Unit 2 - How Do We Protect Ourselves From Collisions?

45 instructional days

New Jersey Student Learning Standards Science

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. [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 sliding 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-PS2-2: 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. [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-PS2-3: Apply science 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-ESS1-2: Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe. [Clarification Statement: Emphasis is on the astronomical evidence of the red shift of light from galaxies as an indication that the universe is currently expanding, the cosmic microwave background as the remnant radiation from the Big Bang, and the observed composition of ordinary matter of the universe, primarily found in stars and interstellar gases (from the spectra of electromagnetic radiation from stars), which matches that predicted by the Big Bang theory (3/4 hydrogen and 1/4 helium).]

HS-ESS1-4: Use mathematical or computational representations to predict the motion of orbiting objects in the solar system. [Clarification Statement: Emphasis is on Newtonian gravitational laws governing orbital motions, which apply to human-made satellites as well as planets and moons.] [Assessment Boundary: Mathematical representations for the gravitational attraction of bodies and Kepler's Laws of orbital motions should not deal with more than two bodies, nor involve calculus.]

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)

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)
- A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment and the science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence. (HS-ESS1-2)

Using Mathematics and Computational Thinking

- Use mathematical representations of phenomena to describe explanations. (HS-PS2-2, HS-ESS1-4)

Constructing Explanations and Designing Solutions

- Apply scientific ideas to solve a design problem, taking into account possible unanticipated effects. (HS-PS2-3)
- Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-ESS1-2)

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, HS-PS2-3)

ESS1.A: The Universe and Its Stars

- The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth. (HS-ESS1-2)
- The Big Bang theory is supported by observations of distant galaxies receding from our own, of the measured composition of stars and non stellar gases, and of the maps of spectra of the primordial radiation (cosmic microwave background) that still fills the universe. (HS-ESS1-2)
- Other than the hydrogen and helium formed at the time of the Big Bang, nuclear fusion within stars produces all atomic nuclei lighter than and including iron, and the process releases electromagnetic energy. Heavier elements are produced when certain massive stars achieve a supernova stage and explode. (HS-ESS1-2)

ESS1.B: Earth and the Solar System

- Kepler's laws describe common features of the motions of orbiting objects, including their elliptical paths around the sun. Orbits may change due to the gravitational effects from, or collisions with, other objects in the solar system. (HS-ESS1-4)

Crosscutting Concepts

Cause and Effect

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-PS2-1)
- 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)

Energy and Matter

- Energy cannot be created or destroyed–only moved between one place and another place, between objects and/or fields, or between systems. (HS-ESS1-2)

Independence of Science, Engineering, and Technology

- Science and engineering complement each other in the cycle known as research and development (R&D). Many R&D projects may involve scientists, engineers, and others with wide ranges of expertise. (HS-ESS1-2, HS-ESS1-4)

Scientific Knowledge Assumes an Order and Consistency in Natural Systems

- Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and they will continue to do so in the future. (HS-ESS1-2)
- Science assumes the universe is a vast single system in which basic laws are consistent. (HS-ESS1-2)

Scale, Proportion, and Quantity

- 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). (HS-ESS1-4)

Rationale and Transfer Goals :

The purpose of this unit is to understand the conservation of momentum and how it relates to observations in the real world. Students will be able to understand the difference between an internal and external force and its effect on a system of objects. Students will then focus on examples they see in the real world such as car accidents. They will then apply it to observations in the universe such as the Big Bang and the motion of planets. They will be able to relate this to Newton's Laws of motion and the resulting kinematics of an applied force. All of this will allow them to answer the overarching question of how to protect yourself during a collision.

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.
- Kepler's Laws of Motion can be used to accurately describe the motion of planets and other stellar bodies.

Essential Questions:

- How can uniform and accelerated linear motion be described and analyzed? [Phenomena]
- Why do we wear seatbelts in a car? [Phenomena]
- How can a piece of space debris the size of a pencil eraser destroy the International Space Station? [Phenomena]
- How can we save the Earth from an asteroid impact? [Phenomena]

Content/Objectives		Instructional Actions	
Content ***What students will know***	**Skills** ***What students will be able to do***	**Activities/Strategies** ***How we teach content and skills***	**Evidence (Assessments)** ***How we know students have learned***
• 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 the time an impact occurs increases, the force applied due to that impact will decrease. • Evidence for the Big Bang is seen by the motion of galaxies observed by a red-shift. • The further away an object is from what it is	• 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 momentums 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.	• 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 momentums will change, but the total momentum of the system will remain constant [link]. • Have students build a device out of readily	• 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 after a cart has collided with it. • Explain how scientists were able to use evidence presented to us today as a way to predict what

revolving around, the longer its period will be.	• Use evidence of the expansion of the universe to show that galaxies in general are moving away from one another. • Use Kepler's Second Law to explain why Halley's comet comes every 76 years.	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]. • Use data recorded by NASA to understand the evidence presented for the Big Bang and relate it to an explosion and how the momentum will still remain conserved [link]. • Determine how far away Halley's comet travels if it appears every 76 years and figure out how far away it must be now [link].	happened 13 billion years ago. • Solve for the distance of any planet in the solar system knowing their orbital period. • Physics Unit 2 Benchmark

Spiraling for Mastery		
Content or Skill for this Unit	**Spiral Focus from Previous Unit**	**Instructional Activity**
• Plan an investigation to provide evidence that the change in an object's motion depends on the sum	• The motion of an object is determined by the sum of the forces acting on it; if the total	• Review the role of acceleration in changing an object's speed.

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. ● Solids may be formed from molecules, or they may be extended structures with repeating subunits (e.g., crystals). ● Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects. ● Develop and use a model of the Earth-sun-moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons. ● Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system.	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. ● When two objects interact, each one exerts a force on the other that can cause energy to be transferred to or from the object. ● Develop models to describe the atomic composition of simple molecules and extended structures. ● 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. ● Patterns of the apparent motion of the sun, the moon, and stars in the sky can be	● Review Newton's Laws of Motion and the role of inertia in these laws. ● Review the role of energy within a collision. ● Review how microscopic components can affect the macroscopic object's motion. ● Review the gravitational force and the variables that affect its strength. ● Review the vocabulary used to describe the solar system and its place within a greater universe.

	observed, described, predicted, and explained with models. ● The solar system appears to have formed from a disk of dust and gas, drawn together by gravity.	

Key resources:

- OpenSTAX College Physics [Link]
- WebAssign Homework [Link]
- PhET Simulations [Link]
- oPhysics [Link]
- Physlet [Link]
- NASA Website [Link]

21st Century Life & Careers:

9.2.12.CAP.2: Develop college and career readiness skills by participating in opportunities such as structured learning experiences, apprenticeships, and dual enrollment programs.

9.2.12.CAP.3: Investigate how continuing education contributes to one's career and personal growth.

9.2.12.CAP.4: Evaluate different careers and develop various plans (e.g., costs of public, private, training schools) and timetables for achieving them, including educational/training requirements, costs, loans, and debt repayment.

Career Readiness, Life Literacies, & Key Skills:

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).

9.4.12.CT.4: Participate in online strategy and planning sessions for course-based, school-based, or other projects and determine the strategies that contribute to effective outcomes.

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.

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.

9.4.12.IML.3: Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions.

9.4.12.IML.4: Assess and critique the appropriateness and impact of existing data visualizations for an intended audience.

9.4.12.IML.5: Evaluate, synthesize, and apply information on climate change from various sources appropriately.

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.

InterDisciplinary Connections/Companion Standards:

NJSLS Math

HSN-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. (HS-PS2-1, HS-PS2-2, HS-ESS1-2, HS-ESS1-4)

HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. (HS-PS2-1, HS-PS2-2, HS-ESS1-2, HS-ESS1-4)

HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-ESS1-2, HS-ESS1-4)

HSA-SSE.A.1 Interpret expressions that represent a quantity in terms of its context. (HS-ESS1-2, HS-ESS1-4)

HSA-CED.A.2 Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. (HS-ESS1-2, HS-ESS1-4)

HSA-CED.A.4 Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. (HS-ESS1-2, HS-ESS1-4)

NJSLS ELA

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-PS2-1, HS-ESS1-2)

RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-PS2-1)

WHST.9-12.7 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. (HS-PS2-3)

WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-ESS1-2)

Companion Standards for ELA in Science and Technical Subjects: Reading

Key Ideas and Details

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.

Integration of Knowledge and Ideas

RST.11-12.7. Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.

RST.11-12.8. Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.

RST.11-12.9. Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.

Companion Standards for ELA in Science and Technical Subjects: Writing

Research to Build and Present Knowledge

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 an understanding of the subject under investigation. WHST.11-12.9. Draw evidence from informational texts to support analysis, reflection, and research.