Unit 7: Physical Science: Motion and Forces

Content Area: **Science**
Course(s):
Time Period: **Marking Period 1**
Length: **4 Weeks**
Status: **Published**

Essential Questions/Enduring Understandings

Essential Questions

1. How do the same fundamental laws govern the motion of a subatomic particle, a skydiver, and an entire galaxy?
2. How can we predict, manipulate, or protect against the outcomes of physical interactions before they occur?
3. In what ways do conservation laws act as cosmic accounting rules for physical systems?

Enduring Understandings

1. Newtonian mechanics and fundamental forces (gravitational, electromagnetic, frictional, contact) govern motion and interactions consistently from subatomic particles to cosmic orbits.
2. Net forces dictate changes in motion, and using vector analysis with free-body diagrams allows us to quantify, model, and forecast system trajectories and structural integrity.
3. Momentum and mechanical energy are conserved in closed systems, providing mathematical tools to analyze interactions, optimize safety designs, and solve complex collision dynamics.

Brief Summary of Unit

Students will investigate the universal principles of classical mechanics to analyze how physical laws govern the motion and interaction of objects across cosmic, macroscopic, and subatomic scales. This unit examines kinematics and dynamics (Newton's Laws of Motion). Students will quantify gravitational, electromagnetic, frictional, and contact forces, using vector analysis and free-body diagrams to predict system trajectories. By applying principles of momentum, impulse, and mechanical energy conservation (kinetic and gravitational potential energy), students will model real-world mechanical systems, evaluate structural and collision dynamics, and prove the scale-invariant nature of Newtonian mechanics.

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Standards

1	Make sense of problems and persevere in solving them
	Mathematically proficient students start by explaining to themselves the meaning of a problem and looking for entry points to its solution. They analyze givens, constraints, relationships, and goals. They make conjectures about the form and meaning of the solution and plan a solution pathway rather than simply jumping into a solution attempt. They consider analogous problems and try special cases and simpler forms of the original problem in order to gain insight into its solution. They monitor and evaluate their progress and change course if necessary. Older students might, depending on the context of the problem, transform algebraic expressions or change the viewing window on their graphing calculator to get the information they need. Mathematically proficient students can explain correspondences between equations, verbal descriptions, tables, and graphs or draw diagrams of important features and relationships, graph data, and search for regularity or trends. Younger students might rely on using concrete objects or pictures to help conceptualize and solve a problem. Mathematically proficient students check their answers to problems using a different method, and they continually ask themselves, “Does this make sense?” They can understand the approaches of others to solving complex problems and identify correspondences between different approaches.
L.SS.11–12.1	Demonstrate command of the system and structure of the English language when writing or speaking.
2	Reason abstractly and quantitatively
	Mathematically proficient students make sense of quantities and their relationships in problem situations. They bring two complementary abilities to bear on problems involving quantitative relationships: the ability to decontextualize—to abstract a given situation and represent it symbolically and manipulate the representing symbols as if they have a life of their own, without necessarily attending to their referents—and the ability to contextualize, to pause as needed during the manipulation process to probe into the referents for the symbols involved. Quantitative reasoning entails habits of creating a coherent representation of the problem at hand; considering the units involved; attending to the meaning of quantities, not just how to compute them; and knowing and flexibly using different properties of operations and objects.
P.4	Demonstrate creativity and innovation.
L.KL.11–12.2	Apply knowledge of language to understand how language functions in different contexts, to make effective choices for meaning or style, and to comprehend more fully when reading or listening.
P.8	Use technology to enhance productivity increase collaboration and communicate effectively.
5	Use appropriate tools strategically
	Mathematically proficient students consider the available tools when solving a mathematical problem. These tools might include pencil and paper, concrete models, a ruler, a protractor, a calculator, a spreadsheet, a computer algebra system, a statistical package, or dynamic geometry software. Proficient students are sufficiently familiar with tools appropriate for their grade or course to make sound decisions about when each of these tools might be helpful, recognizing both the insight to be gained and their limitations. For example, mathematically proficient high school students analyze graphs of functions and solutions generated using a graphing calculator. They detect possible errors by strategically using estimation and other mathematical knowledge. When making mathematical models, they know that technology can enable them to visualize the results of varying assumptions, explore consequences, and compare predictions with data. Mathematically proficient students at various grade levels are able to identify relevant external mathematical resources, such as digital content located on a website, and use them to pose or solve problems. They are able to use technological tools to explore and deepen their understanding of concepts.
6	Attend to precision

	Mathematically proficient students try to communicate precisely to others. They try to use clear definitions in discussion with others and in their own reasoning. They state the meaning of the symbols they choose, including using the equal sign consistently and appropriately. They are careful about specifying units of measure, and labeling axes to clarify the correspondence with quantities in a problem. They calculate accurately and efficiently, express numerical answers with a degree of precision appropriate for the problem context. In the elementary grades, students give carefully formulated explanations to each other. By the time they reach high school they have learned to examine claims and make explicit use of definitions.
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.
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.
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.
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.
HS-PS3-2	Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motion of particles (objects) and energy associated with the relative position of particles (objects).
HS-ESS1-4	Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.
HS-ETS1-2	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-ETS1-3	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-ETS1-4	Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.

Objectives: Students will know/Students will be skilled at

- • Apply Newton's three laws of motion to real life scenarios.
- • Apply the concept of vector positioning and motion to one's frame of reference.
- • Calculate acceleration of a moving object.
- • Calculate how the gravitational force decreases with increasing distance between the two objects.
- • Calculate the momentum of a moving object.
- • Calculate the work done on a system that displaces the position of an object.
- • Create and interpret a distance-time graph.
- • Create and interpret a speed-time graph.
- • Define how any type of energy's ability to do work is conserved.
- • Describe the conservation of momentum.
- • Describe the meaning of net force, balanced forces, and unbalanced forces.

- • Differentiate speed from velocity.
- • Differentiate weight from mass.
- • Distinguish between friction and air resistance forces.
- • Gravity is the attractive force between two masses.

Learning Plan

- • Calculate average acceleration.
- • Calculate average speed. Use average speed and time to calculate distance.
- • Construct and interpret speed-time graphs.
- • Describe the effects of friction and air resistance on motion.
- • Describe the velocities of people walking up and down the aisle of a moving bus. Contrast perspectives of an observer on the bus with an observer on the street (frame of reference).
- • Distinguish between distance and displacement.
- • Draw force diagrams. Emphasize the idea of representing vectors as arrows.
- • Emphasize that all changes in motion are due to forces acting on the object in motion.
- • Explain how positive and negative acceleration affect motion.
- • Explain the difference between speed and velocity (define vector).
- • Explain the effect of forces upon motion.
- • Identify the relationship between acceleration, time, and velocity.
- • Interpret motion graphs.
- • Lab: Design your own experiment to compare motion resulting from different forces. (Teacher: provide a list of materials and allow students to create their own question, hypothesis, and procedure. Teacher approval required on all procedures.)
- • Lab: Force and acceleration – measure the forces required to move different masses at constant velocity.
- • Meaningful participation in guided question/answer sessions, individual/group discussions, demonstrating an understanding of the purpose of the unit lesson(s), key terms, and concepts
- • Newton's First Law: If the net force on an object is zero then no change in its motion will occur. (An object in motion will remain in motion at constant velocity and an object at rest will remain at rest.)
- • Newton's Second Law: F = m x a. Use the second law to calculate force, mass, or acceleration.
- • Newton's Third Law: For every action force there is an equal and opposing reaction force. These forces are not acting upon the same object!
- • Plot distance-time graphs.
- • Preview the essential questions, provide answers, and connect to learning throughout the unit
- • Small Group Project – in class: Create a force diagram that shows how applying downward force on a bicycle pedal results in a net forward force on the bicycle and its rider. (Provide a large line drawing of the pedal, the foot, the chain, gears, rear wheel, and road surface. Use post-it note tabs with arrows pre-drawn. Students work in groups to place the force arrows in such a way that allows them to explain the net forward motion.)
- • Student-designed experiment on motion and forces. Use this as an opportunity to reinforce the scientific method.
- • Unit quizzes and tests.

Assessment

Materials

- quantitative/qualitative lab equipment for activities, experiments
- supplementary interactive multimedia, internet websites, videos
- Textbook, Physical Science with Earth Science, Glencoe, and ancillary resource materials

Accommodations & Modifications