turns of wire on the strength of an electromagnet, or the effect of increasing the number or strength of magnets on the speed of an electric motor. **Assessment Boundary:** Assessment about questions that require quantitative answers is limited to proportional reasoning and algebraic thinking.	**SEP** **Asking Questions and Defining Problems** 6–8 builds from grades K–5 experiences and progresses to specifying relationships between variables, and clarifying arguments and models. • Ask questions that can be investigated within the scope of the classroom, outdoor environment, and museums and other public facilities with available resources and, when appropriate, frame a hypothesis based on observations and scientific principles.	**DCI** **PS2.B: Types of Interactions** • Electric and magnetic (electromagnetic) forces can be attractive or repulsive, and their sizes depend on the magnitudes of the charges, currents, or magnetic strengths involved and on the distances between the interacting objects.	**CCC** **Cause and Effect** • Cause and effect relationships may be used to predict phenomena in natural or designed systems.
	These standards are not meant to be taught individually on their own, but bundled with other standards. Bundles are groups of standards arranged together to create endpoints for instruction and it helps students see connections between concepts and allow more efficient use of instructional time. Work with your local school, or district, on creating bundles for your middle school science courses or you can utilize resources and guidance from NMPED.			
	Common Misconceptions			
	• Magnetic forces only act between objects when they are in contact. • All metals are attracted to magnets. • All magnets are made of iron. • The magnetic field lines exist only outside the magnet. • The separation of a magnet into two halves creates two monopoles; one north and one south. • Electric fields and magnets are unrelated.			
	New Mexico Relevant Phenomena			
	When available, you should use your locally selected or created high quality instructional materials. However, the following is an example phenomenon you can use if you don't have local high quality instructional materials available.			
	How can a magnet move another object without touching it?		*What can we learn about magnets by changing factors like temperature?*	
	Students dissect speakers to explore the inner		A magnetic levitation (Maglev) track in New Mexico,	

workings, and engineer homemade cup speakers to manipulate the parts of the speaker. They identify that most speakers have the same parts–a magnet, a coil of wire, and a membrane. Students investigate each of these parts to figure out how they work together in the speaker system.

Sourced from Open Sci Ed [8.3 Forces at a Distance]

How does advancements in magnet technology demonstrate the principles of magnetism and magnetic fields? How are these principles applied in the design of magnetic devices?

thewonderofscience.com



Researchers from MIT have developed a technique for moving droplets of fluid around using electric fields. This could allow biological tests and research (which normally use pumps) to move micro amounts of fluid around more economically. This design solution could be used as an anchoring or supporting phenomenon around electric charge, electromagnetic fields, and Coulomb's Law.

Sourced from Wonder of Science Programmable Droplets from MIT

Programmable magnets are engineered to have multiple magnetic regions. This allows engineers to build magnets that concentrate force, align spatially, or both attract and repel. Have students watch the original sourced video below. Encourage students to make some notices/wonders and consider other uses or technology. Students can design simple solutions to human problems that use this cutting-edge technology.

Sourced from CMR Demos Its Printed Polarity Magnets

used by the 846th Test Squadron at Holloman Air Force Base, propelled a test sled at speeds of more than 500 miles per hour. Maglev technology uses superconductive electromagnets to lift and propel objects with minimal vibration, demonstrating the principles of electromagnetism and superconductivity.

After reading the article and watching the video, create a Driving Question Board about electromagnets. Examples of questions could include: How does the number of turns of wire in the electromagnets affect their strength? What role does temperature play in achieving superconductivity in the electromagnets? How does the strength of the magnetic field influence the speed of the test sled? What are the effects of increasing the number or strength of magnets on the propulsion system?

For a hands-on experiment, students can make a simple electromagnet following these directions: Build an Electromagnet! | Great Basin Observatory

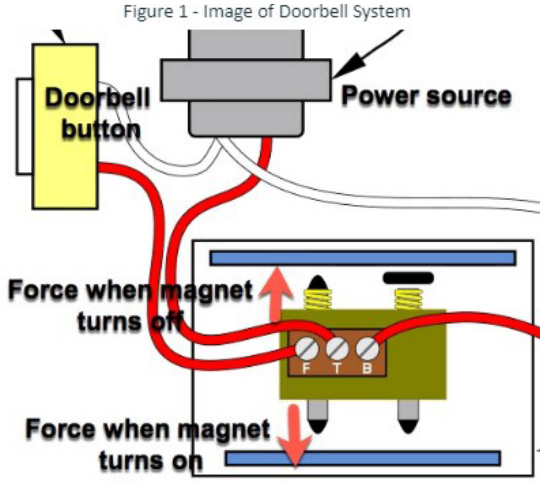
Classroom Assessment Items

When available, you should use your locally selected or created high quality instructional materials. However, the following is an example assessment item you can use if you don't have local high quality instructional materials available.

<u>Stimulus</u>

A student notices that their doorbell is quieter than usual. For decades, doorbells have used electromagnetism to work. However, electromagnetic doorbells are becoming less and less common and are being replaced with digital doorbells. You are going to look at how doorbells worked before the digital world (think 5-10 years ago, not 50-60 years ago).

Figure 1 - Image of Doorbell System



An image of a doorbell button that you have probably seen or may even have on your house right now.

Your Task

In the questions that follow, you will investigate what affects the strength of the electric and magnetic forces and use data to justify your explanation.

Question 1

Based on the information in Figure 1, complete the statements below by selecting the appropriate term.

When the doorbell button is pressed, there is a direct connection between the power source and the electromagnet. When the doorbell button is released, that connection is broken. Therefore, when the doorbell button is pressed, the electromagnet is (on, off). When the doorbell button is released, the electromagnet is (on, off).

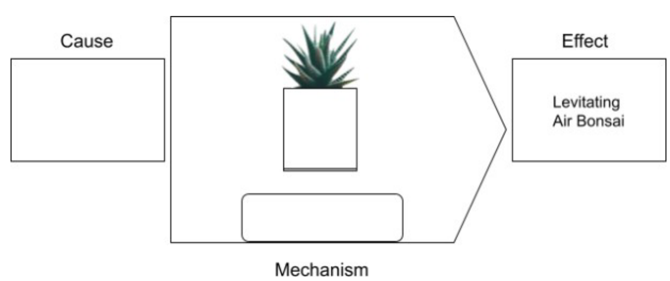
<u>Air Bonsai</u>

In science class, Aaron learned about magnetic forces and how some of the armed forces were using them for levitation in New Mexico. Online, he saw a product for a levitating plant pot and thought he could try and make it himself but he had to do some work first.

Play the following [YouTube video](#) from 9:22-10:00.

Write three questions that could be answered through an investigation of the box?

Choose one of the questions above and fill in the graphic organizer below. Identify the cause and draw a model of the mechanism you think is inside the device.



Design a scientific investigation that would test your model without opening the device.

Adapted from Wonder of Science [MS-PS2-3 Assessment - Air Bonsai](#)

Question 2
A student moves into a new house and notices that their doorbell is quieter than most. They decide to investigate. They know that the doorbell uses electromagnetism to work, but they want to know what factors affect the strength of an electromagnet. Select the three answers that would affect the strength of an electromagnet.

- The amount that the electromagnet costs
- The amount of wire wrapped around the core
- The amount of electricity running through the wire
- The material the core is made of
- The age of the rod

Question 3
*Use the simulator found here to answer the following questions:

Feel free to play around with the simulator to see how it works. Please note that you must drag the rod into the paper clips. Then, collect data about multiple variables to complete the statements that describe how each factor affects the strength of the magnetic force. Make sure to click on "Enable Data Logger" to see your collected lab data.
For Trials 1-3 , pre-set the simulator with 5 fully-charged batteries and a large iron core. Then, test the effects of changing the number of coils around the rod.

Using the data you collected in trials 1-3, answer the following questions:

Trial #	No. of paper clips attracted	No. of batteries	Battery level	No. of coils	Material type	Size of rod
1						
2						
3						

Complete the following statement by circling the correct choices:
To create a stronger magnetic force I need to add ***[more/less/the same amount of]*** coils as shown in trial ***[1,2,3]*** because it holds ***[more/less/the same number of]*** paper clips.

Sourced from SEEd SEEd 7.1.4 Formative Assessment

Magnet and Pencil
Antonio is puzzled. He was at a science fair and watched a demonstration shown in the video. He learns that the black discs on the pencil and on the red wood board are permanent magnets. Antonio knows that magnets have North and South poles. He knows that the labels 'N' and 'S' in the video indicate the poles at the top of or bottom of the magnets. Antonio wants to better understand the role of the magnets in what he observed.

Question 1
Watch the video and write down what you observe when the pencil's tip touches the vertical wood block.

- Make sure to mention the magnetic poles of the interacting magnets attached to the different objects.

Antonio is wondering if there is a relationship between the poles of the interacting magnets and what he observed for the pencil.

Question 2
Based on the observations from the video, write one testable question that Antonio can ask. The question should be about the relationship of the poles of the interacting magnets and the pencil's tip on the red block.

- Remember that a testable question is one where you change one variable to observe what the effect is on another variable

Question 3
How does the testable question above help Antonio understand the relationship between the poles of the interacting magnets and what he observed for the pencil?

Sourced from Next Generation Science Assessment

Culturally and Linguistically Responsive Instruction		
Validate and Affirm	*Build and Bridge*	*Linguistic Vocabulary Support*

	What knowledge and experience have you had that might help us a class understand magnetic and electric forces? (Example: Does the size and shape of a magnet make a difference?)	Why does this phenomenon matter to you , to your community or others and to scientists? (Example: How do we use magnets in everyday life?)	Build a driving question board where students can stick questions and re-address their learning over time. Revisit this board often to help students make sense of their science learning. Bring those questions to group discussion. Encourage students to work with vocabulary in meaningful ways. As students engage in sensemaking, students discuss complex ideas with everyday vocabulary and use many different verbal and non-verbal strategies to community their ideas. A common practice is to create an interactive "word wall" with students, with all the terms they have used when thinking and talking about the phenomena over the course of the unit. Overtime, teachers support, encourage, and/or require students to use proper terms as they ask questions, design experiments, and argue with evidence. Some vocabulary to utilize include: electric force, magnetic force, force, attraction, repulsion, electric charge, electric current, magnet, devices (electromagnet, electric motor, generator), cause and effect.
	Planning for Multi-Layer System of Support (MLSS) & Universal Design Learning		
	Layer 1 ***Core Instruction + Universal***	***Layer 2*** ***Core + Targeted***	***Layer 3*** ***Core + Targeted + Intensive***
	Instructional/Academic Supports		

	Guide information processing and visualization: Provide interactive models and hands-on learning that guide exploration of various sizes and strengths of magnets. Students will also need to explore the relationships electric and magnets are connected with, for example electromagnetic induction. **Recruiting interest:** Giving students choices throughout instruction from asking questions, investigating, or choice of electromagnet to explain increases their autonomy and motivation to participate in the learning. **Universal Design for Learning** Representation Engagement Action and Expression STEM Ready UDL Supports	**Activate or supply background knowledge:** Some students need extra time to understand the different polarities so try to anchor instruction by activating prior knowledge using anchor charts or other visual imagery. Some students may need additional processing and reflection time for questions or tasks posed. Adjust the time as needed. Some students may need further explanation to differentiate electric and magnetic forces. Some students need extra help to understand the concept of electric force and magnetic forces.	Some students may struggle with constructing their explanations on magnetic forces and how to plan an investigation to show an effect. Consider using a cause-effect, or sequencing, graphic organizer with pre-planned items for students to sort and fill the organizer. This can help them in constructing an explanation but also ask them to create a diagram representation of their learning. Allow students multiple opportunities to share their thinking visually and orally through scaffolded questioning and student created models. Provide immediate feedback as students respond to prompts through modeling, drawings, or questioning.
	Social Emotional Supports		
	Integrate CASEL Playbook Strategies into your whole class routines or instruction. Some emphasized strategies/suggested activities are: **Social Awareness**: If you notice students disengaging from investigation, student conversations, or partner work, be sure to assign roles or try smaller groups (no more than	Provide small-group support for students in need of focused skill instruction related to self-awareness, self-management, social awareness, relationship skills, and responsible decision making. Increase positive	Ensure that all learning environments allow students to thrive by considering the PBIS Sensory Tools. Develop consistent Behavior Meetings to help build consistency and support for the students. Additional student stakeholders may offer additional support through

	three) to ensure everyone is contributing to the group and doing the learning. **Self/Social Awareness:** After introducing the phenomenon, utilize the Optimistic Closure-Human Bar Graph (p.39) for their current understanding of the phenomenon or questions.	reinforcement within the classroom for positive behavior.	Counselor Referral or Collaboration with a student's physician or mental health provider.
	Behavioral Supports		
	For all students, the use of Clear, consistent, and predictable consequences helps build a productive learning environment. Ensure the use of a PBIS Behavior Contract during lab investigations and hands-on learning to ensure Layer 1 routines are supported.	Ensure the use of a PBIS Behavior Contract during lab investigations and hands-on learning to ensure Layer 1 routines are supported. With challenging academic learning, utilize PBIS Structured Breaks throughout the learning cycle to support the multi-sensory environment of phenomena-based science.	Utilize the PBIS Check In Check Out (CICO) to engage all student stakeholders in creating a consistent learning environment.

	Cross-Curricular Connections	
	ELA/Literacy	*Mathematics*
	RST.6-8.3 - Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks. **WHST.6-8.1** - Cite specific textual evidence to support analysis of science and technical texts.	**6.EE.A.2** - Write, read, and evaluate expressions in which letters stand for numbers. **7.EE.B.3** - Solve multi-step real-life and mathematical problems posed with positive and negative rational numbers in any form (whole numbers, fractions, and decimals), using tools strategically. Apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies. **7.EE.B.4** - Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities. **MP.2** - Reason abstractly and quantitatively.

Create steps for one of the suggested experiments above and have students research and cite texts in their experiment conclusion.	

Career & Skill Connections	
Astronomy Atmospheric science Biology Chemistry Conservation science Engineering	Farming Landscape architecture & design Mechanical engineering Meteorology Solar energy systems engineering Transportation management Urban planning

Grade	NGSS Discipline Overview
MS	Physical Science
Click to find the standards breakdown.	**Teacher Background by Performance Expectation (PE)**
PS2-4	Students make a claim to be supported about a given phenomenon. In their claim, students include the idea that gravitational interactions are attractive and depend on the masses of interacting objects. Students identify and describe the given evidence that supports the claim, including the masses of objects in the relevant system(s), and the relative magnitude and direction of the forces between objects in the relevant system(s). Students evaluate the evidence and identify its strengths and weaknesses, including types of sources, sufficiency, including validity and reliability, of the evidence to make and defend the claim, and any alternative interpretations of the evidence, and why the evidence supports the given claim as opposed to any other claims. Students use reasoning to connect the appropriate evidence about the forces on objects and construct the argument that gravitational forces are attractive and mass dependent. Students will need to describe that systems of objects can be modeled as a set of masses interacting via gravitational forces, that in systems of objects, larger masses experience and exert proportionally larger gravitational forces, and that in every case for which evidence exists, gravitational force is attractive. To support the claim, students present their oral or written argument concerning the direction of gravitational forces and the role of the mass of the interacting objects.

Standards Breakdown				
MS	Physical Science 2-4			
PS2-4	*The performance expectation below was developed using the following elements from the NRC document, A Framework for K-12 Science Education*			
	MS-PS2-4: Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects. **Clarification Statement:** Examples of evidence for arguments could include data generated from simulations or digital tools; and charts displaying mass, strength of interaction, distance from the Sun, and orbital periods of objects within the solar system. **Assessment Boundary:** Does not include Newton's Law of Gravitation or Kepler's Laws.	**SEP** **Engaging in Argument from Evidence** 6–8 builds from K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world. • Construct and present oral and written arguments supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. ***Connection to Nature of Science*** **Scientific Knowledge is Based on Empirical Evidence** • Science knowledge is based upon logical and conceptual connections between evidence and explanations.	**DCI** **PS2.B: Types of Interactions** • Gravitational forces are always attractive. There is a gravitational force between any two masses, but it is very small except when one or both of the objects have large mass—e.g., Earth and the sun.	**CCC** **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.
	These standards are not meant to be taught individually on their own, but bundled with other standards. Bundles are groups of standards arranged together to create endpoints for instruction and it helps students see connections between concepts and allow more efficient use of instructional time. Work with your local school, or district, on creating bundles for your middle school science courses or you can utilize resources and guidance from NMPED.			
	Common Misconceptions			
	• The magnitudes of the gravitational forces exerted on interacting objects are not equal, with the smaller mass receiving a larger force and the larger mass receiving a smaller force. • Gravitational force only applies to large objects such as planets and stars. • There is no gravity in space. • Gravity moves downwards.			

	New Mexico Relevant Phenomena	
	When available, you should use your locally selected or created high quality instructional materials. However, the following is an example phenomenon you can use if you don't have local high quality instructional materials available.	
	How are we connected to the patterns we see in the sky and space?	*How did the ancient Puebloan communities in Chaco Canyon apply scientific principles to design their structures in alignment with the movements of the sun and moon, and how does this relate to minimizing human impact on the environment?*

	This HQIM phenomenon is also used in ESS1-1 and provides an example of bundling standards for students to see connections between concepts. Humans have always been driven by noticing, recording, and understanding patterns and by trying to figure out how we fit within much larger systems. Students draw on their own experiences and the stories of family or community members to brainstorm a list of patterns in the sky. And listen to a series of podcasts highlighting indigenous astronomies from around the world that emphasize how patterns in the sky set the rhythms for their lives, their communities, and all life on Earth, and these are added to their growing list of related phenomena (other patterns in the sky people have observed). OpenSciEd 8.4: Earth in Space - 8.4 Earth in Space *How does Baumgartner's jump relate to gravitational forces acting upon him during his descent?* Have students view the video on Felix Baumgartner Space Jump World Record and ask them to share some notices and wonders. In 2012 Felix Baumgartner set the World Record for skydiving from a height of 24 miles. The freefall lasted over four minutes and Felix broke the speed of sound. This phenomenon can be used to introduce the gravitational force being directed down in elementary school. This definition can be expanded upon through middle school and high school to include gravitational fields and application of Newton's Second Law of Motion. *What role did Mount Schiehallion's gravitational force play in the deflection of the pendulum during the experiment?* Before showing students the video Weighing the World, have a discussion, or Number Talk, what the mass of the Earth could be. How large would that number be and how could we represent it? Next, ask students to consider how we would try to determine the mass of the Earth since we couldn't use any traditional science equipment due to the size.	This New Mexico phenomenon is also used in ESS1-1 and provides an example of bundling standards for students to see connections between concepts. In Chaco Canyon, New Mexico, ancient Puebloan structures align with the movements of the sun and moon, marking significant events such as solstices and equinoxes. This solar alignment served as a celestial calendar for the ancient inhabitants, guiding agricultural activities and cultural ceremonies. The alignment of these structures with the sun and moon illustrates how scientific principles were applied to design methods for monitoring and minimizing human impact on the environment in a sustainable manner. The alignment of structures in Chaco Canyon with celestial events allowed ancient inhabitants to track the passage of time, seasons, and agricultural cycles. By observing the changing positions of the sun and moon, they could monitor environmental conditions and adapt their activities accordingly, demonstrating an early form of environmental monitoring. The alignment of structures in Chaco Canyon with celestial bodies suggests an intentional effort to harmonize human activities with natural cycles. By designing their settlements in harmony with the natural environment, the ancient Puebloans minimized their impact on the landscape and optimized resource use, showcasing an early example of sustainable environmental practices. More information: Revisiting human-environment interactions in Chaco Canyon and the American Southwest | PAGES

	Show the students the video on the The Schiehallion experiment. This was an attempt to measure the mass of the earth using a pendulum and a mountain (Mount Schiehallion). The mass of the mountain was approximated and the deflection of a pendulum due to the gravitational force of the mountain was measured. Students could attempt to do the calculations or even repeat the experiment on a nearby mountain. Sourced from the Wonder of Science Weighing the World	
	Classroom Assessment Items	
	When available, you should use your locally selected or created high quality instructional materials. However, the following is an example assessment item you can use if you don't have local high quality instructional materials available.	

Do all objects on Earth experience gravitational force?

Oliver, Shana and Nalini are learning about gravitational force in their science class. Their teacher provides them with the masses of four different objects and asks the class, "Do all objects on earth experience gravitational force" . In search of an answer, the three friends make the following claims:

- Oliver's Claim: Gravitational force acts on only heavy objects.
- Shana's Claim: Gravitational force acts on all objects that have mass.
- Nalini's Claim: Gravitational force does not depend on the mass of the object.

The friends decide to work together to investigate.They use an interactive table from their science class in which they can choose different objects and calculate the gravitational force between them.

Question 1

Object 1	Gravitational force between object and Earth
9,200,000,000 kg	90,220,000 N
6,400 kg	62,763 N
0.0045 kg	0.0441 N
0.43 kg	4.231 N

Note: This is an online interactive question set. If possible, access the digital bank to be able to select various objects to explore. The full table has been completed and inserted above to be able to answer the questions.

Question 2

Venus and Earth

While at the New Mexico Museum of Natural History and Science, Clara, Luis and Cami learned that the planet Venus is called Earth's sister. This is because it is similar in size to Earth. They also learned about different types of forces acting on the planets. At the end of the field trip, they were presented with an interactive table that compared the gravitational forces that were calculated between different objects and each of the two planets, Earth and Venus.

The museum guide asked the class, "What causes the differences in gravitational force of objects with the same mass on Venus and Earth?"

Clara, Luis and Cami each made a claim.

- Clara: Objects will feel a greater gravitational force on Earth, because Earth has more mass than Venus.
- Luis: Objects will feel the same gravitational force on Venus and Earth.
- Cami: Objects will feel a greater gravitational force on Venus, because Venus has less mass than Earth.

Question 1

Use the interactive shown in Question 3 below to gather data to support one of the claims. Based on the information from the table, whose claim do you support?

I support the claim made by: (choose one)

- Clara
- Luis
- Cami

Question 2

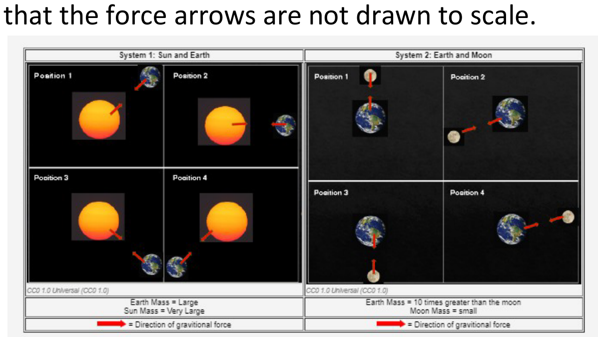
Use the interactive to gather data to support one of the claims. Based on the data that you collect, whose claim do you support?

I support the claim made by: (select one)
- Oliver
- Shana
- Nalini

Question 3
Write an argument that would help the other friend understand why the claim you chose is best supported by the evidence. In your argument make sure to:
- Include data as evidence to show how mass of the object is related to gravitational force. Provide two or three examples from the table.
- Reasoning that supports the claim you chose by describing the conditions under which objects experience gravitational force.

Sourced from [Next Generation Science Assessment]

Gravitational Force in Space
Keisha was using a telescope to identify various systems of objects in space. She wondered whether gravitational forces pull (towards each other) or push (away from each other) objects in space given their differences in mass and distance from each other. She found a table with masses and distances of various objects. Using this information, she ran a simulation that shows how gravitational forces influence a system of planetary objects in space. The following images obtained from the simulation show gravitational forces for Sun and Earth (System 1) and Earth and Moon (System 2) at various positions. Please note that the force arrows are not drawn to scale.

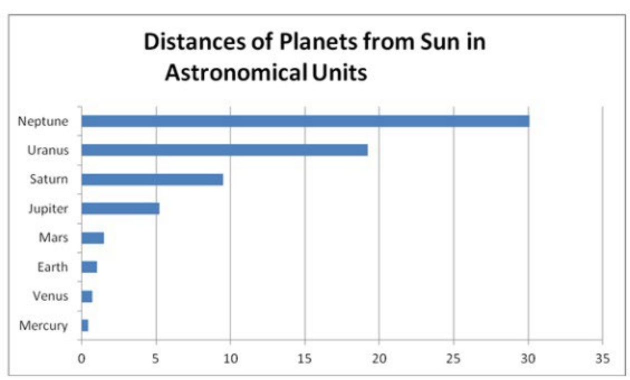


Write an argument that would help the other two classmates understand why you support the claim. In your argument make sure to:
- Include data as evidence to show how mass of the object is related to gravitational force. Provide two or three examples from the table. Be sure to include the mass and gravitational forces when comparing objects.
- Reasoning that supports the claim you chose by describing the conditions under which objects experience gravitational force.

Sourced from [Next Generation Science Assessment]

Stimulus
Gravitational interactions play a fundamental role in shaping the dynamics of our solar system. As objects with mass exert gravitational forces on each other, these interactions influence the orbits, movements, and stability of celestial bodies.

Planet Nine, also known as Planet X, is a hypothetical celestial body theorized to exist in our solar system, positioned beyond the orbit of Neptune. The concept emerged to account for gravitational anomalies observed in the orbits of distant Kuiper Belt objects. If it exists, Planet Nine is believed to be a sizable planet, potentially 9.5 times the mass of Earth, and its proposed orbit would place it in the distant reaches of the Kuiper Belt. It is believed that Planet 9 is between 400 to 800 Astronomical Units from the sun.

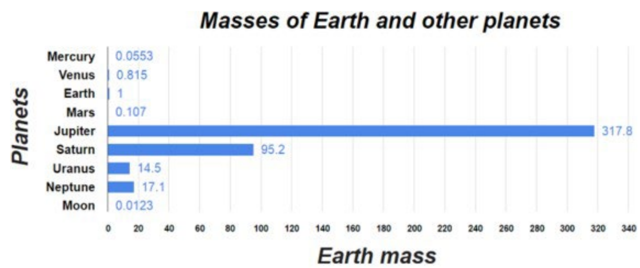


Distances from the sun of planets in our solar system, expressed in A.U. Graph via planetsforkids.org

Question 1 Identify and describe for Keisha the patterns you see in the direction of gravitational forces in System 1 (Sun and Earth) and in System 2 (Earth and Moon).

Question 2
Based on your identified patterns, describe for Keisha whether gravitational forces pull or push objects in space. Make sure to describe if the masses of objects play a role in the direction of gravitational force.

Sourced from [Next Generation Science](#) [Assessment](#)



This graph shows how many Earth's it would take to make up the mass of each planet.

Your Task
In the questions that follow, you will use the information provided, you will engage in argument from evidence about how mass influences the gravitational force.

Question 1
The Earth is 1 AU from the sun, and Planet 9 is between 400-800 AU from the sun. Noting that Planet 9 has a mass 9.5 times greater than the Earth.

Argue using evidence from the stimulus above as to which of these two planets would have a greater gravitational interaction with the sun.
Additional questions and items on the original source.
Sourced from SEEd [SEEd 7.1.5 Formative Assessment](#)

Culturally and Linguistically Responsive Instruction

Validate and Affirm	*Build and Bridge*	*Linguistic Vocabulary Support*
What questions do we need to answer to test your ideas about what gravity feels like on other planets?	Why does this phenomenon matter to you, to your community or others and to scientists? (Example : Is gravity constant on planet earth and universe? Does gravity create stars and planets?)	Starting with the phenomenon discussion, and throughout the remainder of instruction, utilize language support sentence frames to support language learners during discussion. I think ____because _____. An example of _____is _____. The reason why is _____. I agree with you because _____. I disagree with you because ____. Build a driving question board where students can stick questions and re-address their learning over time. Revisit this board often to help students make sense of their science learning. Bring those questions to group discussion. Encourage students to work with

			vocabulary in meaningful ways. As students engage in sensemaking, students discuss complex ideas with everyday vocabulary and use many different verbal and non-verbal strategies to community their ideas. A common practice is to create an interactive "word wall" with students, with all the terms they have used when thinking and talking about the phenomena over the course of the unit. Overtime, teachers support, encourage, and/or require students to use proper terms as they ask questions, design experiments, and argue with evidence.. Some suggested vocabulary for this standard include: gravity, gravitational interactions, gravitation force, objects, mass, attraction, systems
	Planning for Multi-Layer System of Support (MLSS) & Universal Design Learning		
	Layer 1 ***Core Instruction + Universal***	***Layer 2*** ***Core + Targeted***	***Layer 3*** ***Core + Targeted + Intensive***
	Instructional/Academic Supports		

	Recruiting interest: Support all students during instruction in making connections across other standards. **Perception:** Provide different ways for visual information like simulations in which students can observe patterns of movement in two or more objects interacting via gravity after altering the mass or relative distance between the objects. **Action & Expression:** Model think-alouds of your thought process as the teacher while demonstrating gravity impacts on Earth as well as at different locations in space. **Universal Design for Learning** Representation Engagement Action and Expression STEM Ready UDL Supports	**Representation:** Present problems in multiple ways, with diagrams, drawings, pictures, media, tables, graphs, or other mathematical representations showing the impacts of gravity weight on earth and on other planets . Provide blank or partially-completed outlines, graphic organizers, or representations, to emphasize key ideas and relationships between gravity and mass. Some students need more understanding on comparing gravity on earth to gravity to the solar system and how the masses determine the gravity relationship. Provide multiple and different examples than provided in Layer 1.	Have students in small groups create model, or drawing, representations of gravitational attraction between different objects. Allow students within the small group to compare one another's models and ask students if they notice similarities and differences between them. Provide immediate feedback as students respond to prompts through modeling, drawings, or questioning. Some questions for sharing ideas could be: ● Can anyone restate someone else's idea in their own words? ● Who agrees and why with what was said? Who disagrees and why?
	Social Emotional Supports		
	Integrate CASEL Playbook Strategies into your whole class routines or instruction. Some emphasized strategies/suggested activities are: **Self/Social Awareness:** After introducing the phenomenon, utilize the Optimistic Closure-Human Bar Graph (p.39) for their current understanding of the phenomenon or questions.	Provide small-group support for students in need of focused skill instruction related to self-awareness, self-management, social awareness, relationship skills, and responsible decision making. Increase positive reinforcement within the classroom for positive behavior.	Ensure that all learning environments allow students to thrive by considering the PBIS Sensory Tools. Develop consistent Behavior Meetings to help build consistency and support for the students. Additional student stakeholders may offer additional support through Counselor Referral or Collaboration with a student's physician or mental health provider.

	Behavioral Supports

	For all students, the use of [Clear, consistent, and predictable consequences] helps build a productive learning environment. Ensure the use of a PBIS [Behavior Contract] during lab investigations and hands-on learning to ensure Layer 1 routines are supported.	Ensure the use of a PBIS [Behavior Contract] during lab investigations and hands-on learning to ensure Layer 1 routines are supported. With challenging academic learning, utilize PBIS [Structured Breaks] throughout the learning cycle to support the multi-sensory environment of phenomena-based science.	Utilize the PBIS [Check In Check Out (CICO)] to engage all student stakeholders in creating a consistent learning environment.

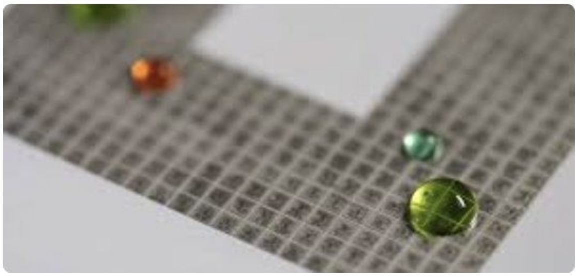
Cross-Curricular Connections	
ELA/Literacy	*Mathematics*
WHST.6-8.1: Write arguments focused on discipline-specific content. (MS-PS2-4) --- Using the examples above, have students write an argument that explains one of the patterns in the sky.	None identified.
Career & Skill Connections	
Astronomy Atmospheric science Engineering	Mechanical engineering Meteorology

Grade	NGSS Discipline Overview
MS	**Physical Science**
Click to find the standards breakdown.	**Teacher Background by Performance Expectation (PE)**
PS2-5	Students will investigate forces acting at a distance. They'll use a provided investigation plan to learn about the concept of objects interacting and exerting forces on each other even when they're not touching. The goal is to gather evidence that invisible fields exist around objects and can exert these forces. Students should have a plan that outlines specific data collection methods. Students will look for evidence that: ● Two objects can exert forces on each other even without physical contact. ● Electric and magnetic forces are distinct from each other. ● The force on one object is caused by its interaction with the other object (e.g., the force disappears when the second object is removed). The plan includes specific steps for a students to understand the rationale for: ● Changing the distance between objects: See how distance affects the force. ● Changing object properties (charge, magnetism): See how these properties influence the force. ● Measuring the force: Detect and quantify the presence of electric or magnetic forces. Students will follow the plan, record observations, and collect data. This data may include: object movements due to forces, object suspension (levitation) caused by forces, simulations of electric or magnetic fields affecting nearby objects, and forces felt on the hand holding an object. Students will assess how well the experiment is designed. They'll consider whether the collected data can truly show evidence of unseen fields causing forces between objects at a distance.

Standards Breakdown				
MS	**Physical Science 2-5**			
PS2-5	*The performance expectation below was developed using the following elements from the NRC document, A Framework for K-12 Science Education*			
	MS-PS2-5: Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact. **Clarification Statement:** Examples of this phenomenon could include the interactions of magnets, electrically-charged strips of tape, and electrically-charged pith balls. Examples of investigations could include first-hand experiences or simulations. **Assessment Boundary:** Assessment is limited to electric and magnetic fields, and limited to qualitative evidence for the existence of fields.	**SEP** **Planning and Carrying Out Investigations** 6–8 builds on K–5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or design solutions. • Conduct an investigation and evaluate the experimental design to produce data to serve as the basis for evidence that can meet the goals of the investigation.	**DCI** **PS2.B: Types of Interactions** • Forces that act at a distance (electric, magnetic, and gravitational) can be explained by fields that extend through space and can be mapped by their effect on a test object (a charged object, or a ball, respectively).	**CCC** **Cause and Effect** • Cause and effect relationships may be used to predict phenomena in natural or designed systems.
	These standards are not meant to be taught individually on their own, but bundled with other standards. Bundles are groups of standards arranged together to create endpoints for instruction and it helps students see connections between concepts and allow more efficient use of instructional time. Work with your local school, or district, on creating bundles for your middle school science courses or you can utilize resources and guidance from NMPED.			
	Common Misconceptions			
	• Electric/magnetic fields do not exist because they cannot be seen. • Electric/magnetic fields exist in one dimension. • Electric and magnetic fields are the same. • Magnetism results from how electrons are distributed in a magnet and that the poles of a magnet are charged, with the North Pole as “positive” and the South Pole as “negative.” • A force exerted by a field stems from charged objects moving across field lines to either push or pull on other objects.			

	New Mexico Relevant Phenomena	
	When available, you should use your locally selected or created high quality instructional materials. However, the following is an example phenomenon you can use if you don't have local high quality instructional materials available.	
	How might the principles of electric charge, electromagnetic fields, and Coulomb's Law be applied in other contexts to manipulate and control fluid dynamics?	*What role do electric motors and cables play in the operation of the Sandia Crest Tramway?* *How does the Sandia Peak Tramway demonstrate the application of electric fields and electromagnetism in its operation?*

thewonderofscience.com



Researchers from MIT have developed a technique for moving droplets of fluid around using electric fields. This could allow biological tests and research (which normally use pumps) to move micro amounts of fluid around more economically. This design solution could be used as an anchoring or supporting phenomenon around electric charge, electromagnetic fields, and Coulomb's Law.

Sourced from Wonder of Science [Programmable Droplets from MIT]

What was Henry Cavendish's experiment, and how did he measure the gravitational force between two objects in the laboratory?

thewonderofscience.com

Henry Cavendish was the first scientist to measure the gravitational force between two objects in the laboratory using a gravitational torsion balance. In this video physics teacher Andrew Bennett attempts to recreate this experiment. Reading the

Show students the [video] of the Sandia Peak Tramway. The Sandia Crest Tramway in Albuquerque, New Mexico, exemplifies the application of electric fields and electromagnetism. The tramway relies on electric motors and cables to move tramcars from the base of the Sandia Mountains to the summit of Sandia Crest.

In the Sandia Crest Tramway, electric motors serve as the powerhouse behind the tramcars' motion. These motors generate electric fields when current flows through them, which in turn produce magnetic fields. These magnetic fields interact with cables, inducing forces that propel the tramcars along their route. Despite no direct physical contact, the presence of magnetic fields between the motors and cables enables the efficient transfer of energy, which raises the tramcars to the summit.

Teachers should ask students to create drawings of the tramway and in the drawing show how the current is made, how the magnetic fields move, and how the magnetic fields move the tram.

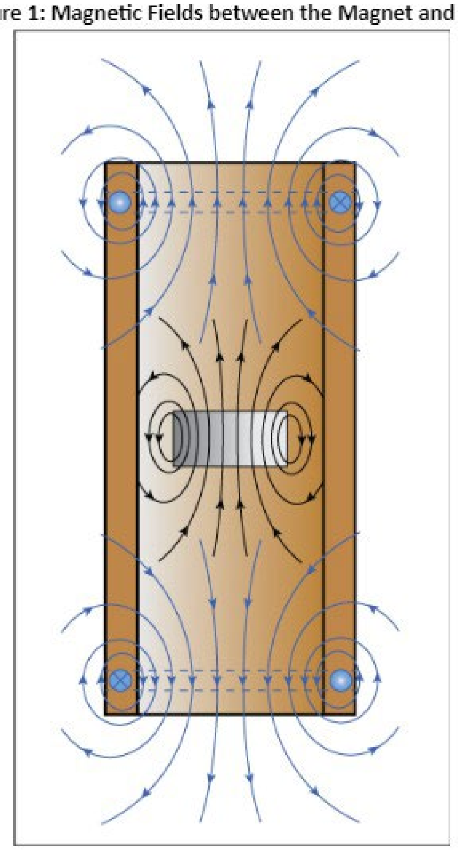
	comments section is very interesting. Pseudoscientific flat-earthers attempt to point out errors in Mr. Bennett's experiment. Students could attempt to recreate the experiment or join in the conversation. Sourced from Wonder of Science Cavendish Experiment	
	Classroom Assessment Items	
	When available, you should use your locally selected or created high quality instructional materials. However, the following is an example assessment item you can use if you don't have local high quality instructional materials available.	

<u>Stimulus</u>

The motion of a magnet changes as it is dropped through a copper pipe. This video shows a magnet being dropped through a copper pipe.

This image shows a disk magnet falling inside a copper pipe. The magnetic field lines of the magnet are in black (north pole up). The created fields around the perimeter of the pipe are shown in blue with blue field lines. https://sciphile.org

Figure 1: Magnetic Fields between the Magnet and Pipe



Your Task

In the questions that follow, you will create a model to describe why a magnet slows down as it falls through a copper pipe.

<u>PVC Pipe and Empty Can</u>

On the table is an empty can and a PVC pipe. Jinni wipes the pipe clean with a towel and puts it back on the table. She then notices something interesting and records what she sees. Here is the video of the phenomenon.

Jinni tells her sister what she observed. Her sister knows a bit about electricity and tells Jinni that rubbing the pipe with a towel may have created an electric field that causes the can to move.

Based on your observation, formulate a testable question that Jinni can use to investigate what causes the can to move after the PVC pipe was rubbed.

a. Describe your observation

b. Formulate a testable question

c. Explain why your question can be tested.

<u>Toy Crane</u>

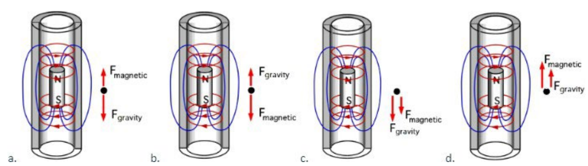
A toy company is designing a toy crane that can lift small things. The toy designers want to use an electromagnet. They know that an electromagnet is a type of device that behaves like a magnet when electricity flows around its iron core. Electricity can be supplied by batteries.

Question 1: After you watch Video 1 showing the magnet falling through the pipe, write down your observations that relate to the motion of the magnet.

Question 2: Based on the information in Figure 1, complete the sentence below by circling the correct word from the selections.

- The magnetic fields from the magnet and the metal are (attractive/repulsive) because they are in the (same/opposite) directions.

Question 3: Using Figure 1 above and the information from Question 2, select the model that correctly shows the forces acting on the magnet as it moves through the pipe.



Question 4: Choose the three components that you could use in an explanation to explain the cause of the magnet slowing in the copper pipe.

- Friction
- Magnetic field
- Magnetic force
- Magnet
- Earth's magnetic field
- Force of gravity
- Metal
- Plastic

Question 5: Based on the information in Figure 1, complete the sentence below by selecting the correct word from the selections.

- The magnet moves (slower/faster) in the tube than out of the tube because the magnetic force between the tube and the magnet is in the (same/opposite) direction as the force of gravity.

Question 6: Explain why the magnet moves at a different speed through the copper pipe than when it moves outside the pipe. Make sure to provide evidence and reasoning from the videos and images.

Sourced from SEEd SEEd 7.1.3 Formative Assessment

The toy designers want the electromagnet to be strong enough to pick up toy cars of different masses. One option they have is to vary how much electric current flows through the electromagnet.

The toy designers have asked the question: How can the crane be changed to lift the toy cars?

The toy designers feel their question could be better. They know that they need to consider the ideas of force and electric current.

Question1: Refine their question so that it is testable and relates the ideas "electric current" and "force" to one another.

Remember that a testable question is one where you change one variable to observe what the effect is on another variable.

Question 2: Describe what data the toy designers can collect for the question you came up with. Be sure the data can be used to show how the idea of "electric current" in electromagnets relates to "force."

Sourced from Next Generation Science Assessment

	Culturally and Linguistically Responsive Instruction		
	Validate and Affirm	*Build and Bridge*	*Linguistic Vocabulary Support*
	What questions do we need to answer to test your ideas about freely rotating platforms with charged objects nearby?	Why does this phenomenon matter to you , to your community or others and to scientists?	Encourage students to create their own personal dictionaries for some of the key vocabulary words. Students should create for each word: an example representation, an non-example, a drawing representation, as well as investigation or data that is associated with that vocabulary. Suggested key vocabulary: electric field, magnetic field, gravitational field, forces (magnetic, electric, gravitational), testing, interaction, investigation, variables
	Planning for Multi-Layer System of Support (MLSS) & Universal Design Learning		
	Layer 1 Core Instruction + Universal	***Layer 2 Core + Targeted***	***Layer 3 Core + Targeted + Intensive***
	Instructional/Academic Supports		

	Guide information processing and visualization: Provide various interactive models, simulations, and hands-on investigations for students to explore the magnetic and electric field through investigation, for example magnetic field lines using iron filings. As well as exploring earth's magnetic field and to identify the impact of magnetic field **Comprehension**: Provide multiple real world, local community application of science investigations like local sports or attractions in the area for students to explore the forces that act on objects. **Universal Design for Learning** Representation Engagement Action and Expression STEM Ready UDL Supports	**Representation**: Ensure that through instruction, critical concepts are emphasized through various anchor charts to show concepts of the electric and magnetic forces. **Language & Symbols:** Provide students with explicit instruction and emphasis on using arrows during diagram interactions of forces. Some students need further understanding of forces between the objects and forces acting in both directions and not in one direction .	Students may struggle with developing a plan for an investigation on their own. Utilize smaller groups to collaborate and develop an investigation together. Have some of the tools and data tables ready for students to use as manipulatives. Provide multiple opportunities for small-groups to respond, both verbally and in writing, as they process through the steps of how to organize the rationale behind investigations. Consider providing checklists for students or creating a card sort of the steps for students to manipulate.

	Social Emotional Supports		
	Integrate CASEL Playbook Strategies into your whole class routines or instruction. Some emphasized strategies/suggested activities are: **Self/Social Awareness:** After introducing the phenomenon, utilize the Optimistic Closure-Human Bar Graph (p.39) for their current understanding of the phenomenon or questions.	Provide small-group support for students in need of focused skill instruction related to self-awareness, self-management, social awareness, relationship skills, and responsible decision making. Increase positive reinforcement within the classroom for positive behavior.	Ensure that all learning environments allow students to thrive by considering the PBIS Sensory Tools. Develop consistent Behavior Meetings to help build consistency and support for the students. Additional student stakeholders may offer additional support through Counselor Referral or Collaboration with a student's physician or mental health provider.
	Behavioral Supports		

	For all students, the use of Clear, consistent, and predictable consequences helps build a productive learning environment. Ensure the use of a PBIS Behavior Contract during lab investigations and hands-on learning to ensure Layer 1 routines are supported.	Ensure the use of a PBIS Behavior Contract during lab investigations and hands-on learning to ensure Layer 1 routines are supported. With challenging academic learning, utilize PBIS Structured Breaks throughout the learning cycle to support the multi-sensory environment of phenomena-based science.	Utilize the PBIS Check In Check Out (CICO) to engage all student stakeholders in creating a consistent learning environment.

	Cross-Curricular Connections	
	ELA/Literacy	*Mathematics*
	RST.6-8.3: Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks. (MS-PS2-5) **WHST.6-8.7**: Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration. (MS-PS2-5)	None indicated
	If technology is available, have students Investigate Comparing Attractive Forces with the difference in attractive force between polar and nonpolar molecules by "pulling" apart pairs of molecules. After some initial exploration, have students create an investigative question and plan that someone else could utilize to complete the online simulation.	
	Career & Skill Connections	
	Astronomy Atmospheric science	Mechanical engineering Meteorology
	Chemistry Engineering	Solar energy systems engineering Transportation management Urban planning

Section 3 – Planning Resources

Overview

Science is not just a body of knowledge that reflects current understanding of the world; it is also a set of practices used to establish, extend, and refine that knowledge[1]. Our core science instruction must also allow for students to develop their science and engineering practices over time in addition to disciplinary core ideas. We know that children enter kindergarten with a surprisingly complex way of thinking about the world [2]. We know that students need sustained opportunities to work with and develop the underlying ideas and to appreciate those ideas' interconnections over a period of years rather than weeks or months. We know that in order for students to develop a sustained attraction to science and for them to appreciate the many ways in which it is pertinent to their daily lives, classroom learning experiences in science need to connect with their own interests and experiences. To this end, the National Research Council lays out a three-dimensional framework that is foundational to the development of the *Next Generation Science Standards (NGSS)*.

Dimension 1 describes the scientific and engineering practices (SEP). Dimension 2 describes the crosscutting concepts (CCC). Dimension 3 describes the core ideas (DCI) in the science disciplines and the relationships among science, engineering, and technology. All three of these dimensions must be interwoven in curriculum, instruction, and assessment.

Getting Started with Using the Standards

The first step of any teacher in planning instruction is to deeply understand the end result that is required. The standards section of the NMIS Science document is placed first so that teachers have quick access to these requirements. The *NGSS* describe the essential learning goals and how those goals will be assessed at each grade level or band.

It is generally accepted that planning for instruction begins with the selection of the endpoint, or desired results of the instruction, and working backward through an instructional sequence to the beginning knowledge students have coming into the instruction. The description of such a process has been documented by Wiggins and McTighe in *Understanding by Design* (1998).

For the purpose of the NMIS Science document, a process for moving from the New Mexico STEM Ready! Science Standards to classroom instruction should minimally include the following[3]:

- Read the performance expectation, clarification statement, and assessment boundary.
- Read the disciplinary core idea in the foundation box.
    - Read the applicable disciplinary core idea essay in *A Framework for K–12 Science Education*, located in chapters 5, 6, 7, and 8. As you read, consider the following questions:
        - What are some commonly held student ideas about this topic?
        - How could instruction build on helpful ideas and confront troublesome

[1] National Research Council. (2012). *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas.* Committee on a Conceptual Framework for New K-12 Science Education Standards. Board on Science Education, Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press.

[2] National Research Council. (2007). *Taking Science to School: Learning and Teaching Science in Grades K-8.* Committee on Science Learning, Kindergarten through Eighth Grade. R.A. Duschl, H.A. Schweingruber, and A.W. Shouse (Eds.). Board of Science Education, Center for Education. Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press.

[3] Bybee, Rodger W. (2013) *Translating the NGSS for Classroom Instruction.*

ideas?
        - What prior ideas or concepts do students need to learn to understand this core idea?
        - What level of abstractness is expected of students?
        - What are some phenomena and experiences that could provide observational or experimental evidence that the DCI is an accurate description of the natural world?
        - What representations or media would be helpful for students to use in making sense of the core idea?
- Read the science and engineering practices associated with the performance expectation.
    - Read the applicable SEP essay in *A Framework for K–12 Science Education* located in chapter 3, consider the following questions:
        - While the PE describes one SEP to be used, others will be needed in the instructional sequence, which ones and in what order will you use them?
        - How will each SEP be used to develop an understanding of the DCI?
        - What practices could students engage in to explore phenomena?
- Read the crosscutting concept associated with the performance expectation.
    - Read the applicable CCC essay in *A Framework for K–12 Science Education* located in chapter 4, consider the following questions:
        - How will the CCC indicated in the PE support the understanding of the core idea?
        - Are there other CCC that could also support learning the core idea?
- Read the connections box
    - When reading the connections to other DCI at this grade level that are relevant to the standard, consider the following question:
        - How can instruction be designed so that students note the connections between the core ideas?
    - When reading the articulation of DCI across grade levels that are relevant to the standard, consider the following questions:
        - Examine the standard at earlier grade levels, do they provide an adequate prior knowledge for the core ideas in the standard being reviewed?
        - Examine the standard at later grade levels, does the standard at this level provide adequate prior knowledge for the core ideas in the later standards?
    - When reading the CCSS in mathematics and English language arts (ELA), consider the following questions:
        - Should students have achieved these mathematics and ELA standards to engage in the learning of science, or could they be learned together?
        - In what ways do the referenced mathematics and ELA standards help clarify the science performance expectations?
        - Can any of the science core ideas be included as examples in the mathematics or ELA instruction?
- Create one or more descriptions of the desired results or learning goals for the instruction integrating the three dimensions in the foundation box.
- Determine the acceptable evidence for the assessment of the desired results.
- Create the learning sequence
    - The NMIS Science document includes aspects of instruction considerations that can be used to assist with this process.

- Create or utilize the summative assessment and check its alignment with the performance expectation.

Engaging in the Science and Engineering Practices

Students provided sustained opportunities to engage in the practices of science and engineering better understand how knowledge develops and provides them an appreciation of the diverse strategies used to investigate, model, and explain the world. The practices for K–12 science classrooms are:

1. Asking questions (science) and defining problems (engineering)
    a. Science asks:
        i. What exists and what happens?
        ii. Why does it happen?
        iii. How does one know?
    b. Engineering asks:
        i. What can be done to address a particular human need or want?
        ii. How can the need be better specified?
        iii. What tools or technologies are available, or could be developed, for addressing this need?
    c. Both ask:
        i. How does one communicate about phenomena, evidence, explanations, and design solutions?
2. Developing and using models
    a. Mental models: functional, used for thinking, making predictions, and making sense of experiences.
    b. Conceptual models: allow scientists and engineers to better visualize and understand phenomena and problems.
    c. Are used to represent current understanding of a system (or parts of a system) under study, to aid in the development of questions or explanations, and to communicate ideas to others.
3. Planning and carrying out investigations
    a. Used to systematically describe the world and to develop and test theories and explanations of how the world works.
4. Analyzing and interpreting data
    a. Once collected, data are presented in a form that can reveal any patterns and relationships and that allows results to be communicated to others.
5. Using mathematics and computational thinking
    a. Enables the numerical representation of variables, the symbolic representation of relationships between physical entities, and the prediction of outcomes.
6. Constructing explanations (science) and designing solutions (engineering)
    a. Explanations are accounts that link scientific theory with specific observations or phenomena.
    b. Engineering solutions must include specifying constraints, developing a design plan, producing and testing models/prototypes, selecting among alternative design features to optimize achievement, and refining design ideas based on prototype performance.
7. Engaging in argument from evidence
    a. Scientists and engineers use reasoning and argumentation to make their case

concerning new theories, proposed explanations, novel solutions, and/or fresh interpretations of old data.

8. Obtaining, evaluating, and communicating information
    a. Being literate in science and engineering requires the ability to read and understand their literature. Science and engineering are ways of knowing that are represented and communicated by words, diagrams, charts, graphs, images, symbols, and mathematics.

STEM Teaching Tools develop briefs to assist STEM teachers with issues that arise in the teaching of STEM. Here are some briefs that address scientific practices. All of these can be found at www.stemteachingtools.org/tools

Why focus on science and engineering practices – and not "inquiry?" Why is "the scientific method" mistaken? - STEM Teaching Tool #32

> For decades science education has engaged students in a version of science inquiry that reduces the investigation of the natural world to a fixed, linear set of steps—sometimes devoid of a deep focus on learning and applying science concepts. Rigid representations of a single "scientific method" do not accurately reflect the complex thinking or work of scientists. The new vision calls for engaging students in multifaceted science and engineering practices in more complex, relevant, and authentic ways as they conduct investigations.

Practices should not stand alone: how to sequence practices in a cascade to support student investigations – STEM Teaching Tool #3

> Science and engineering practices should strongly shape instruction—and be integrated with disciplinary core ideas and cross-cutting concepts. Some people might treat the practices as "stand alone" activities to engage students, but research shows that it is more effective to think about designing instruction as a cascade of practices. Practices should be sequenced and intertwined in different ways to support students in unfolding investigations.

What is meant by engaging youth in scientific modeling? - STEM Teaching Tool #8

> A model is a representation of an idea or phenomenon that otherwise may be difficult to understand, depict, or directly observe. Models are integral to the practice of science and are used across many disciplines in a variety of ways. Scientists develop, test, refine, and use models in their research and to communicate their findings. Helping students develop and test models supports their learning and helps them understand important aspects of how science and engineering work.

Beyond a written C-E-R: supporting classroom argumentative talk about investigations – STEM Teaching Tool #17

> Argumentation, a central scientific practice, relies on the coordination of claims, evidence, and reasoning (C-E-R). C-E-R scaffolds can help students compose a written argument for an investigation. However, there are additional important dimensions to argumentation beyond individually written claims. Classroom discussions that require students to make evidence-based claims and collectively build understanding also reflect argumentation. Several types of discussions can be used and can help build a supportive classroom culture.

Why should students learn to plan and carry out investigations in science and engineering? - STEM Teaching Tool #19

The NRC Framework for K-12 Science Education specifies eight science and engineering practices to be incorporated into science education from kindergarten through twelfth grade. One of these is planning and carrying out investigations. Although many existing instructional models and curricula involve engaging students in planned investigations, this tool will help you think about ways you can promote student agency by having them plan and conduct science investigations.

How can assessments be designed to engage students in the range of science and engineering practices? - STEM Teaching Tool #26

The new vision for K-12 science education calls for engaging students in three-dimensional science learning. This approach requires us to figure out new ways to assess student learning across these multiple dimensions—including the eight science and engineering practices. But there aren't many assessment tasks that require students to apply their understanding of core ideas using practices. In this tool, we describe how to use "task formats" to guide the development of such items. The formats can also spark ideas for designing classroom instruction.

Integrating science practices into assessment tasks – STEM Teaching Tool #30

This detailed and flexible tool suggests activity formats to help teachers create three-dimensional assessments based on real-world science and engineering practices. In response to this felt need being expressed among educators, researchers at the Research + Practice Collaboratory has developed a series of "task format" tables, which suggest different possible templates for student activities that integrate real-world science and engineering practices with disciplinary core ideas. This tool also combines two of the Research + Practice Collaboratory's major focuses: formative assessment and engaging learners in STEM practices. This tool offers between four and eight possible task formats for each of the science and engineering practices listed in the Next Generation Science Standards. It can be a great way for educators to brainstorm new activities or to adapt their existing lesson plans to this new three-dimensional vision.

Engaging students in computational design during science investigations – STEM Teaching Tool #56

Inquiry in science has become increasingly computational over the past several decades. The broad availability of computational devices, sensor networks, visualizations, networking infrastructure, and programming have revolutionized the way science and engineering investigations are carried out. Computational thinking practices enable unique modes of scientific inquiry that allow scientists to create models and simulations to generate data, and to understand and predict complex phenomena. K-12 science classrooms are natural contexts in which students can engage in computational thinking practices during their investigations.

Designing 'productive uncertainty' into investigations to support meaningful engagement in science practices – STEM Teaching Tool #60

We want students to engage from the earliest ages in science and engineering practices with sincere curiosity and purpose. Science investigations can be viewed as "working through uncertainty." However, 3D instructional materials often try to support engagement in science practices by making them very explicit and scaffolding the process to make it easy to accomplish—arguably, too easy. An alternative approach that emphasizes productive uncertainty focuses on how uncertainty might be strategically built into learning environments so that students establish a need for the practices and experience them as meaningful ways of developing understanding.

Using science investigations to develop caring practices for social-ecological systems – STEM Teaching Tool #61

Science investigations are a powerful way to foster caring practices for social-ecological systems. It encourages building relationships between learners and local ecosystems, highlighting the importance of multispecies justice and interconnectedness. The approach integrates diverse cultural perspectives, promotes empathy and ethical considerations, and supports transdisciplinary inquiry-based learning. Educators are urged to create opportunities for students to engage with their environment through observation, inquiry, and actions that benefit both humans and more-than-humans.

How to integrate the argumentation from evidence practice into engineering design projects – STEM Teaching Tool #63

The practice brief explains how to integrate argumentation from evidence into engineering design projects. It highlights the importance of teaching students to support engineering claims with specific evidence and reasoning, aligning with scientific practices. This process involves evaluating design merits, using diverse forms of evidence, and fostering collaborative problem-solving. The brief also addresses equity, suggesting accommodations to ensure all students can engage in argumentation, and provides actionable strategies for educators to create robust, argument-driven engineering projects.

How can arguing from evidence support sensemaking in elementary science? – STEM Teaching Tool #72

The practice brief focuses on the importance of integrating argumentation from evidence into elementary science education to support sensemaking. It highlights the need for students to engage in evidence-based discussions, propose and critique claims, and collaboratively build explanations for phenomena. The brief emphasizes creating equitable learning environments where diverse perspectives are valued and students develop skills in scientific reasoning. It also provides practical strategies for educators to foster a classroom culture that supports inquiry, curiosity, and the development of critical thinking skills.

Crosscutting concepts

A Framework for K-12 Science Education identifies seven concepts that bridge disciplinary boundaries. These concepts provide students with an organizational framework for connecting knowledge from the various disciplines into a coherent and scientifically based view of the world. These crosscutting concepts are:

1. Patterns – guide organization and classification, prompt questions about relationships and the factors that influence them.
2. Cause and effect: mechanisms and explanations – a major activity of science is investigating and explaining causal relationships and the mechanisms by which they are mediated. Such mechanisms can then be tested across contexts and used to predict and explain events in new contexts.
3. Scale, proportion, and quantity – in considering phenomena, it is critical to recognize what is relevant at different measures of size, time, and energy and to recognize how changes in scale, proportion, or quantity affect a system's structure or performance.
4. Systems and system models – Defining systems under study provides tools for understanding and testing ideas that are applicable throughout science and engineering.
5. Energy and matter: flows, cycles, and conservation – Tracking fluxes of energy and matter into, out of, and within systems helps one understand the systems' possibilities and limitations.
6. Structure and function – The way in which an object or living thing is shaped and its substructure determine many of its properties and functions.
7. Stability and change – conditions of stability and determinants of rates of change or evolution of a system are critical elements of study.

STEM Teaching Tools develop briefs to assist STEM teachers with issues that arise in the teaching of STEM. Here are some briefs that address scientific practices. All of these can be found at www.stemteachingtools.org/tools

Prompts for integrating crosscutting concepts into assessment and instruction – STEM Teaching Tool #41

> This set of prompts is intended to help teachers elicit student understanding of crosscutting concepts in the context of investigating phenomena or solving problems. These prompts should be used as part of a multi-component extended task. These prompts were developed using the *Framework for K-12 Science Education* and Appendix G of the Next Generation Science Standards, along with relevant learning sciences research.

> The planning and implementation of instruction in your classroom should allow your students multiple and sustained opportunities to learn disciplinary core ideas through the science and engineering practices, as well as using appropriate crosscutting concepts as lenses to understand the disciplinary core idea and its relationship to other core ideas.

Planning Guidance for Culturally and Linguistically Responsive Instruction

"Equity in science education requires that all students are provided with equitable opportunities to learn science and become engaged in science and engineering practices; with access to quality space, equipment, and teachers to support and motivate that learning and engagement; and adequate time spent on science. In addition, the issue of connecting to students' interests and experiences is particularly important for broadening participation in science."[1]

In order to ensure our students from marginalized cultures and languages view themselves as confident and competent learners and doers of science within and outside of the classroom, educators must intentionally plan ways to counteract the negative or missing images and representations that exist in our curricular resources. The guiding questions below support the design of lessons that validate, affirm, build, and bridge home and school culture for learners of science:

> **Validate/Affirm:** How can you design your classroom to intentionally and purposefully legitimize the home culture and languages of students and reverse the negative stereotypes regarding the science abilities of students of marginalized cultures and languages?
>
> **Build/Bridge:** How can you create connections between the cultural and linguistic behaviors of your students' home culture and language and the culture and language of school science to support students in creating identities as capable scientists that can use science within school and society?

STEM Teaching Tools highlight ways of working on specific issues that arise during STEM teaching. Here are some tools that have been created to guide STEM instruction around the concept of culturally and linguistically responsive instruction. All of these can be found at [www.stemteachingtools.org/tools.](http://www.stemteachingtools.org/tools)

How can we promote equity in science education? - STEM Teaching Tool #15

> Equity should be prioritized as a central component in all educational improvement efforts. All students can and should learn complex science. However, achieving equity and social justice in science education is an ongoing challenge. Students from non-dominant communities often face "opportunity gaps" in their educational experience. Inclusive approaches to science instruction can reposition youth as meaningful participants in science learning and recognize their science-related assets and those of their communities.

Building an equitable learning community in your science classroom – STEM Teaching Tool #54

> Equitable classroom communities foster trusting and caring relationships. They make cultural norms explicit in order to reduce the risk of social injuries associated with learning together. Teachers are responsible for disrupting problematic practices and developing science classroom communities that welcome all students into safe, extended science learning opportunities. However, this is tricky work. This tool describes a range of classroom activities designed to cultivate communities that open up opportunities for all students to learn.

How can you advance equity and justice through science teaching? - STEM Teaching Tool #71

> Inequities are built into the systems of science education such that “students of color, students who speak first languages other than English, and students from low-income communities… have had limited access to high-quality, meaningful opportunities to learn science.” Intersecting equity projects can guide the teaching and learning of science towards social justice. Science educators who engage in these projects help advance Indigenous self-determination (details) and racial justice by confronting the consequences of legacies of injustice and promoting liberatory approaches to education.

Why you should stop pre-teaching science vocabulary and focus on students developing conceptual meeting first – STEM Teaching Tool #66

> In New Mexico, and in the *Framework for K–12 Science Education,* we promote an inclusive educational environment for all students. Students should first develop conceptual understanding through sensemaking and observation. It is important to leverage students' home languages and diverse communication methods to enhance learning and participation, especially for multilingual and historically marginalized students. The approach promotes linguistic equity, encouraging environments where all forms of communication are valued, and suggests practical strategies for educators to integrate this methodology into their teaching practices.

Focusing science and engineering learning on justice-centered phenomena across PK-12 – STEM Teaching Tool #67

> In the Framework vision for science education, students engage in active investigations to make sense of natural phenomena and analyze and build solutions to problems. Basing these investigations on justice-centered phenomena can be a powerful and rightful way to support science and engineering learning. Justice-centered investigations can open up important opportunities for students to engage in projects that support equity for communities and to see how the application of science and engineering are fundamentally entwined with political and ethical questions, dimensions, and decisions.

Teaching STEM in ways that respect and build upon indigenous peoples’ rights – STEM Teaching Tool #10

> Indigenous ways of knowing are sometimes thought to be in opposition to and detrimental to the learning of Western Science or STEM. Consequently, indigenous ways of knowing are rarely engaged to support learning. If STEM learning is to be meaningful and transformative for Indigenous youth, respecting Indigenous peoples' rights and related critical issues, including Indigenous STEM, settler-colonialism, and decolonization, must be understood and explicitly addressed in Indigenous youths' informal and formal STEM learning experiences.

How can formative assessment support culturally responsive argumentation in a classroom community? - STEM Teaching Tool #25

> Argumentation has long been seen as an important practice in science and thus in science

education. Formative assessment can be used to help students value the contributions and perspectives of others as they engage in argumentation to make sense of natural phenomena. Educators can use these strategies to help foster argumentation that is culturally responsive, meaning it draws from and respects students' cultural resources, backgrounds, and personal experiences. Culturally responsive formative assessment happens within a community of learners where the teacher has cultivated explicit norms for increasing student-centered discourse, making decisions for their own purposes through democratic processes, and using clear guidelines for maintaining mutual respect.

Engaging English learners in science and engineering practices – STEM Teaching Tool #27

Routinely engaging all students in the practices of science and engineering is a crucial fixture of the new vision for K-12 science education. The practices can be seen as a barrier to participation for English Learners (ELs), or they can be viewed as an opportunity to provide rich instruction that builds science-related competencies and identities. Certain elements of the practices and related instructional approaches can be beneficial for students learning science while also learning the language of instruction.

How can I promote equitable sensemaking by setting expectations for multiple perspectives? - STEM Teaching Tool #47

In a phenomena-focused, 3D approach to science learning, students use science practices to consider each other's ideas based on available interpretations and evidence. To promote deep and equitable learning, plan purposefully to ensure that the various perspectives that students bring to making sense of phenomena are solicited, clarified, and considered. It is important to support students as they develop a shared understanding of the different perspectives in the group.

Supporting observations, wonderings, systems thinking & "Should We" deliberations through Learning in Places - STEM Teaching Tool #82

The practice brief emphasizes the importance of integrating observations, wonderings, and systems thinking in science education to support socioecological understanding and ethical decision-making. It advocates for field-based practices where learners and families engage with their environments, ask meaningful questions, and consider ethical implications. This approach values diverse cultural perspectives and aims to create equitable, place-based learning experiences that connect science with community well-being.

Identifying local environmental justice, phenomena for science and engineering investigations - STEM Teaching Tool #87

The practice brief highlights the need for science and engineering education to focus on local environmental justice (EJ) issues. It encourages engaging students with personally relevant EJ phenomena to develop a deeper understanding of these issues and to promote civic action. By investigating local EJ concerns, students can explore causes, impacts, and diverse perspectives, fostering individual and collective agency. The brief also emphasizes the importance of community-based learning and the integration of interdisciplinary approaches to address EJ and support frontline communities.

UDL: Action and Expression

- Provide independent think time before students engage with others or responses are discussed.
- Ensure students have enough time to complete tasks and provide extra time if needed.
- Provide access to pre-cut materials, assistive tools, devices, and software.
- Offer flexibility and choice with the ways students demonstrate and communicate their understanding.
- Invite students to explain their thinking verbally or nonverbally with manipulatives, drawings, diagrams.
- Support fluency with graduated levels of support or practice.
- Apply and gradually release scaffolds to support independent learning.
- Support discourse with sentence frames or visible language displays.
- Support the development of organizational skills in problem-solving with access to templates, rubrics, and checklists.
- Post visible goals, objectives, and schedules.
- Provide opportunities for self-assessment and enable students to monitor their own progress.

Throughout the curriculum, students should be invited to share both their understanding and their reasoning about mathematical ideas with others. Offer flexibility and choice with the ways students demonstrate and communicate their understanding and invite students to explain their thinking verbally or nonverbally with manipulatives, drawings, diagrams. Provide independent think time before students engage with others or responses are discussed and support discourse with sentence frames or visible language displays. Ensure students have enough time to complete tasks and provide extra time if needed, as well as pre-cut materials, assistive tools, devices, and software. Support fluency with graduated levels of support or practice, applying and gradually releasing scaffolds to support independent learning. Support the development of organizational skills in problem-solving with access to templates, rubrics, and checklists and provide opportunities for self-assessment and enable students to monitor their own progress. Post visible goals, objectives, and schedules.

UDL: Engagement

- Provide choice by inviting students to decide which problem to start with, select a subset of problems to complete, which strategy to use, the order they complete a task, etc.
- Provide access to a variety of tools or materials.
- Leverage curiosity and students' existing interests and invite students to name connections to their own lived experiences.
- Use visible timers and alerts to prepare for transitions.
- Chunk tasks into more manageable parts and check in with students to provide feedback and encouragement after each chunk.
- Differentiate the degree of difficulty or complexity by starting with accessible values.
- Periodically revisit community norms and provide group feedback that encourages collaboration and community.
- Provide ongoing feedback that helps students maintain sustained effort and persistence during a task.
- Encourage self-reflection and identification of personal goals.
- Provide access to tools and strategies designed to help students self-motivate and become more independent.

Students' attitudes, interests, and values help to determine the ways in which they are most engaged and motivated to learn. Provide access to a variety of tools, strategies, and materials designed to help students self-motivate and become more independent. Leverage curiosity and students' existing interests and invite students to name connections to their own lived experiences. Provide choice by inviting students to decide which problem to start with, select a subset of problems to complete, which strategy to use, the order they complete a task, etc. Use visible timers and alerts to prepare for transitions, and chunk tasks into more manageable parts and check in with students to provide feedback and encouragement after each chunk. Differentiate the degree of difficulty or complexity by starting with accessible values. Periodically revisit community norms and provide group feedback that encourages collaboration and community. Provide ongoing feedback that helps students maintain sustained effort and persistence during a task and encourage self-reflection and identification of personal goals.

UDL: Representation

- Present content using multiple modalities.
- Annotate displays with specific language, different colors, shading, arrows, labels, notes, diagrams, or drawings.
- Provide appropriate reading accommodations.
- Support use of vocabulary, mathematical notation, and symbols with charts, pictures, diagrams, and tables.
- Highlight connections between representations to make patterns and properties explicit.
- Present problems or contexts in multiple ways, using diagrams, drawings, pictures, media, tables, graphs, and other mathematical representations.
- Use translations, descriptions, movement, and images to support unfamiliar words or phrases.
- Activate or supply background knowledge to build connections to prior understandings and experiences.
- Provide access to blank or partially-completed outlines, graphic organizers, or representations, to emphasize key ideas and relationships.
- Maximize transfer and generalization by naming connections to previous examples, inviting students to identify important details or features to remember

Teachers can reduce barriers and leverage students' individual strengths by presenting content using multiple modalities and annotating displays with specific language, different colors, shading, arrows, labels, notes, diagrams, drawings, etc. Support the use of vocabulary, mathematical notation, and symbols with charts, pictures, diagrams, and tables, and use translations, descriptions, movement, and images to support unfamiliar words or phrases. Present problems or contexts in multiple ways, using diagrams, drawings, pictures, media, tables, graphs, and other mathematical representations, and highlight connections between different mathematical representations to make patterns and properties explicit. Activate or supply background knowledge to build connections to prior understandings and experiences and maximize transfer and generalization by naming connections to previous examples, inviting students to identify important details or features to remember. Provide reading accommodations as needed, as well as blank or partially-completed outlines, graphic organizers, or representations, to emphasize key ideas and relationships.