(2026) 01 Motion and Forces

Content Area: **Science**
Course(s): **Physics A**
Time Period: **Semester 1**
Length: **10 weeks**
Status: **Published**

Standards

	Patterns
SCI.HS.PS2.B	Types of Interactions
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.A	Forces and Motion
	Cause and Effect
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.
	Scale, Proportion, and Quantity
	Using Mathematics and Computational Thinking
SCI.HS-ESS1-4	Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.
SCI.HS.ESS1.B	Earth and the Solar System
	Analyzing and Interpreting Data

Enduring Understandings

1. Students will be able to explain how net force, mass, and acceleration dictate predictable changes in macroscopic motion by using dynamic cart-and-pulley systems to mathematically model Newton's Second Law.
2. Students will be able to apply the mathematical models of Newton's Law of Universal Gravitation and Coulomb's Law to predict how distance and magnitude alter electrostatic and gravitational forces by analyzing simulated data sets of interacting point charges and stellar masses.
3. Students will be able to analyze how gravity governs the elliptical orbits and long-term cyclical motions of planetary bodies by utilizing computational modeling software to simulate orbital variations, gravitational disruptions, and planetary axis shifts.
4. To align with the NGSS Crosscutting Concepts of Cause and Effect and Systems, students will be able to evaluate how invisible gravitational and electromagnetic fields transfer energy and dictate macro-system behaviors by mapping force fields and tracking chaos vs. predictability in multi-component environments.

Essential Questions

1. How can an object be moving and completely stationary at the same time, and how do we use this to

predict changes in its motion?

2. How does the mathematical relationship between force, mass, and acceleration dictate everything from a safe highway tailgating distance to vehicle safety designs?
3. What causes a system of objects to maintain a stable, predictable motion versus descending into unpredictable chaos?
4. What underlying forces explain the vast variety of push-and-pull interactions we observe in the universe?
5. How do gravity and electricity allow distant objects to exert massive forces on each other through invisible fields without ever touching?
6. How do scale, proportion, and quantity determine whether electrostatic forces or gravitational forces dominate a system's behavior?
7. Why does the Earth orbit the Sun in an elliptical path rather than flying off into deep space or crashing into the solar core?
8. What predictable macroscopic patterns—from daily tides to ice ages spanning hundreds of thousands of years—are caused by Earth's movement in the solar system?

Knowledge and Skills

Knowledge:

1. Motion can be modeled simultaneously across four domains (mathematical equations, vector diagrams, graphs, and narrative prose), and objects are in a state of static or dynamic equilibrium when the vector sum of all forces equals zero.
2. Deconstruct how an observer's frame of reference dictates their perception of motion. Students analyze why Newton's First Law appears to fail in a non-inertial (accelerating) reference frame.
3. Critique the common misconception that an object moving at a high, constant velocity requires a continuous net force. Evidence: Cite data from deep-space probes (e.g., Voyager) or frictionless air-track data to prove that acceleration—not velocity—is directly proportional to net force and inversely proportional to mass
4. Describe how forces are mutual vector interactions that always exist in equal and opposite pairs (Newton's Third Law), categorizable into macroscopic contact forces (friction, normal force) or long-range field forces (gravity, electromagnetism).
5. Analyze how contact forces are actually macroscopic manifestations of electromagnetic field repulsions occurring at the atomic scale.
6. Critique the flawed student claim that a massive truck exerts a greater force on a tiny car during a head-on collision than the car exerts on the truck. Evidence: Cite high-speed force-sensor collision data demonstrating that Newton's Third Law pairs are identical in magnitude at every millisecond of the impact, proving that the differing structural damage is a function of differing mass and resulting acceleration, not unequal forces.
7. Describe how Kepler's Laws dictate that planets move in predictable elliptical orbits governed by universal gravitation, while Earth's long-term rotational and orbital variations cause massive shifts in solar radiation distribution.
8. Critique the claim that global climate change is historically random or driven solely by solar flare variations.

Skills :

1. Instead of just drawing a position-time graph, students must translate a complex physical scenario

between all four domains simultaneously. They must look at a flawed velocity-time graph (e.g., one showing an instantaneous, discontinuous change in velocity) and critique why it violates physical laws regarding infinite force.

2. Students will design an experimental pipeline using modified Atwood machines or low-friction dynamics tracks. They cannot just verify Newton's Second Law; they must deliberately introduce systematic errors (like uncompensated track friction or string mass) and use their data to mathematically isolate and quantify how those hidden forces skew their predictive models.

3. Analyze the periodicities in the planet's temperature drops using Fourier analysis or graphical tracking.

4. Critique an existing flawed hypothesis that blames a fluctuating sun for the planet's ice ages.

5. Cite Evidence by building a Keplerian/Newtonian orbital model of this exoplanet system to prove that a nearby gas giant is gravitationally destabilizing the planet's eccentricity, driving its cyclical climate crises.

Modifications

https://docs.google.com/document/d/1ODqaPP69YkcFiyG72fIT8XsUIe3K1VSG7nxuc4CpCec/edit?usp=sharing

Assessments

https://docs.google.com/document/d/1wR7bQF-8AQoRrt0g4C3hKja0yjwDjC9_BiAmONWbTcI/edit?usp=sharing