Englewood Public School District
Science
Physics
Second Marking Period

Unit 2: Gravitation, Rotational Motion, Momentum and Energy Conservation

Overview: In this unit of study, students are expected to *plan and conduct investigations*, *analyze data and using math to support claims*, and *apply scientific ideas to solve design problems* students in order to make sense of Newton's law of gravitation. They apply these laws to describe and predict the gravitational forces between objects. Energy is understood as a quantitative property of a system that depends on the motion and interactions of matter, and the total change of energy in any system is equal to the total energy transferred into and out of the system. Students also demonstrate their understanding of engineering principles when they design, build, and refine devices associated with the conversion of energy and develop an understanding that the total momentum of a system of objects is conserved when there is no net force on the system. Students are also able to apply science and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision. The crosscutting concepts of *patterns*, *cause and effect*, and *systems and systems models* are called out as organizing concepts for these disciplinary core ideas. Students are expected to demonstrate proficiency in *planning and conducting investigations*, *analyzing data and using math to support claims*, and *applying scientific ideas to solve design problems* and to use these practices to demonstrate understanding of the core ideas.

Time Frame: 40 to 45 days

Enduring Understandings:
Newton's Law of Universal Gravitation provides the 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.
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 is conserved.
Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system.
At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy.
Energy cannot be created or destroyed. It only moves between one place and another place, between objects and/or fields, or between systems.

Essential Questions:
How can one explain and predict interactions between objects and within systems of objects?
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 can a piece of space debris the size of a pencil eraser destroy the International Space Station?
How is energy transferred and conserved?

Standards	Topics and Objectives	Activities	Resources	Assessments
(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-ESS1-4)** **Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.** **(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-PS2-3)** **Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.** **(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 motions**	**Topics** Gravitation Rotational Motion Momentum Work Energy Twenty-First Century Themes and Skills include: • The Four C's • Life and Career Skills • Information and Media literacy **Objectives** Students will: Use mathematical representations of phenomena to describe or explain how gravitational force is proportional to mass and inversely proportional to distance squared. Demonstrate how Newton's Law of Universal Gravitation provides explanations for observed scientific phenomena. Use mathematical or computational representations to predict the motion of	Students will complete hands on activities and labs for the following topics: 1. Circular motion 2. Momentum and collision 3. Mechanical energy conservation Students will complete Chapter Launch Labs (see pgs. 171, 197, 229, 257, and 285) to introduce concepts. Students will visualize the gravitational force that two objects exert on each other in the Gravity Force Lab simulation and complete a Lab Sheet. (N-Q.A.1, HS-PS2-3) Students will understand Kepler's laws of motion plus the effects of velocity and force on a satellites' orbit in the Planetary Orbits Lab simulation. (A-CED.A.2, NJSLSA.R8, HS-PS2-2) Students will create their own planetary orbits in the My Solar System simulation. (MP.2, HS-PS3-2, HS-ESS1-4) Students will learn about conservation of energy in the Energy Skate Park: Basics, Energy in a Roller Coaster	**Text:** Glencoe Science: Physics Principals and Problems **Materials:** For Circular Motion Labs • Circular Motion Kit For Mechanical energy conservation lab • Mechanical Energy Conservation Kit For Momentum and Collision Labs • Momentum and collision Laws Kit For Chapter Launch Labs (see pgs. 171, 197, 229, 257, 285) • Protractor • Metric ruler • Objects that roll • Meter stick • Foam or wood board • One hollow plastic ball with cut outs in one hemisphere • One bocce ball • Pie plate • Fine sand • Metal balls or glass marbles of varied sizes • Basketball • Graph paper **Websites:** • Gravity Force Lab • Planetary Orbits Lab	**Formative Assessments:** • Student prior knowledge will be evaluated after completing the *Launch Labs* • Student portfolios will be used to monitor progress • Response Logs • Discussion **Summative Assessments:** • Projects • Written Essays • Simulations • Students will receive a grade for completed lab reports generated in the scientific lab notebook. • Student needs will be assessed after completion of online simulations **Benchmark Assessment:** A Common Formative Assessment will be given at the close of this unit to assess students' mastery of the skills identified. **Alternative Assessments:** • Visual Representations • Questioning • Charts

of particles (objects) and energy associated with the relative position of particles (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-PS3-3)** **Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.** **(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 tradeoffs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.**	orbiting objects in the solar system. 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. Use mathematical representations of the quantitative conservation of momentum and the qualitative meaning of this principle in systems of two macroscopic bodies moving in one dimension. Use qualitative evaluations and /or algebraic manipulations to design and refine a device that minimizes the force on a macroscopic object during a collision. Develop and use models based on evidence to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with motions of particles (objects) and energy associated with the relative position of particles (objects). Develop and use models based on evidence to illustrate that energy cannot be created or destroyed. It only moves	Ride, and Collison Lab simulation. (A-SSE.A.1, HS-PS3-1) Students will watch the videos, How to Think About Gravity, Gravity and the Human Body, and How Does Work…Work? and complete an online post viewing quiz. (HS-PS2-4) Students will review concepts by watching the videos Roller Coaster Physics and Rotational Inertia and Torque. (8.2.12.C.4, NJSLSA.R9) Students will construct and measure the energy efficiency and solar heat gain of a cardboard model house in the simulation Build a Solar House. (A-SSE.B.3, A-CED.A.1, HS-ETS1-2, N-Q.A.2, MP.4, HS-ETS1-3, HS-ETS1-2,HS-PS3-3) **Enrichment Activities:** Student will complete additional textbook Mini Labs. (CRP4) Students use a series of 31 images of Jupiter's 4 Galilean moons to find their orbit periods and orbit radii in the Period of Jupiter's moons activity. (A-CED.A.4, N-Q.A.3 NJSLSA.W7, HS-	• My Solar System • Energy Skate Park: Basics • Energy in a Roller Coaster Ride • Collison Lab • Build a Solar House **Videos:** • How to Think About Gravity • Gravity and the Human Body • How Does Work…Work? • Roller Coaster Physics • Rotational Inertia and Torque **Enrichment Lesson Plans:** See textbook Mini Labs and Period of Jupiter's moons activity	• Data Tables • Models • Peer Assessments • Graphic Organizers • Students will use mathematical or computational representations to predict the motion of orbiting objects in the solar system. • Students will use mathematical and computational representations of Newtonian gravitational laws governing orbital motion that apply to moons and human-made satellites. • Students will use algebraic thinking to examine scientific data and predict the motion of orbiting objects in the solar system.

(HS-ETS1-3) **Evaluate a solution to a complex real-world problem based on prioritized criteria and tradeoffs 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**.	between one place and another place, between objects and/or fields, or between systems. Use mathematical expressions to quantify how the stored energy in a system depends on its configuration (e.g., relative positions of charged particles, compressions of a spring) and how kinetic energy depends on mass and speed. Use mathematical expressions and the concept of conservation of energy to predict and describe system behavior. Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.	ETS1-4, 8.2.12.C.4, 6.1.12.C.3.a)

Accommodations and Modifications:

Students with special needs: Support staff will be available to aid students related to IEP specifications. 504 accommodations will also be attended to by all instructional leaders. Physical expectations and modifications, alternative assessments, and scaffolding strategies will be used to support this learning. The use of Universal Design for Learning (UDL) will be considered for all students as teaching strategies are considered.

ELL/ESL students: Students will be supported according to the recommendations for “can do’s” as outlined by WIDA –

https://www.wida.us/standards/CAN_DOs/. This particular unit has limited language barriers due to the physical nature of the curriculum.

Students at risk of school failure: Formative and summative data will be used to monitor student success at first signs of failure student work will be reviewed to determine support. This may include parent consultation, basic skills review and differentiation strategies. With considerations to UDL, time may be a factor in overcoming developmental considerations. More time and will be made available with a certified instructor to aid students in reaching the standards.

Gifted and Talented Students: Students excelling in mastery of standards will be challenged with complex, high level challenges related to the complexity in planning and carrying out investigations and analyzing and interpreting data.

English Language Learners	Special Education	At-Risk	Gifted and Talented
● Provide ELL students with multiple literacy strategies. ● Speak and display terminology ● Teacher modeling ● Peer modeling ● Word walls ● Use peer readers ● Give page numbers to help the students find answers ● Provide a computer for written work ● Provide two sets of textbooks, one for home and one for school ● Provide visual aides ● Provide additional time to complete a task ● Use graphic organizers	● Use multi-sensory teaching approaches. ● Utilize modifications & accommodations delineated in the student's IEP ● Work with paraprofessional ● Work with a partner ● Provide concrete examples ● Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA). ● Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).	● Using visual demonstrations, illustrations, and models ● Give directions/instructions verbally and in simple written format. Oral prompts can be given. ● Peer Support ● Increase one on one time ● Teachers may modify instructions by modeling what the student is expected to do ● Instructions may be printed out in large print and hung up for the student to see during the time of the lesson. ● Review behavior expectations and make adjustments for personal space or other behaviors as needed.	● Increase the pace of lessons ● Inquiry-based instruction ● Independent study ● Higher order thinking skills ● Interest based content ● Real world scenarios ● Student Driven Instruction ● Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings. ● Use project-based science learning to connect science with observable phenomena. ● Structure the learning around explaining or solving a social or community-based issue. ● Collaborate with after-school programs or clubs to extend learning opportunities.

		• Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community. • Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies).	

Interdisciplinary Connections:

ELA-NJSLS/ELA:
NJSLSA.R8: Delineate and evaluate the argument and specific claims in a text, including the validity of the reasoning as well as the relevance and sufficiency of the evidence. RST.11-12.8 (HS-ETS1-3)
NJSLSA.R9: Analyze and reflect on how two or more texts address similar themes or topics in order to build knowledge or to compare the approaches the authors take. RST.11-12.9 (HS-ETS1-3)
NJSLSA.W7: Conduct short as well as more sustained research projects, utilizing an inquiry-based research process, based on focused questions, demonstrating understanding of the subject under investigation. WHST.11-12.7 (HS-PS2-3),(HS-ETS1-3)

Mathematics:
MP.2: Reason abstractly and quantitatively. (HS-PS2-2), (HS-PS2-4), (HS-ETS1-1),(HS-ETS1-3), (HS-ESS1-4)
MP.4: Model with mathematics. (HS-PS2-2), (HS-PS2-4), (HS-ETS1-2),(HS-ETS1-3), (HS-ESS1-4)
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. (HS-PS2-2), (HS-PS2-4), (HS-ESS1-4)
N-Q.A.2: Define appropriate quantities for the purpose of descriptive modeling. (HS-PS2-2), (HS-PS2-4), (HS-ESS1-4)
N-Q.A.3: Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS2-2), (HS-PS2-4), (HS-ESS1-4)
A-CED.A.1: Create equations and inequalities in one variable and use them to solve problems. (HS-PS2-2)
A-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-PS2-2), (HS-ESS1-4)

A-CED.A.4: Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. (HS-PS2-2), (HS-ESS1-4)
A-SSE.A.1: Interpret expressions that represent a quantity in terms of its context. (HS-PS2-4), (HS-ESS1-4)
A-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-PS2-4)

Career Ready Practices:
CRP4: Communicate clearly and effectively and with reason.

Social Studies:
6.1.12.C.3.a: Analyze how technological developments transformed the economy, created international markets, and affected the environment in New Jersey and the nation.

Integration of Technology Standards NJSLS 8:
8.2.12.C.4: Explain and identify interdependent systems and their functions.

Integration of 21st Century Skills:
9.3.ST-ET.2: Display and communicate STEM information.
9.3.ST.2: Use technology to acquire, manipulate, analyze and report data.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Using Mathematics and Computational Thinking Mathematical and computational thinking at the 9–12 level builds on K–8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Use mathematical representations of phenomena to describe explanations. (HS-PS2-4)	**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. (HS-PS2-4) • 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. (HS-PS2-4)	**Patterns** • 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 phenomena. (HS-PS2-4) - ***Connections to Nature of Science*** **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)