2024 Unit 1: Why do objects move the way they do?

Content Area:	**Science**
Course(s):	
Time Period:	**MP1**
Length:	**45 instructional days**
Status:	**Published**

NJSLS - Science

SCI.HS-PS3-1	Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.
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-PS2-3	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-PS2-1	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.

Science and Engineering Practices

Using Mathematics and Computational Thinking

- Create a computational model or simulation of a phenomenon, designed device, process, or system. (HS-PS3-1)
- 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. (HS-PS-2-3)

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)

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)

Disciplinary Core Ideas

PS3.A: Definitions of Energy

- Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms. (HS-PS3-1)

PS3.B: Types of Interactions

- Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system. (HS-PS3-1)
- Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. (HS-PS3-1)
- Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g. relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior. (HS-PS3-1)
- The availability of energy limits what can occur in any system. (HS-PS3-1)

PS2.A: Forces and Motion

- 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, HS-PS-2-3)
- Newton's second law accurately predicts changes in the motion of macroscopic objects. (HS-PS2-1)

ETS1.A: Defining and Delimiting an Engineering Problem

- 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. (HS-PS2-3)

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 (trade-offs) may be needed. (HS-PS2-3)

Crosscutting Concepts

Systems and System Models

- Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models. (HS-PS3-1)
- When investigating or describing a system, the boundaries and initial conditions of the system need to be defined. (HS-PS2-2)

Cause and Effect

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

specific causes and effects. (HS-PS2-1)

Rationale and Transfer Goals

The purpose of this unit is to have students gain an understanding of how forces and energy affect the motion of an object. Students will review the concept of kinematics and how we study motion before understanding the dynamics of what causes that motion in the first place. Students will also investigate collisions in this unit when objects interact with each other. By studying kinematics, forces, energy and collisions, students should be able to answer the question of why objects move the way they do.

Enduring Understandings

- Acceleration is the rate of change of velocity.
- Acceleration is caused by an unbalanced force.
- For every action there must be an equal, but opposite reaction.
- When an outside force is exerted upon a system, the momentum of the system will change.
- The collision of two objects within the same system will obey the conservation of momentum.
- In an isolated system, energy is always conserved.

Essential Questions

- How can uniform and accelerated linear moon be described and analyzed?
- Why do we wear seat belts in a car?
- How can a piece of space debris the size of a pencil eraser destroy the International Space Station?
- How can we save the Earth from an asteroid impact?
- I have heard it since kindergarten, but what is energy?

Content - What will students know?

- Force and acceleration are directly related while mass and acceleration are inversely related.
- If no impulse is applied, a system of objects will always conserve total momentum.
- As time of an impact increases, the force applied due to that impact will decrease.
- Acceleration changes the velocity of an object.
- Forces can balance each other out to have zero net force.
- Newton's Laws of motion describe how net force and acceleration are related.

Skills - What will students be able to do?

- Use the equation F = ma to determine the acceleration of an object based on the object's mass and net force applied to the object.
- Solve for the individual momentum of objects in a system before and after a collision to confirm the total momentum is conserved.
- Design a device that will increase the time of impact during a collision to decrease the force an object will feel during a collision.
- Use the five kinematic equations to solve the motion of an object.
- Determine if the forces that act on an object are balanced.
- Restate Newton's Laws of Motion by understanding how net force and acceleration are related.

Activities - How will we teach the content and skills?

- Develop an activity that allows students to apply different amounts of force to objects of different masses to investigate the reactive accelerations form this force [link].
- Using a closed system, discover that when objects within the system collide, their individual momentum will change, but the total momentum of the system will remain constant [link].
- Have students build a device out of readily available materials within the classroom that will affect the collision between a cart and a force sensor to investigate the purpose of crumple zones and airbags [link].

Evidence/Assessments - How will we know what students have learned?

- Students will be able to answer the unit question, why do objects move the way they do?
- Students will be able to solve word problems using F = ma.
- Students will be able to solve for an unknown final velocity given the velocities of two known masses before a collision occurs.
- Build a device that will decrease the force observed on a force sensor are a cart has collided with it.
- Physics Quarter 1 Benchmark on LinkIT website.

Spiraling for Mastery

Content or Skill for this Unit	Spiral Focus from Previous Unit	Instructional Activity
• 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. • A system of objects may also contain stored energy, depending on their relative positions. • When two objects interact, each one exerts a force on the other that can cause energy to be transferred to or from the object. • Plan an invasion to provide evidence that the change in an object's moon depends on the sum • of the forces on the object and the mass of the object. • Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system. • Kinetic energy depends on mass and speed. • Stored energy depends on configuration in terms of the relative position of masses. • Use mathematical expressions to quantify how stored energy in a system depends on configuration—for example, the stretching or compression of a spring.	• Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system. • Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object. • The moon 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 moon will change. The greater the mass of the object, the greater the force needed to achieve the same change in the moon. For any given object, a larger force causes a larger change in the moon. • When two objects interact, each one exerts a force on the other that can cause energy to be transferred to or from the object. • A system of objects may also contain stored (potential) energy, depending on their relative positions.	• Review of Newton's Laws of Motion. • Review the role of velocity and mass in determining the kinetic energy of an object. • A review of kinetic and potential energy and what they represent. • Review the different forms of potential energy that can arise due to the relative location to other objects.

Key Resources

OpenSTAX College Physics [Link]

WebAssign Homework [Link]

PhET Simulaons [Link]

oPhysics [Link]

Physlet [Link]

Career Readiness, Life Literacies, & Key Skills

TECH.9.4.12.CT.3	Enlist input from a variety of stakeholders (e.g., community members, experts in the field) to design a service learning activity that addresses a local or global issue (e.g., environmental justice).
TECH.9.4.12.CT.4	Participate in online strategy and planning sessions for course-based, school-based, or other project and determine the strategies that contribute to effective outcomes.
TECH.9.4.12.GCA.1	Collaborate with individuals to analyze a variety of potential solutions to climate change effects and determine why some solutions (e.g., political. economic, cultural) may work better than others (e.g., SL.11-12.1., HS-ETS1-1, HS-ETS1-2, HS-ETS1-4, 6.3.12.GeoGI.1, 7.1.IH.IPERS.6, 7.1.IL.IPERS.7, 8.2.12.ETW.3).
TECH.9.4.12.IML.2	Evaluate digital sources for timeliness, accuracy, perspective, credibility of the source, and relevance of information, in media, data, or other resources (e.g., NJSLSA.W8, Social Studies Practice: Gathering and Evaluating Sources.
TECH.9.4.12.IML.3	Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions (e.g., S-ID.B.6a., 8.1.12.DA.5, 7.1.IH.IPRET.8).
TECH.9.4.12.IML.4	Assess and critique the appropriateness and impact of existing data visualizations for an intended audience (e.g., S-ID.B.6b, HS-LS2-4).
TECH.9.4.12.IML.5	Evaluate, synthesize, and apply information on climate change from various sources appropriately (e.g., 2.1.12.CHSS.6, S.IC.B.4, S.IC.B.6, 8.1.12.DA.1, 6.1.12.GeoHE.14.a, 7.1.AL.PRSNT.2).
TECH.9.4.12.IML.6	Use various types of media to produce and store information on climate change for different purposes and audiences with sensitivity to cultural, gender, and age diversity (e.g., NJSLSA.SL5).

Interdisciplinary Connections/Companion Standards

MA.N-Q.A.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
MA.N-Q.A.2	Define appropriate quantities for the purpose of descriptive modeling.
MA.N-Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
LA.RST.11-12.1	Accurately cite strong and thorough evidence from the text to support analysis of science and technical texts, attending to precise details for explanations or descriptions.

LA.RST.9-10.7	Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.
LA.WHST.11-12.2	Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.
LA.WHST.11-12.7	Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.
LA.WHST.11-12.8	Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.
LA.WHST.11-12.9	Draw evidence from informational texts to support analysis, reflection, and research.
LA.SL.11-12.5	Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest.