Orange Public Schools

Office of STEM-Focused Learning & Gifted Education
Science Curriculum Guide

Physics Honors

Unit 1: Forces and Motion

23.5 Instructional Days

Board Approved: 9/13/23

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YEARLONG SCOPE AND SEQUENCE

UNIT 1	UNIT 2	UNIT 3	UNIT 4	UNIT 5
Forces and Motion	**Forces at a Distance**	**Energy Conversion**	**Waves and Electromagnetic Radiation**	**From the Nucleus to the Universe**
23.5 days	45 days	48 days	27.5 days	33.5 days
In Storyline 1, students learn how to model motion using models that are grounded in mathematical relationships. They investigate and model uniform motion, nonuniform motion, circular motion, and projectile motion. Students also explore how various forces affect the motion of objects. Students explore the relationship between forces and motion. *This unit addresses HS-PS2-1, HS-PS2-2, HS-PS2-4, and HS-ESS2-1.*	In Storyline 2, students investigate gravitational forces, electrical forces, magnetic forces, and forces in materials. They connect orbital motion to gravitational forces and construct explanations about electric fields and currents. Students investigate gravitational, electric, and magnetic forces, and the forces within atoms. *This unit addresses HS-PS1-3, HS-PS2-4, HS-PS2-5, HS-PS2-6, HS-PS3-5, and HS-ESS1-4.*	In Storyline 3, students explore energy conversions by quantifying how much energy transfers between objects and energy fields. They use bar charts and equations to define systems and to model energy conversions. They consider heat transfer in engines, heat pumps, and Earth's interior, connecting the convection of Earth's mantle to plate tectonics. Students evaluate the costs and benefits associated with different methods of energy production and identify variables essential to a sustainable energy future for Earth's growing human population. Students explore energy conversions in collisions, in engines and heat pumps, and in electromagnetic systems. *This unit addresses HS-PS2-2, HS-PS2-3, HS-PS2-5, HS-PS3-1, HS-PS3-2, HS-PS3-3, HS-PS3-4, HS-PS3-5, HS-ESS2-1, HS-ESS2-3, HS-ESS3-2, and HS-ESS3-3.*	In Storyline 4, students explore waves and electromagnetic radiation, as well as technological applications of transmitting and capturing information and energy. In Investigation 1 1, students experiment with waves. In Investigation 12, students explore electromagnetic radiation. In Investigation 13, students design instrumentation to transmit information. Students investigate the properties and behaviors of waves, using mathematical relationships. *This unit addresses HS-PS3-3, HS-PS4-1, HS-PS4-2, HS-PS4-3, HS-PS4-4, and HS-PS4-5.*	In Storyline 5, students investigate and model atomic nuclei and the processes they undergo. They learn how the predictable decay processes of specific atomic nuclei are used by scientists to date materials. They also explore evidence relating to the origin of the universe and compare the sun to other stars in the universe. Students explore the beginning of the universe, the death of stars, and the radioactive decay of atoms. *This unit addresses HS-PS1-8, HS-ESS1-1, HS-ESS1-2, HS-ESS1-3, HS-ESS1-5, HS-ESS1-6, and HS-ESS2-1.*

UNIT OVERVIEW AND CONCEPTUAL FLOW

Content Area	Science	**Course**	Physics Honors
Unit Plan Title	Unit 1: Forces and Motion	**Duration**	23.5 days

UNIT OVERVIEW

In Storyline 1, students learn how to model motion using models that are grounded in mathematical relationships. They investigate and model uniform motion, nonuniform motion, circular motion, and projectile motion. Students also explore how various forces affect the motion of objects. Students explore the relationship between forces and motion.

This unit addresses HS-PS2-1, HS-PS2-2, HS-PS2-4, and HS-ESS2-1.

CONCEPTUAL FLOW

Anchoring Phenomenon	How will we get to Mars?
Investigations	**Investigation #1:** Modeling Motion • **Experience 1** - Displacement and Velocity • **Experience 2** - Acceleration • **Experience 3** - Circular and Projectile Motion **Investigation #2:** Forces • **Experience 1** - Force, Mass, and Acceleration • **Experience 2** - Types of Forces • **Experience 3** - Forces on Systems • **Experience 4** - Earth's Surface Forces

ESSENTIAL QUESTION(S) AND ENDURING UNDERSTANDINGS

Essential Questions /Focus Questions	Enduring Understandings
• Why are people on Earth stuck here while astronauts appear to be weightless? • How does the weight (force of gravity) of an astronaut of a specific mass (100 kg including gear) change at specific distances from Earth as the shuttle flies toward the moon? • How far away can my finger be from my sister or brother if I want to zap them with static electricity?	• Newton's Law of Universal Gravitation provides the mathematical models to describe and predict the effects of gravitational forces between distant objects. • Forces at a distance are explained by fields (gravitational) permeating space that can transfer energy through space. • Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of the gravitational force between objects. • Coulomb's Law provides the mathematical models to describe and predict the effects of electrostatic forces between distant objects. • Forces at a distance are explained by fields (electric and magnetic) that permeate space and can transfer energy through space. • Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields. • Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of electrostatic attraction and repulsion.

NGSS PERFORMANCE EXPECTATION(S)

Students who demonstrate understanding can:

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-ESS2-1 Develop a model to illustrate how Earth's internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features.

3-DIMENSIONAL LEARNING

SCIENCE AND ENGINEERING PRACTICES	DISCIPLINARY CORE IDEAS	CROSSCUTTING CONCEPTS
☐ **Asking Questions and Defining Problems** ☒ **Developing and Using Models** ☐ **Planning and Carrying Out Investigations** ☒ **Analyzing and Interpreting Data** ☒ **Using Mathematics and Computational Thinking** ☐ **Constructing Explanations and Designing Solutions** ☐ **Engaging in Argument from Evidence** ☐ **Obtaining, Evaluating, and Communicating Information**	**PS2.A: Forces and Motion** Newton's second law accurately predicts changes in the motion of macroscopic objects. Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object. 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. **PS2.B: Types of Interactions** Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects. Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields. **ESS2.A: Earth Materials and Systems** Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. **ESS2.B: Plate Tectonics and Large-Scale System Interactions** Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geologic history. Plate movements are responsible for most continental and ocean-floor features and for the distribution of most rocks and minerals within Earth's crust. (ESS2.B Grade 8 GBE)	☒ **Patterns** ☒ **Cause and Effect** ☐ **Scale, Proportion, and Quantity** ☒ **Systems and System Models** ☐ **Energy and Matter** ☐ **Structure and function.** ☒ **Stability and change**.

INTERDISCIPLINARY CONNECTIONS

English Language Arts

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)
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.11-12.9 Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS2-1)
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. (HS-ESS2-1)

Mathematics

MP.2 Reason abstractly and quantitatively. (HS-PS2-1) (HS-PS2-2) (HS-PS2-4) (HS-ESS2-1)
MP.4 Model with mathematics. (HS-PS2-1) (HS-PS2-2) (HS-PS2-4) (HS-ESS2-1)
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-PS2-4) (HS-ESS2-1)
HSN.Q.A.2: Define appropriate quantities for the purpose of descriptive modeling. (HS-PS2-1) (HS-PS2-2) (HS-PS2-4) (HS-ESS2-1)
HSN.Q.A.3: Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS2-1) (HS-PS2-2) (HS-PS2-4) (HS-ESS2-1)
HSA.SSE.A.1: Interpret expressions that represent a quantity in terms of its context. (HS-PS2-1) (HS-PS2-4)
HSA.SSE.B.3: Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression. (HS-PS2-1) (HS-PS2-4)
HSA.CED.A.1: Create equations and inequalities in one variable and use them to solve problems. (HS-PS2-1) (HS-PS2-2)
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-PS2-1) (HS-PS2-2)
HSA.CED.A.4: Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. (HS-PS2-1) (HS-PS2-2)
HSF-IF.C.7: Graph functions expressed symbolically and show key features of the graph, by in hand in simple cases and using technology for more complicated cases. (HS-PS2-1)
HSS-IS.A.1: Represent data with plots on the real number line (dot plots, histograms, and box plots). (HS-PS2-1)

INTEGRATED ACCOMMODATIONS & MODIFICATIONS

Special Education / 504

- Adhere to all modifications and health concerns stated in each IEP.
- Give students a MENU of options, allowing them to choose assignments from different levels based on difficulty.
- Accommodate Instructional Strategies: use of post-its, reading aloud text, graphic organizers, one-on-one instruction, class website (Google Classroom), handouts, definition list with visuals, extended time
- Allow extra time to complete assignments or tests
- Allow students to demonstrate understanding of a problem by drawing a functional model of the answer and then explaining the reasoning orally and/or writing.
- Provide breaks between tasks, use positive reinforcement, use proximity
- Work in a small group
- Use large print books, Braille, or digital texts

Strategies for students with 504 plans

English Language Learners

- Simplify written and verbal instructions
- Use manipulatives to promote conceptual understanding and enhance vocabulary usage
- Allow for alternate forms of responses- drawing or speaking instead of writing to demonstrate knowledge when you are not specifically assessing writing
- Allow the use of an online dictionary to look up the definition and hear the pronunciation of unknown words
- Provide graphic representations, gestures, drawings, equations, and pictures during all segments of instruction
- Utilize program translations tools such as Snap and Read (if available)
- Utilize graphic organizers which are concrete, pictorial ways of constructing knowledge and organizing information
- Use sentence frames and questioning strategies so that students will explain their thinking/ process of how to solve real life problems.
- Reword questions in simpler language
- Provide class notes ahead of time to allow students to preview material and increase comprehension
- Provide extended time

Gifted and Talented

- Organize and offer flexible small group learning opportunities / activities.
- Utilize elevated contextual complexity
- Inquiry based or open-ended assignments, performance tasks and projects
- Allow more time to study concepts with greater depth
- Provide options, alternatives and choices to differentiate and broaden the curriculum.
- Promote the synthesis of concepts and making real world connections
- Provide students with enrichment practice that are imbedded in the curriculum
    - allowing students to design problems to be addressed by the class
    - allowing students to modify the lesson by introducing a related phenomenon
    - allow for interest-based extension activities
- Utilize an enhanced set of introductory activities (e.g. phenomena, organizers, concept maps etc.)
- Provide whole group enrichment explorations.
- Teach cognitive and methodological skills
- Allow for the use of stations
- Organize integrated problem-solving simulations.

Students at Risk for Failure

- Assure students have experiences that are on the Concrete-Pictorial- Abstract spectrum
- Modify Instructional Strategies; extended time, reading aloud text, graphic organizers, flexible grouping, one-on-one instruction, class website (Google Classroom), inclusion of more visuals and manipulatives, Utilize Scaffolded Questioning, Field Trips, Google Expeditions, Peer Support, Modified Assignments, Chunking of Information, Peer Buddies
- Assure constant parental/ guardian contact throughout the year with successes/ challenges
- Provide academic contracts to students and guardians
- Create an interactive notebook with samples, key vocabulary words, student goals/ objectives.
- Always plan to address students at risk in the designing of learning tasks, instructions, and directions.
- Try to anticipate where the needs will be and then address them prior to lessons.
- Teacher should allow for preferential seating
- Include Visual Cues/Modeling
- Allow for technology Integration, especially Assistive Technology

21ST CENTURY SKILLS
NJSLS CAREER READINESS, LIFE LITERACIES AND KEY SKILLS

An education in career readiness, life literacies, and key skills fosters a population that: continually self-reflects and seeks to improve the essential life and career practices that lead to success; uses effective communication and collaboration skills and resources to interact with a global society; possesses financial literacy and responsibility at home and in the broader community; plans, executes, and alters career goals in response to changing societal and economic conditions; and seeks to attain skill and content mastery to achieve success in a chosen career path.

New Jersey Student Learning Standards for Career Readiness, Life Literacies and Key Skills

9.1 Personal Financial Literacy

Civic Responsibility:

You can give back in areas that matter to you.

- **9.1.12.CFR.1:** Compare and contrast the role of philanthropy, volunteer service, and charities in community development and quality of life in a variety of cultures.

9.2 Career Awareness, Exploration and Preparation

Career Awareness and Planning:

An individual's passions, aptitude and skills can affect his/her employment and earning potential.

- **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.

9.3 Career and Technical Education

Engineering and Technology Career Pathway

- **9.3.ST-ET.5:** Apply the knowledge learned in STEM to solve problems.

Science and Mathematics Career Pathway

- **9.3.ST-SM.2:** Apply science and mathematics concepts to the development of plans, processes and projects that address real world problems.
- **9.3.ST-SM.3:** Analyze the impact that science and mathematics has on society.

9.4 Life Literacies and Key Skills

Creativity and Innovation:

Collaboration with individuals with diverse perspectives can result in new ways of thinking and/or innovative solutions. Curiosity and a willingness to try new ideas (intellectual risk-taking) contributes to the development of creativity and innovation skills.

- **9.4.12.CI.1:** Demonstrate the ability to reflect, analyze and use creative skills and ideas.
- **9.4.12.CI.3:** Investigate new challenges and opportunities for personal growth, advancement and transition.

Critical Thinking and Problem-solving:

The ability to solve problems effectively begins with gathering data, seeking resources, and applying critical thinking skills.

- **9.4.12.CT.1:** Identify problem-solving strategies used in the development of an innovative product or practice.
- **9.4.12.CT.3:** Collaborate with individuals to analyze a variety of potential solutions to climate change effects and determine why solutions may work better than others (e.g., political. economic, cultural).

Digital Citizenship:

Sending and receiving copies of media on the internet creates the opportunity for unauthorized use of data, such as personally owned video, photos, and music. Digital identities must be managed in order to create a positive digital footprint.

- **9.4.12.DC.4:** Explain the privacy concerns related to the collection of data (e.g. cookies) and generation of data through automated processes that may not be evident to users

Information and Media Literacy:

Digital tools can be used to modify and display data in various ways that can be organized to communicate ideas.

- **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.

Technology Literacy:

Different digital tools have different purposes. Collaborating digitally as a team can often develop a better artifact than an individual working alone.

	• **9.4.12.TL.1**: Assess digital tools based on features such as accessibility options, capacities and utility for accomplishing a specified task • **9.4.12.TL.3**: Analyze the effectiveness of the process and quality of collaborative environments. • **9.4.12.TL.4**: Collaborate in online learning communities or social networks or virtual worlds to analyze and propose a resolution to a real-world problem.

Practices

- Act as a responsible and contributing community member and employee.
- Consider the environmental, social and economic impacts of decisions.
- Demonstrate creativity and innovation.
- Utilize critical thinking to make sense of problems and persevere in solving them.
- Model integrity, ethical leadership and effective management.
- Plan education and career paths aligned to personal goals.
- Use technology to enhance productivity increase collaboration and communicate effectively.

NJSLS COMPUTER SCIENCE & DESIGN THINKING

All students will be prepared to succeed in today's knowledge-based economy by providing equitable and expanded access to high-quality, standards-based computer science and technological design education.
https://www.nj.gov/education/standards/compsci/Docs/2020%20NJSLS-CSDT.pdf

8.1 Computer Science

Data & Analysis: Computing systems exist to process data. The amount of digital data generated in the world is rapidly expanding, so the need to process data effectively is increasingly important. Data is collected and stored so that it can be analyzed to better understand the world and make more accurate predictions.

- **8.1.12.DA.5**: Create data visualizations from large data sets to summarize, communicate, and support different interpretations of real-world phenomena.
- **8.1.12.DA.6**: Create and refine computational models to better represent the relationships among different elements of data collected from a phenomenon or process.

Algorithms & Programming: An algorithm is a sequence of steps designed to accomplish a specific task. Algorithms are translated into programs, or code, to provide instructions for computing devices. Algorithms and programming control all computing systems, empowering people to communicate with the world in new ways and solve compelling problems.

- **8.1.12.AP.1**: Design algorithms to solve computational problems using a combination of original and existing algorithms.
- **8.1.12.AP.2**: Create generalized computational solutions using collections instead of repeatedly using simple variables.
- **8.1.12.AP.3**: Select and combine control structures for a specific application based upon performance and readability, and identify trade-offs to justify the choice.
- **8.1.12.AP.5**: Decompose problems into smaller components through systematic analysis, using constructs such as procedures, modules, and/or objects.
- **8.1.12.AP.6**: Create artifacts by using procedures within a program, combinations of data and procedures, or independent but interrelated programs.

8.2 Design Thinking

Engineering Design:
People design for enjoyment and to solve problems, extend human capabilities, satisfy needs and wants, and improve the human condition. Engineering Design, a systematic approach to creating solutions to technological problems and finding ways to meet people's needs and desires, allows for the effective and efficient development of products and systems.

- **8.2.12.ED.1**: Use research to design and create a product or system that addresses a problem and make modifications based on input from potential consumers.
- **8.2.12.ED.4**: Design a product or system that addresses a global problem and document decisions made based on research, constraints, trade-offs, and aesthetic and ethical considerations and share this information with an appropriate audience.

Interaction of Technology and Humans:
Societies influence technological development. Societies are characterized by common elements such as shared values, differentiated roles, and cultural norms, as well as by entities such as community institutions, organizations, and businesses. Interaction of Technology and Humans concerns the ways society drives the improvement and creation of new technologies, and how technologies both serve and change society.

- **8.2.12.ITH.1**: Analyze a product to determine the impact that economic, political, social, and/or cultural factors have had on its design, including its design constraints.
- **8.2.12.ITH.2**: Propose an innovation to meet future demands supported by an analysis of the potential costs, benefits, trade-offs, and risks related to the use of the innovation.

UNIT PACING GUIDE			
Lesson/Investigation	**Learning Goal(s)**	**NGSS Performance Expectation(s)**	**Pacing**
Investigation #1: Modeling Motion	Students construct various models to represent the motion of macroscopic objects that obey Newton's laws.	**HS-PS2-1, HS-PS2-2, HS-PS2-4**	**10 days** (Plus, optional extension task(s) if time allows within the allotted 10-day window.)
Investigation #2: Forces	Students explore forces and how they affect the motion of objects.	**HS-PS2-1, HS-ESS2-1**	**13 days** (Plus, optional extension task(s) if time allows within the allotted 13-day window.)

LESSON #1 PACING GUIDE WITH EMBEDDED ASSESSMENTS

Suggested Instructional Days: (10)

Investigation #1: Modeling Motion

Students construct various models to represent the motion of macroscopic objects that obey Newton's laws. In this investigation, students explore the use of models to explain and understand motion. Each of the model types presented in the investigation is grounded in mathematical relationships: vectors drawn to scale to represent the magnitude and direction of velocity or acceleration, dot diagrams that show how displacement changes with time, and graphs of position, velocity, or acceleration.

NJSLS Specific to this Investigation/Lesson		
Performance Expectation	**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 & Engineering Practices	**Cross-Cutting Concepts**	**Disciplinary Core Ideas**
Analyzing and Interpreting Data	Cause and Effect	PS2.A: Forces and Motion
Performance Expectation	**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.	
Science & Engineering Practices	**Cross-Cutting Concepts**	**Disciplinary Core Ideas**
Using Mathematics and Computational Thinking	Systems and System Models	PS2.A: Forces and Motion
Performance Expectation	**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.	
Science & Engineering Practices	**Cross-Cutting Concepts**	**Disciplinary Core Ideas**
Using Mathematics and Computational Thinking	Patterns	PS2.B: Types of Interactions

Anchoring Phenomenon

How will we get to Mars?	**Explaining Phenomena** To understand the challenge of sending a rocket to Mars, students must understand motion, forces, and how forces affect objects. They must apply the concepts of velocity and acceleration. **Anchoring Phenomenon video** → How will we get to Mars? **Student Handbook** → Inquiry Launch, p. 2

Investigative Phenomenon

How did this rock move across the valley?	**Explaining Phenomena** Analyzing the motion of objects is essential to understanding all physical systems. In this investigation, students construct various models to represent the motion of macroscopic objects that obey Newton's laws. They define acceleration and explore mathematical methods to calculate instantaneous velocity and displacement when velocity is changing. **Investigative Phenomenon video** → How did this rock move across the valley? **Modeling Worksheet** Modeling Motion → Student Handbook p. 4-49

Learning Goal	Teacher Preparation	Instructional Sequence	Assessments
EXPERIENCE 1 (2.5 days) **Displacement and Velocity**	**Teacher's Guide** → p. 10 **Differentiation**	**ENGAGE** **Teachers' Guide:** **Everyday Phenomenon**	**Experience Assessment** **Student Handbook** → Revisit Investigative **Quiz:**

Students learn about the use of mathematical representations to model motion.	→ Review the versions of each lab; select the appropriate version(s) for each student/student group → See "Address Misconceptions" section of Teacher Guide; provides ideas to address common student preconceptions with tips and explanations. → See "Differentiated Instruction" section of Teacher Guide for advice and tips for special needs students → See "Remediation Suggestions" section of Teacher Guide; provides multiple suggestions for students struggling with specific concepts. → ⊕**Analyzing Data/** ⊕**Phet Simulation/** ⊕**Explain Video/** ⊕**Math Tutorial/**⊕**Writing About Science** These OPTIONAL activities can be personalized and assigned to enhance instruction, as time allows. **Connection to Anchoring Phenomenon** → Students apply the concepts of velocity and acceleration to construct a motion diagram for a mission to Mars and to design a solution to acclimate the astronauts to the acceleration due to gravity on Mars during the trip. **Connection to Investigative Phenomenon** → Students explain how different models might be used to analyze motion in various real-world systems, including the "sailing stones" of the Investigative Phenomenon.	→ Everyday Phenomenon, p. 10 **NOTE:** Introduce students to this investigation with the Investigative Phenomenon video. Its purpose is to provide students with another opportunity to interact with an engaging event and gather knowledge necessary to make sense of the Anchoring Phenomenon. **EXPLORE** **Inquiry Lab:** → Motion Plots ⊕ **PhET Simulation:** → Displacement and Velocity **EXPLAIN** **Claim-Evidence-Reasoning:** → Position vs. Time Graphs ⊕ **Explain Video:** → Velocity and Speed Are Different **Student Handbook:** → pgs. 6—20 **ELABORATE** **Discussion Rubric:** → Position vs. Time Graphs ⊕ **Writing About Science:** → Skills in Displacement and Velocity **EVALUATE** **Quiz:** → Displacement and Velocity	→ Displacement and Velocity **Investigation Assessment** **Performance-Based Assessment** → Speed, Acceleration, and Trajectory **Virtual Lab PBA** **Engineering Workbench** **Investigation Assessment** **NJSLA Released Item/Question(s) link:** → Using Newton's second law (F = ma), select the option that best completes the table to describe the relationships between force, mass, and acceleration of airplanes.
EXPERIENCE 2 (2.5 days) **Acceleration** Students explore methods to analyze motion when velocity is changing (acceleration).	**Teacher's Guide** → p. 17 **Differentiation** → Review the versions of each lab; select the appropriate version(s) for each student/student group → See "Address Misconceptions" section of Teacher Guide; provides ideas to address common student preconceptions with tips and explanations.	**ENGAGE** **Teachers' Guide:** **Everyday Phenomenon** → Everyday Phenomenon, p. 17 **NOTE:** Introduce students to this investigation with the Investigative Phenomenon video. Its purpose is to provide students with another opportunity to interact with an engaging event and gather knowledge necessary to make	**Experience Assessment** **Student Handbook** → Revisit Investigative **Quiz:** → Acceleration **Investigation Assessment** **Performance-Based Assessment** → Speed, Acceleration, and Trajectory **Virtual Lab PBA** **Engineering Workbench**

	→ See "Differentiated Instruction" section of Teacher Guide for advice and tips for special needs students → See "Remediation Suggestions" section of Teacher Guide; provides multiple suggestions for students struggling with specific concepts. → ⊕**Analyzing Data/** ⊕**Phet Simulation/** ⊕**Explain Video/** ⊕**Math Tutorial/**⊕**Writing About Science** These OPTIONAL activities can be personalized and assigned to enhance instruction, as time allows. **Connection to Anchoring Phenomenon** → Students apply the concepts of velocity and acceleration to construct a motion diagram for a mission to Mars and to design a solution to acclimate the astronauts to the acceleration due to gravity on Mars during the trip. **Connection to Investigative Phenomenon** → Students use a variety of mathematical representations to analyze constant acceleration.	sense of the Anchoring Phenomenon. **EXPLORE** **Inquiry Lab:** → Free Fall Acceleration ⊕ **Analyzing Data:** → Fast Cars ⊕ **PhET Simulation:** → Acceleration **EXPLAIN** **Student Handbook:** → pgs. 21—34 **Claim-Evidence-Reasoning:** → Acceleration on a Ramp ⊕ **Explain Video:** → Common Free-Fall Pitfalls ⊕ **Math Tutorial:** **ELABORATE** **Peer Review Rubric:** → Evaluate Acceleration on a Ramp ⊕ **Writing About Science:** → Skills in Acceleration **EVALUATE** **Quiz:** → Acceleration	**Investigation Assessment** **NJSLA Released Item/Question(s) link:** → According to Newton's second law (F = ma), which statement best explains why the pilot of the receiver aircraft must increase the throttle to keep up with the tanker aircraft?
EXPERIENCE 3 (3 days) **Circular and Projectile Motion** Students develop and use models to analyze common types of accelerated motion, including projectile motion and circular motion.	**Teacher's Guide** → p. 24 **Differentiation** → Review the versions of each lab; select the appropriate version(s) for each student/student group → See "Address Misconceptions" section of Teacher Guide; provides ideas to address common student preconceptions with tips and explanations. → See "Differentiated Instruction" section of Teacher Guide for advice and tips for special needs students → See "Remediation Suggestions" section of Teacher Guide; provides multiple suggestions for students struggling with specific concepts. → ⊕**Analyzing Data/** ⊕**Phet Simulation/** ⊕**Explain Video/** ⊕**Math Tutorial/**⊕**Writing About Science** These OPTIONAL activities	**ENGAGE** **Teachers' Guide:** **Everyday Phenomenon** → p. 24 **NOTE:** Introduce students to this investigation with the Investigative Phenomenon video. Its purpose is to provide students with another opportunity to interact with an engaging event and gather knowledge necessary to make sense of the Anchoring Phenomenon. **EXPLORE** **Inquiry Lab:** → Model Projectile Motion ⊕ **Analyzing Data:** → Satellites in Circular Orbits ⊕ **PhET Simulation:**	**Experience Assessment** **Student Handbook** → Revisit Investigative Phenomenon: **Quiz:** → Circular and Projectile Motion **Investigation Assessment** **Performance-Based Assessment** → Speed, Acceleration, and Trajectory **Virtual Lab PBA** **Engineering Workbench Investigation Assessment** **NJSLA Released Item/Question(s) link:** → The receiver aircraft has a mass of 110,000 kg and has an acceleration of 4.5 m/s2 prior to refueling in flight. The

	can be personalized and assigned to enhance instruction, as time allows. **Connection to Anchoring Phenomenon** → Students apply the concepts of velocity and acceleration to construct a motion diagram for a mission to Mars and to design a solution to acclimate the astronauts to the acceleration due to gravity on Mars during the trip. **Connection to Investigative Phenomenon** → Students use vector representations to explore motion in two or more dimensions.	→ Circular and Projectile Motion **EXPLAIN** **Student Handbook:** → pgs. 35—48 **Claim-Evidence-Reasoning:** → Horizontal Motion of Falling Objects ⊕ **Explain Video:** → Demonstrating the Components of Projectile Motion ⊕ **Math Tutorial** **ELABORATE** **Discussion Rubric:** → Horizontal Motion of Falling Objects ⊕ **Writing About Science:** → Skills in Circular and Projectile Motion **EVALUATE** **Quiz:** → Circular and Projectile Motion	receiver aircraft then receives 30,000 kg of fuel from the tanker aircraft. Using Newton's second law (F = ma), describe the change in acceleration after refueling. Complete the sentence by choosing the correct answers from the drop-down menus.
OPTIONAL Alternate Phenomena by Performance Expectation			
HS-PS2-1, HS-PS2-2, HS-PS2-4 Note: Optional extension task(s) if time allows within the allotted 10-day window.			

LESSON #2 PACING GUIDE WITH EMBEDDED ASSESSMENTS

Suggested Instructional Days: (13)

Investigation #2: Forces

Students explore forces and how they affect the motion of objects. In this investigation, students explore forces and how they affect the motion of objects. They examine the molecular-scale forces that underlie contact forces. They examine the relationship of forces and the geology and changes to Earth's surface.

NJSLS Specific to this Investigation/Lesson		
Performance Expectation	**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 & Engineering Practices	**Cross-Cutting Concepts**	**Disciplinary Core Ideas**
Analyzing and Interpreting Data	Cause and Effect	PS2.A: Forces and Motion
Performance Expectation	**HS-ESS2-1** Develop a model to illustrate how Earth's internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features.	
Science & Engineering Practices	**Cross-Cutting Concepts**	**Disciplinary Core Ideas**
Developing and Using Models	Stability and Change	ESS2.A: Earth Materials and Systems ESS2.B: Plate Tectonics and Large-Scale System Interactions

Anchoring Phenomenon

How will we get to Mars?	**Explaining Phenomena** To understand the challenge of sending a rocket to Mars, students must understand motion, forces, and how forces affect objects. They must apply the concepts of velocity and acceleration. **Anchoring Phenomenon video** → How will we get to Mars? **Student Handbook** → Inquiry Launch, p. 50

Investigative Phenomenon

What caused this rockslide?	**Explaining Phenomena** To fully understand the phenomenon of rockslides, students must understand the effects of balanced and unbalanced forces. **Investigative Phenomenon video** → What caused this rockslide? **CER Worksheet** → Forces

Learning Goal	Teacher Preparation	Instructional Sequence	Assessments
EXPERIENCE 1 (2.5 days) **Force, Mass, and Acceleration** Students are introduced to Newton's laws of motion and the concepts of inertia and momentum.	**Teacher's Guide** → p. 36 **Differentiation** → Review the versions of each lab; select the appropriate version(s) for each student/student group → See "Address Misconceptions" section of Teacher Guide; provides ideas to address common student preconceptions with tips and explanations.	**ENGAGE** **Teachers' Guide:** **Everyday Phenomenon** → Title, p. 36 **NOTE:** Introduce students to this investigation with the Investigative Phenomenon video. Its purpose is to provide students with another opportunity to interact with an engaging event and gather knowledge necessary to make sense of the Anchoring Phenomenon.	**Experience Assessment** **Student Handbook** → Revisit Investigative **Quiz:** → Force, Mass, and Acceleration **Investigation Assessment** **Performance-Based Assessment** → Force, Mass, and Acceleration

	→ See "Differentiated Instruction" section of Teacher Guide for advice and tips for special needs students → See "Remediation Suggestions" section of Teacher Guide; provides multiple suggestions for students struggling with specific concepts. → ⊕**Analyzing Data/** ⊕**Phet Simulation/** ⊕**Explain Video/** ⊕**Math Tutorial/**⊕**Writing About Science** These OPTIONAL activities can be personalized and assigned to enhance instruction, as time allows. **Connection to Anchoring Phenomenon** → Students identify the forces acting on a spacecraft at different points in a mission. They use these considerations to identify criteria for spacecraft materials. **Connection to Investigative Phenomenon** → Students explore the direction of motion and forces acting on the rock. They determine the direction of the sum of the forces.	**EXPLORE** **Inquiry Lab:** → Forces and Motion ⊕ **PhET Simulation:** → Force, Mass, and Acceleration **EXPLAIN** **Student Handbook:** → pgs. 52-64 **Claim-Evidence-Reasoning:** → Force, Mass, and Acceleration in Action ⊕ **Explain Video:** → Newton's Third Law of Motion ⊕ **Math Tutorial** **ELABORATE** **Discussion Rubric:** → Force, Mass, and Acceleration in Action ⊕ **Writing About Science:** → Skills in Force, Mass, and Acceleration **EVALUATE** **Quiz:** → Force, Mass, and Acceleration	**Virtual Lab PBA** **Engineering Workbench Investigation Assessment** **NJSLA Released Item/Question(s) link:** → Using Newton's second law (F = ma), describe the relationships between force, mass, and acceleration of airplanes. Type your answer in the box provided.
EXPERIENCE 2 (2.5 days) **Types of Forces** Students explore different types of forces, including spring, tension, surface, and centripetal forces.	**Teacher's Guide** → p. 42 **Differentiation** → Review the versions of each lab; select the appropriate version(s) for each student/student group → See "Address Misconceptions" section of Teacher Guide; provides ideas to address common student preconceptions with tips and explanations. → See "Differentiated Instruction" section of Teacher Guide for advice and tips for special needs students → See "Remediation Suggestions" section of Teacher Guide; provides multiple suggestions for students struggling with specific concepts. → ⊕**Analyzing Data/** ⊕**Phet Simulation/** ⊕**Explain Video/** ⊕**Math Tutorial/**⊕**Writing About Science** These OPTIONAL activities	**ENGAGE** **Teachers' Guide:** **Everyday Phenomenon** → Title, p. 42 **NOTE:** Introduce students to this investigation with the Investigative Phenomenon video. Its purpose is to provide students with another opportunity to interact with an engaging event and gather knowledge necessary to make sense of the Anchoring Phenomenon. **EXPLORE** **Inquiry Lab:** → The Buoyant Force ⊕ **Analyzing Data:** → Vehicle Stopping Distance ⊕ **PhET Simulation:** → Types of Forces **EXPLAIN** **Student Handbook:** → pgs. 65-78	**Experience Assessment** **Student Handbook** → Revisit Investigative **Quiz:** → Types of Forces **Investigation Assessment** **Performance-Based Assessment** → Force, Mass, and Acceleration **Virtual Lab PBA** **Engineering Workbench Investigation Assessment** **NJSLA Released Item/Question(s) link:** → Which question is best addressed by analyzing the data?

	can be personalized and assigned to enhance instruction, as time allows. **Connection to Anchoring Phenomenon** → Students identify the forces acting on a spacecraft at different points in a mission. They use these considerations to identify criteria for spacecraft materials. **Connection to Investigative Phenomenon** → Students explain what changed in the environment to lead to a net force on the rock.	**Modeling:** → Pinball Launcher Model ⊕ **Explain Video:** → Introduction to Static and Kinetic Friction ⊕ **Math Tutorial** **ELABORATE** **Peer Review Rubric:** → Evaluate Pinball Launcher Model ⊕ **Writing About Science:** → Skills in Types of Forces **EVALUATE** **Quiz:** → Types of Forces	
EXPERIENCE 3 (3 days) **Forces on Systems** Students distinguish internal and external forces in systems and investigate forces applied at different locations in a system.	**Teacher's Guide** → p. 48 **Differentiation** → Review the versions of each lab; select the appropriate version(s) for each student/student group → See "Address Misconceptions" section of Teacher Guide; provides ideas to address common student preconceptions with tips and explanations. → See "Differentiated Instruction" section of Teacher Guide for advice and tips for special needs students → See "Remediation Suggestions" section of Teacher Guide; provides multiple suggestions for students struggling with specific concepts. → ⊕Analyzing Data/ ⊕Phet Simulation/ ⊕Explain Video/ ⊕Math Tutorial/⊕Writing About Science These OPTIONAL activities can be personalized and assigned to enhance instruction, as time allows. **Connection to Anchoring Phenomenon** → Students identify the forces acting on a spacecraft at different points in a mission. They use these considerations to identify criteria for spacecraft materials. **Connection to Investigative Phenomenon**	**ENGAGE** **Teachers' Guide:** **Everyday Phenomenon** → p. 48 **NOTE:** Introduce students to this investigation with the Investigative Phenomenon video. Its purpose is to provide students with another opportunity to interact with an engaging event and gather knowledge necessary to make sense of the Anchoring Phenomenon. **EXPLORE** **Inquiry Lab:** → Friction ⊕ **PhET Simulation:** → Simulation Forces on Systems **EXPLAIN** **Student Handbook:** → pgs. 79-94 **Modeling:** → Atmospheric Pressure on a Sealed Container ⊕ **Explain Video:** → What Forces Are Acting on You? ⊕ **Math Tutorial** **ELABORATE** **Peer Review Rubric:** → Evaluate Atmospheric Pressure on a Sealed Container ⊕ **Writing About Science:** → Skills in Forces on Systems	**Experience Assessment** **Student Handbook** → Revisit Investigative **Quiz:** → Forces on Systems **Investigation Assessment** **Performance-Based Assessment** → Force, Mass, and Acceleration **Virtual Lab PBA** **Engineering Workbench Investigation Assessment** **NJSLA Released Item/Question(s) link:** → Which statements are best supported by the data? Select two of the six statements.

	→ Students construct a model of the forces acting on a rock on a steep hill. They consider the effects on stability from both torques and from the components of the surface force.	**EVALUATE** **Quiz:** → Forces on Systems	
EXPERIENCE 4 (3 days) **Earth's Surface Forces** Students explore the applications of force and Newton's laws in geology.	**Teacher's Guide** → p. 54 **Differentiation** → Review the versions of each lab; select the appropriate version(s) for each student/student group → See "Address Misconceptions" section of Teacher Guide; provides ideas to address common student preconceptions with tips and explanations. → See "Differentiated Instruction" section of Teacher Guide for advice and tips for special needs students → See "Remediation Suggestions" section of Teacher Guide; provides multiple suggestions for students struggling with specific concepts. → ⊕Analyzing Data/ ⊕Phet Simulation/ ⊕Explain Video/ ⊕Math Tutorial/⊕Writing About Science These OPTIONAL activities can be personalized and assigned to enhance instruction, as time allows. **Connection to Anchoring Phenomenon** → Students identify the forces acting on a spacecraft at different points in a mission. They use these considerations to identify criteria for spacecraft materials. **Connection to Investigative Phenomenon** → Students choose and explain one way that human activities can affect the likelihood of a rockslide occurring.	**ENGAGE** **Teachers' Guide:** **Everyday Phenomenon** → p. 54 **NOTE:** Introduce students to this investigation with the Investigative Phenomenon video. Its purpose is to provide students with another opportunity to interact with an engaging event and gather knowledge necessary to make sense of the Anchoring Phenomenon. **EXPLORE** **Inquiry Lab:** → Mechanical Weathering of Rock ⊕ **Analyzing Data:** → Topography ⊕ **PhET Simulation:** → Earth's Surface Forces **EXPLAIN** **Student Handbook:** → pgs. ## **Claim-Evidence-Reasoning:** → Title ⊕ **Explain Video:** → Title ⊕ **Math Tutorial** **ELABORATE** **Peer Review Rubric:** → Evaluate Mountain Building ⊕ **Writing About Science:** → Skills in Earth's Surface Forces **EVALUATE** **Quiz:** → Earth's Surface Forces	**Experience Assessment** **Student Handbook** → Revisit Investigative **Quiz:** → Earth's Surface Forces **Investigation Assessment** **Performance-Based Assessment** → Force, Mass, and Acceleration **Virtual Lab PBA** **Engineering Workbench Investigation Assessment** **NJSLA Released Item/Question(s) link:** → Based on Figure 1, which statement best summarizes the pattern of sunspot activity over the past 2,000 years?
OPTIONAL Alternate Phenomena by Performance Expectation			
HS-PS2-1, HS-ESS2-1 Note: Optional extension task(s) if time allows within the allotted 13-day window.			