Unit 3 2018. Forces

Content Area: **Science**
Course(s):
Time Period: **November**
Length: **10 Blocks**
Status: **Published**

Enduring Understandings

Big things they want to know.

- Ideas can be represented in numerous ways such as graphs, mathematical formulas
- Scientific laws can be used to make predictions about outcomes.
- Problems can be solved in many different ways and using many different formulas/topics.

Essential Questions

What should they be able to answer at the end of course.

- What causes objects to change speed or direction?
- What is the difference between mass and weight?
- What is the mathematical relationship between force, mass and acceleration?
- What forces are at work on an object in free-fall?
- What phenomena can be explained by the strong nuclear, weak nuclear, electromagnetic and gravitational forces?

Student Learning Objectives (PE, SEP, DCI, CCC) & Aligned Standards

Given a graph of position or velocity as a function of time, recognize in what time intervals the position, velocity and acceleration of an object are positive, negative, or zero and sketch a graph of each quantity as a function of time. *[Clarification Statement: Students should be able to accurately move from one representation of motion to another.]* (PS2.A)

Represent forces in diagrams or mathematically using appropriately labeled vectors with magnitude, direction, and units during the analysis of a situation. (PS2.A)

Understand and apply the relationship between the net force exerted on an object, its inertial mass, and its acceleration to a variety of situations. (PS2.A)

Performance Expectations

Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration. *[Clarification Statement: Examples of data could include tables or graphs of position or velocity as a function of time for objects subject to a net unbalanced force, such as a falling object, an object rolling down a ramp, or a moving object being pulled by a constant force.] [Assessment Boundary: Assessment is limited to one-dimensional motion and to macroscopic objects moving at non-relativistic speeds.]* (HS-PS2-1)

Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system. *[Clarification Statement: Emphasis is on the quantitative conservation of momentum in interactions and the qualitative meaning of this principle.] [Assessment Boundary: Assessment is limited to systems of two macroscopic bodies moving in one dimension.]* (HS-PS2-2)

Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision. *[Clarification Statement: Examples of evaluation and refinement could include determining the success of the device at protecting an object from damage and modifying the design to improve it. Examples of a device could include a football helmet or a parachute.] [Assessment Boundary: Assessment is limited to qualitative evaluations and/or algebraic manipulations.]* (HS-PS2-3)

Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. (HS-ETS1-2)

Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts. (HS-ETS1-3)

Science and Engineering Practices

Analyzing and Interpreting Data

- Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. (HS-PS2-1)

Using Mathematics and Computational Thinking

- Use mathematical representations of phenomena to describe explanations. (HS-PS2-2)

Constructing Explanations and Designing Solutions

- Apply scientific ideas to solve a design problem, taking into account possible unanticipated effects. (HSPS2-3)

- Design a solution to a complex real world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-ETS1-2)
- Evaluate a solution to a complex real world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-ETS1-3)

Disciplinary Core Ideas

PS2.A: Forces and Motion

- Newton's second law accurately predicts changes in the motion of macroscopic objects. (HS-PS2-1)
- Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object. (HS-PS2-2)
- If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system. (HS-PS2-2)

ETS1.A: Defining and Delimiting Engineering Problems

- Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (secondary to HS-PS23)

ETS1.C: Optimizing the Design Solution

- Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (tradeoffs) may be needed. (secondary to (HS-PS2-3)

ETS1.B: Developing Possible Solutions

- When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. (HS-ETS1-3)

Crosscutting Concepts

Cause and Effect

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-PS21)
- Systems can be designed to cause a desired effect. (HS-PS2-3)

Systems and System Models

- When investigating or describing a system, the boundaries and initial conditions of the system need to be defined. (HS-PS2-2)

Connections to Engineering, Technology, and Applications of Science

Influence of Science, Engineering, and Technology on Society and the Natural World

- New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology. (HS-ETS1-3)

Connections to Nature of Science

Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena

- Theories and laws provide explanations in science. (HS-PS2-1)
- Laws are statements or descriptions of the relationships among observable phenomena. (HS-PS2-1)

	Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.
SEP.1.a	Ask questions
CCC.2.1	students understand that empirical evidence is required to differentiate between cause and correlation and to make claims about specific causes and effects. They suggest cause and effect relationships to explain and predict behaviors in complex natural and designed systems. They also propose causal relationships by examining what is known about smaller scale mechanisms within the system. They recognize changes in systems may have various causes that may not have equal effects.
SEP.1.a.3	to determine relationships, including quantitative relationships, between independent and dependent variables.
SEP.1.b	Evaluate a question to determine if it is testable and relevant.
SEP.1.d	Ask and/or evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set, or the suitability of a design.
	Defining the system under study—specifying its boundaries and making explicit a model of that system—provides tools for understanding and testing ideas that are applicable throughout science and engineering.
SEP.2.b	Design a test of a model to ascertain its reliability.
SEP.2.c	Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.
SEP.2.f	Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.
SEP.3.b	Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.
SEP.3.c	Plan and conduct an investigation or test a design solution in a safe and ethical manner including considerations of environmental, social, and personal impacts.

SEP.3.d	Select appropriate tools to collect, record, analyze, and evaluate data.
SEP.3.f	Manipulate variables and collect data about a complex model of a proposed process or system to identify failure points or improve performance relative to criteria for success or other variables.
SEP.4.b	Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible.
SEP.4.c	Consider limitations of data analysis (e.g., measurement error, sample selection) when analyzing and interpreting data.
SEP.4.d	Compare and contrast various types of data sets (e.g., self-generated, archival) to examine consistency of measurements and observations.
SEP.4.f	Analyze data to identify design features or characteristics of the components of a proposed process or system to optimize it relative to criteria for success.
SEP.5.b	Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations.
SEP.5.c	Apply techniques of algebra and functions to represent and solve scientific and engineering problems.
SEP.5.e	Apply ratios, rates, percentages, and unit conversions in the context of complicated measurement problems involving quantities with derived or compound units (such as mg/mL, kg/m^3, acre-feet, etc.).
SEP.6.a	Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables.
SEP.6.c	Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects.
SEP.6.e	Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade-off considerations.
SEP.7.a	Compare and evaluate competing arguments or design solutions in light of currently accepted explanations, new evidence, limitations (e.g., trade-offs), constraints, and ethical issues.
SEP.7.b	Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments.
SEP.7.c	Respectfully provide and/or receive critiques on scientific arguments by probing reasoning and evidence, challenging ideas and conclusions, responding thoughtfully to diverse perspectives, and determining additional information required to resolve contradictions.
SEP.7.d	Construct, use, and/or present an oral and written argument or counter-arguments based on data and evidence.
SEP.7.e	Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge and student-generated evidence.
SEP.7.f	Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and/or logical arguments regarding relevant factors (e.g., economic, societal, environmental, ethical considerations).
SEP.8.b	Compare, integrate and evaluate sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a scientific question or solve a problem.
SCI.9-12.1.2	Classifications or explanations used at one scale may fail or need revision when information from smaller or larger scales is introduced; thus requiring improved investigations and experiments.
SCI.9-12.1.4	Mathematical representations are needed to identify some patterns.

SCI.9-12.1.5	Empirical evidence is needed to identify patterns.
SCI.9-12.2.3	Systems can be designed to cause a desired effect.
SCI.9-12.2.4	Changes in systems may have various causes that may not have equal effects.
SCI.9-12.3.2	Some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly.
SCI.9-12.3.3	Patterns observable at one scale may not be observable or exist at other scales.
SCI.9-12.3.5	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).
SCI.9-12.6.2	The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials.
SCI.9-12.7.2	Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.
SCI.HS-PS2-1	Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.
SCI.HS-PS2-3	Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.
SCI.HS-PS2-2	Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system.
SCI.HS-PS2-4	Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.
SCI.HS-PS2-6	Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.

Resources

Forces in One Dimension: Explore the forces at work when you try to push a filing cabinet. Create an applied force and see the resulting friction force and total force acting on the cabinet. Charts show the forces, position, velocity, and acceleration vs. time. View a Free Body Diagram of all the forces (including gravitational and normal forces).

Forces and Motion: Explore the forces at work when you try to push a filing cabinet. Create an applied force and see the resulting friction force and total force acting on the cabinet. Charts show the forces, position, velocity, and acceleration vs. time. View a Free Body Diagram of all the forces (including gravitational and normal forces).

Parachute and Terminal Velocity: How does an object's speed change as it falls through the atmosphere? When first learning about how objects fall, usually just one force—gravity—is considered. Such a simplification only accurately describes falling motion in a vacuum. This model of a parachute carrying a load incorporates a second force—air resistance—and allows experimentation with two variables that affect its speed: the size of the parachute and the mass of its load. This model graphs both the parachute's height above the Earth's surface and its speed after it is released. Motion continues until a constant speed is achieved, the terminal velocity.

Physics Teaching Technology Resource (http://paer.rutgers.edu/pt3/)
Videos to help students develop ideas using the scientific process, test ideas, and disprove ideas.

The Physics Classroom (http://www.physicsclassroom.com/class)
Tutorials and resources for all physics topics. For this unit, there are helpful graphing, motion diagram, and free body diagram activities.