Unit 2: How Do We Protect Ourselves from Collisions?

Content Area: **Science**
Course(s):
Time Period: **MP2**
Length: **45 instructional days**
Status: **Published**

NJSLS - Science

9-12.HS-ESS1-4	Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.
9-12.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.
9-12.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.
9-12.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.
9-12.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.

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-PS2-4)

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

- Theories and laws provide explanations in science. (HS-PS2-4)
- Laws are statements or descriptions of the relationships among observable phenomena. (HS-PS2-4)
- A scienfic theory is a substanated 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)

Constructing Explanations and Designing Solutions

- Apply scienfic ideas to solve a design problem, taking into account possible unancipated effects. (HS-PS2-3)
- Construct an explanaon based on valid and reliable evidence obtained from a variety of sources (including students’ own invesgaons, theories, simulaons, peer review) and the assumpon that theories and laws that describe the natural world operate today as they did in the past and will connue to do so

in the future. (HS-ESS1-2)

Disciplinary Core Ideas

PS2.A: Forces and Moon

- Newton's second law accurately predicts changes in the moon of macroscopic objects. (HS-PS2-1)
- Momentum is defined for a parcular frame of reference; it is the mass mes 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 idenfy composional elements of stars, their movements, and their distances from Earth. (HS-ESS1-2)
- The Big Bang theory is supported by observaons of distant galaxies receding from our own, of the measured composion of stars and non stellar gases, and of the maps of spectra of the primordial radiaon (cosmic microwave background) that sll fills the universe. (HS-ESS1-2)
- Other than the hydrogen and helium formed at the me of the Big Bang, nuclear fusion within stars produces all atomic nuclei lighter than and including iron, and the process releases electromagnec 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 moons of orbing objects, including their ellipcal paths around the sun. Orbits may change due to the gravitaonal effects from, or collisions with, other objects in the solar system. (HS-ESS1-4)

Crosscutting Concepts

Cause and Effect

- Empirical evidence is required to differenate between cause and correlaon 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 investing or describing a system, the boundaries and inial 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 sciensts, engineers, and others with wide ranges of experse. (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 connue 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 moon of planets. They will be able to relate this to Newton's Laws of moon 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 moon of planets and other stellar bodies.

Essential Questions

How can uniform and accelerated linear moon 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 Internaonal Space Staon? [Phenomena]

How can we save the Earth from an asteroid impact? [Phenomena]

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 the time an impact occurs increases, the force applied due to that impact will decrease.
- Evidence for the Big Bang is seen by the moon of galaxies observed by a red-shift.
- The further away an object is from what it is revolving around, the longer its period will be.

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 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.
- 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

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 momentums 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].
- 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 sll 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].

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

- Students will be able to solve word problems using F = ma.
- Students will be able to solve for an unknown final velocity given the velocies of two known masses before a collision occurs.
- Build a device that will decrease the force observed on a force sensor aer a cart has collided with it.
- Explain how sciensts were able to use evidence presented to us today as a way to predict what 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 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. • 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 arriving and depend on the masses of interacting	• 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. • Develop models to describe the atomic composition of simple molecules and extended structures. Gravitational forces are always active.	• Review of the structure of the atom and the properties of the atom. • Review of Newton's Laws of the Moon. • Review the types of reactions that can occur between electric charges and magnec poles. • A review of kinetic and potential energy and what they represent. • A review of the gravitational force and its purpose within the solar system.

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 moons within galaxies and the solar system.	There is a gravitational force between any two masses, but it is very small except when one or both of the objects have large masses—e.g., Earth and the sun. • Paerns of the apparent moon of the sun, the moon, and stars in the sky can be 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 Simulaons [Link]

Physics [Link]

Physlet [Link]

NASA Website [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.