Mini-Map for SCI.EE.12.PS.Forces-1

Subject: Science
Physical Science (PS)
Grade band: 9–12

Grade-Level Expectation

DLM Essential Element	DLM Disciplinary Core Idea Family[1]	Framework Disciplinary Core Ideas
SCI.EE.12.PS.Forces-1 Conduct an investigation to describe the relationships between force, mass, and acceleration.	Physical Science – Interacting Forces	PS2.A: Forces and Motion PS2.B: Types of Interactions PS2.C: Stability and Instability in Physical Systems PS3.C: Relationship Between Energy and Forces

[1] DLM Science Essential Elements organize Disciplinary Core Ideas (defined in the *Framework for K-12 Science Education*) into DCI families. By combining similar concepts within a domain, science content from the general education standards is reduced in depth, breadth, and complexity to provide access for students that qualify for the DLM alternate assessment.

Linkage Level Descriptions

Initial Precursor	Distal Precursor	Proximal Precursor	Target[2]
Identify the observed properties that characterize common materials.	Make and compare observations to identify pushes and pulls of different strengths and directions as forces (a type of variable) that can change the motion (a different variable) of an object (i.e., direction of motion and distance traveled only).	Conduct tests to determine the effects of mass on the force needed to change similar objects' motion (i.e., speed, direction, distance traveled).	Investigate and describe the relationships (i.e., direct and inverse relationships) between the Force (F), mass (m), and acceleration (a) variables in the F = ma equation.

[2] The target linkage level description is a measurement target that describes the expectations (content and performance) of the Essential Element for assessment purposes.

Essential Element Three Dimensions

Each Essential Element is defined in the three dimensions described in the *Framework for K-12 Science Education*: disciplinary core ideas (DCIs), science and engineering practices (SEPs), and crosscutting concepts (CCCs). The table below lists the details of each dimension from the individual DLM Essential Element descriptions, with color-coding of dimensions corresponding to the Next Generation Science Standards (NGSS). The first row (in blue) lists the SEP(s) used to construct the Essential Element and describes ways each SEP could be incorporated. The second row (in orange) describes the science concepts within the DCI family related to this Essential Element. The third row (in green) lists the CCC(s) associated with the Essential Element and explains how each might be incorporated in the grade band (quoted from NSTA, 2013, matrix of CCCs). Note that the SEP is presented first here (rather than second, as it is in the full list of Essential Elements) to reflect the emphasis on practices in instruction and across the linkage levels. The final row (in white) includes examples of how the three dimensions could work together to support instruction for the Essential Element. These examples provide ideas for integrating the dimensions and are not exhaustive, nor are they intended to limit instruction.

Science and Engineering Practices	**Planning and Carrying Out Investigations:** Planning and carrying out investigations in grades 9–12 builds on K–8 experiences and progresses to gathering and analyzing data in an investigation to evaluate claims and design solutions. • Manipulate variables and collect data to serve as evidence for claims about the natural world. • Gather and use data to inform the improvement of a design solution. **Analyzing and Interpreting Data:** Analyzing data in grades 9–12 builds on K–8 experiences and progresses to analyzing and evaluating to support explanations about relationships and solutions to problems in the natural world. • Represent and analyze data to determine and describe relationships between variables. • Use data to construct and evaluate arguments. • Analyze data to design and evaluate solutions to problems. **Using Mathematics and Computational Thinking:** Mathematical and computational thinking in grades 9–12 builds on K–8 experiences and progresses to analyzing and interpreting data and mathematical concepts to construct meaning about systems in the natural and designed world. • Use mathematical reasoning to construct and support claims about the relationships between variables. • Analyze and interpret data to investigate the relationships and characteristics of the components of a system.
Disciplinary Core Ideas	**Interacting Forces** • Acceleration is the rate of change of velocity of a macroscopic object. o Usually, acceleration means the speed or direction of an object's motion is changing. o If an object is not changing its speed or direction, then the object is not accelerating.

	• Newton's second law of motion is *F* = *ma*, where *F* = (net) force, *m* = mass, and *a* = acceleration. o When acceleration is constant, there is a direct relationship between force and mass. A larger force is needed for a more massive object to experience the same acceleration as a less massive object. o When mass is constant, there is a direct relationship between force and acceleration. A larger force is needed to increase the acceleration of an object. o When force is constant, there is an inverse relationship between mass and acceleration. When the same force is applied to two objects of differing masses, the acceleration of the more massive object is less than that of the less massive object.
Crosscutting Concepts	**Cause and Effect: Mechanism and Explanation**: Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering. • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. • Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. • Systems can be designed to cause a desired effect. • Changes in systems may have various causes that may not have equal effects. **Scale, Proportion, and Quantity**: In considering phenomena, it is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change. • The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. • Some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly. • Patterns observable at one scale may not be observable or exist at other scales. • Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale. • Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth).

How three dimensions support instruction for this Essential Element	By changing one of the variables of Newton's second law at a time, students can use the F = ma equation to analyze cause and effect relationships on the other two variables. Students can recognize proportion and quantity by comparing metrics of mass, force, and acceleration. For example, if mass is increased, the force needed to move an object increases. Students can use mathematical thinking to analyze what happens when a quantity, such as total force, is changed.

Instructional Resources

Resources
Learning modules and additional science instructional resources can be found at https://www.dlmpd.com/science/
A glossary defining key science terms found in the Essential Elements can be found at DLM Glossary for Science Learning Maps.

Link to Text-Only Map

SCI.EE.12.PS.Forces-1 Conduct an investigation to describe the relationships between force, mass, and acceleration.