Course: *Physics* **Unit #2:** Forces	**Year of Implementation:** 2023-2024

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Stage One - Desired Results

Link(s) to New Jersey Student Learning Standards for this course:
https://www.state.nj.us/education/cccs/2020/
https://www.state.nj.us/education/cccs/2020/2020%20NJSLS-CLKS.pdf
https://www.nj.gov/education/standards/ela/Docs/2016NJSLS-ELA_Companion9-10.pdf
https://www.nj.gov/education/standards/ela/Docs/2016NJSLS-ELA_Companion11-12.pdf

- **Unit Standards:**
  - ***Content Standards***
    - 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-PS2-3 - Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.
    - HS-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.
  - ***21st Century Life & Career Standards***
    - 9.4.12.CI.1 - Demonstrate the ability to reflect, analyze and use creative skills and ideas
    - 9.4.12.IML.3 - Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions.
  - ***English Companion Standards***

- 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.
- WHST.9-10.2 - Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.
- 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
- WHST.9-10.9 - Draw evidence from informational texts to support analysis, reflection, and research

- ***Interdisciplinary Content Standards***
  - MP.2 - Reason abstractly and quantitatively.
  - MP.4 - Model with mathematics.
  - 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.
  - HSN-Q.A.2 - Define appropriate quantities for the purpose of descriptive modeling.
  - HSN-Q.A.3 - Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
  - HSA-SSE.A.4 - Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.

- ***NJ Statutes:*** NJ State law mandates the inclusion of the following topics in lesson design and instruction as aligned to elementary and secondary curriculum.

  Amistad Law: N.J.S.A. 18A 52:16A-88 Every board of education shall incorporate the information regarding the contributions of African-Americans to our country in an appropriate place in the curriculum of elementary and secondary school students.

  Holocaust Law: N.J.S.A. 18A:35-28 Every board of education shall include instruction on the Holocaust and genocides in an appropriate place in the curriculum of all elementary and secondary school pupils. The instruction

shall further emphasize the personal responsibility that each citizen bears to fight racism and hatred whenever and wherever it happens.

LGBT and Disabilities Law: N.J.S.A. 18A:35-4.35 A board of education shall include instruction on the political, economic, and social contributions of persons with disabilities and lesbian, gay, bisexual, and transgender people, in an appropriate place in the curriculum of middle school and high school students as part of the district's implementation of the New Jersey Student Learning Standards (N.J.S.A.18A:35-4.36) A board of education shall have policies and procedures in place pertaining to the selection of instructional materials to implement the requirements of N.J.S.A. 18A:35-4.35.

Diversity and Inclusion (N.J.S.A. 18A:35-4.36a) A board of education shall incorporate instruction on diversity and inclusion in an appropriate place in the curriculum of students in grades kindergarten through 12 as part of the district's implementation of the New Jersey Student Learning Standards.

Asian American and Pacific Islanders (AAPI) P.L.2021, c.410 Ensures that the contributions, history, and heritage of Asian Americans and Pacific Islanders (AAPI) are included in the New Jersey Student Learning Standards (NJSLS) for Social Studies in kindergarten through Grade 12 (P.L.2021, c.416)

For additional information, see

NJ Amistad Curriculum: http://www.njamistadcurriculum.net/

Diversity and Inclusion: https://www.nj.gov/education/standards/dei/index.shtml

- *(Sample Activities/ Lessons): https://www.nj.gov/education/standards/dei/samples/index.shtml*

Asian American and Pacific Islanders:

- *Asian American and Pacific Islander Heritage and History in the U.S.*
  A Teacher's Guide from EDSITEment offering a collection of lessons and resources for K-12 social studies, literature and arts classrooms that center around the experiences, achievements and perspectives of Asian Americans and Pacific Islanders across U.S. history.

Transfer Goal: Students will be able to independently use their learning to employ mathematical, computational, and logical thinking to analyze the various interactions between and within systems in order to predict and describe the resulting motion.

As aligned with LRHSD Long Term Learning Goal(s):

Students will be better able to:

- design, critique, and carry out experiments in order to investigate scientific questions and/or propose solutions.
- collect, interpret, and analyze data in order to solve a defined problem.
- apply mathematics to express relationships efficiently and accurately.
- draw evidence-based conclusions from data in order to make informed decisions.
- construct, interpret, and refine models (scientific and mathematical) to explain the physical and natural world.
- effectively communicate scientific ideas and evidence-based arguments to an appropriate audience through written and oral means.

Enduring Understandings	*Essential Questions*
Students will understand that. . . *EU 1* a net force will change the velocity of an object.	*EU 1* ● What causes an object to move? ● Why do objects slow down or speed up? ● How much force is necessary for an object to stay in motion? ● What are the most important considerations for a highway engineer when designing a circular exit ramp? ● Which factor is most important in ensuring that a person is not pulled out of a loop-the-loop roller coaster when not wearing a safety harness? ● How significant is the gravitational pull of the sun, earth and moon on an object?

EU 2 the total momentum of an isolated system of objects is always conserved.	*EU 2* ● What is the best way to make a car safe during a collision? ● How can one best change the momentum of an object? ● Why is momentum conserved in some situations but not others? ● How does conservation of momentum affect velocities of objects during a collision?
<u>Knowledge</u> *Students will know . . .* *EU 1* ● an object's inertia is determined by its mass. ● inertia is the tendency of an object to maintain its state of motion. ● weight is the gravitational force on an object and differs from its mass. (PS2.B) ● an object at rest will stay at rest and an object in motion will stay in motion in a straight line at constant speed unless acted upon by a net force (Newton's First Law). ● net forces cause acceleration. (PS2.A) ● that the acceleration of an object is proportional to the net force on it and is inversely proportional to the object's mass (Newton's Second Law). (PS2.A) ● all forces exist in pairs.	*<u>Skills</u>* *Students will be able to. . .* *EU 1* ● determine whether or not an object or system of objects is in equilibrium. ● calculate the frictional force acting on an object. (SEP5) ● compute the weight of an object. (SEP5) ● determine the static or kinetic friction force acting on an object. (SEP5) ● interpret and construct free-body diagrams to analyze an object's state of motion. (SEP2) ● analyze data to support the mathematical relationship between the net force that acts on an object, its mass, and the resulting acceleration. (SEP4) ● plan and carry out an investigation that determines the centripetal acceleration experienced by an object in

● a free body diagram is a model that represents all of the forces that act on an object. ● that the normal force determines apparent weight. (PS2.B) ● that in order for an object to move along a circular path at constant speed, there must be a centripetal force present which points to the center of the circle. ● the velocity of an object moving along a circular path always acts tangent to the circle. ● an object moving at constant speed along a circle is still accelerating. ● all objects in the universe attract one another. (PS2.B) ● that the gravitational force between two masses is inversely proportional to the square of the distance between their centers. (PS2.B) ● that gravity is a weak force and only large masses can produce an observable gravitational force. (PS2.B) *EU 2* ● that when one object exerts a force on another object, the second object exerts an equal force back on the first object (Newton's Third Law). ● momentum is the product of an object's mass and its velocity. (PS2.A) ● momentum is a vector quantity that has both magnitude and direction. (PS2.A) ● the total momentum of an isolated system is always conserved. (PS2.A) ● that impulse is the product of force and time. (PS2.A)	uniform circular motion (centrifuge, roller-coaster, mass on a string). (SEP3) ● use computational thinking and mathematics to determine if a vehicle will be able to safely navigate a curve. (SEP5) ● use mathematical representations of Newton's Law of Gravitation to describe and predict the gravitational force between objects. (SEP5) ● apply a mathematical model to solve for the acceleration due to gravity on or near other planets, moons, and stars. (SEP2) ● develop a model that relates the path of a satellite in a circular orbit to its velocity. (SEP2) ● analyze and interpret data that confirms the relationship between the radius of a satellite's orbit and its orbital velocity. (SEP4) *EU 2* ● identify the action/reaction (force) pairs that occur in a collision. ● construct an explanation that supports the assertion that both objects in a collision experience the same impulse and change in momentum. (SEP6) ● define the boundaries and initial conditions of a system. ● develop a model to account for momentum of a system of objects both before and after a collision. (SEP2) ● 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 object. (SEP5)

● that impulse is equivalent to the change in momentum that the object experiences (the Impulse-Momentum Theorem). (PS2.A) ● that extending the time for a collision will reduce the force of impact. (PS2.A) ● an isolated system is one in which no external forces act. (PS2.A) ● that conserved quantities in physics are those that do not change. (PS2.A) ● that in an elastic collision, no energy is lost. (PS2.A) ● objects experiencing inelastic collisions will lose some energy during the interaction. (PS2.A)	● apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on an object during a collision. (SEP6)
Stage Two - Assessment	

Stage Three - Instruction

Learning Plan: **Suggested Learning Activities to Include Differentiated Instruction and Interdisciplinary Connections: Each learning activity listed must be accompanied by a learning goal of A= Acquiring basic knowledge and skills, M= Making meaning and/or a T= Transfer.** *The following color codes are used to notate activities that correspond with interdisciplinary connections and 21st Century Life & Career Connections (which involves Technology Literacy): Red = Interdisciplinary Connection; Purple = 21st Century Life & Career Connection*

PHENOMENON 1: Tablecloth pull demo (A/M, EU1)
Goal: Students will be able to identify Newton's first law of motion and apply the concept of inertia.

1. Student Inertia Demos (T, EU1)
    a. Students will perform the penny in the cup challenge.(A/M, EU1)
        i. Students must remove an index card (that has a penny on top of it) from the top of a cup to get the penny in the cup below; the restriction is that they cannot lift the card or touch the penny. (A, EU1)
        ii. Discuss strategies that students discovered and used to successfully complete the challenge. (A, EU1)
2. Show students the tablecloth pull demo. (A/M, EU1)
    a. Discussion on observations and outcomes of the demo. (A/M, EU 1). Possible guiding questions:
        i. What happens if you pull the cloth quickly? Why?
        ii. What happens if you pull the cloth slowly? Why?
        iii. What do expect to happen if the objects are more massive?
        iv. What is the relationship between mass and inertia based on your observations?
    b. Analyze the interactions, including why the tablecloth moves, why the objects on top might move, and other possible interactions (M, EU1)
3. Reflect back on projectile motion: Have students answer the question "How does inertia relate to an object's motion?" (M/T, EU1)
4. Discuss: Students should make the connection between the demo and the concept of inertia to our daily lives by answering the following question: "Are there any examples you can think of in which it might APPEAR that the Law of Inertia seems to NOT be true?" (ex: rolling soccer ball comes to a stop on it's own). (M, EU1)

PHENOMENON 2: Force demonstrations on the ISS **https://www.youtube.com/watch?v=KvPF0cQUW7s** (A/M, EU 1)
Goal: Students will be able to make the connection that a net force causes a change in motion.

1. Show students video, see link above (A, EU1)

2. Discussion: How are forces experienced in everyday life? (A, EU1)
3. Teacher-led discussion regarding mass vs. weight and apparent weightlessness. Ask questions such as "How does your weight change when riding in an elevator?" (A/M, EU1)
4. Students should use the mathematical equation for weight to calculate how the weight of an object will change on different planets. (M, EU1)
5. Teacher-led steps regarding the process of finding the net force on an object and calculating the object's acceleration due to that net force. (A, EU1)
6. Friction demonstration on horizontal planes with teacher-led questions (A/M, EU1)
    - Ex: Slide a book across a lab table. Once you have let go of the book, why does the book come to rest? If the same push was applied but the book was on an icy surface, what could be different? Why?
7. Students will create free-body diagrams based on different situations and utilize the necessary equations to solve for quantities such as the acceleration and friction on objects. (M, EU1)
8. Lab: Friction on horizontal planes. (T, EU1)

PHENOMENON 3: The Earth orbits the Sun in a nearly circular path but does not fall into it.
Goal: Students will be able to describe the forces on an object traveling in a circular path and how the acceleration is similar and different to straight-line acceleration.

1. Discussion: How do we keep an object in a circular path? (A, EU1)
2. Teacher-led steps in finding tangential velocity, centripetal acceleration and centripetal force. (A, EU1)
3. Practice problems. Students will calculate quantities such tangential velocity, centripetal acceleration and centripetal force. (M, EU1)
4. Activity: "Keep the ball in a circle" Students will place a circle on the ground and figure out how to keep the ball following that circular path as it enters the circle traveling in a straight line. (T, EU1)
5. Lab - "Stopper on a string" (M, EU1)
6. Discussion: Why doesn't the Earth fall into the Sun as it revolves around it? (M, EU1)
7. Think, Pair, Share: How can an automobile safely navigate a curve? (A/M, EU1)

PHENOMENON 4: Car Crash Video/DVD - "Understanding Car Crashes: It's Basic Physics." (A/M, EU1,2)
Goal: Students will be able to make connections between forces and momentum by analyzing a car crash and developing ideas that would make cars safer on occupants within the vehicle.

1. Show students the video "Understanding Car Crashes." (A, EU1,2)
2. Student-led discussions concerning what they observed. (A/M, EU1,2)
    - Possible questions to guide student thinking and refer back to during subsequent lessons:
        - What happened to the car?
        - What happened to the crash dummies?

- Are there any other general observations you made?
- What might have caused the outcome of what you observed?
- What could be done to have greater safety during a car crash?

3. Demo: Newton's Cradle - introduce the concept of momentum and connect to Newton's three laws of motion. (A/M, EU1,2)
4. Demo: PASCO track dynamic cars colliding and teacher demonstrated types of collisions. (A, EU2)
5. Discussion: Students should develop a list, give examples of, and explain everyday collisions. (M, EU2)
    - Some examples could include a relationship to sports (ex: tennis ball colliding with a racquet, two football players colliding, etc), air molecules, a bug colliding with a windshield, bumper cars, etc.
6. Students will apply equations involving force, impulse, and conservation of momentum to solve 1-dimensional collision problems. (M, EU1,2)
7. Activity: PASCO track dynamic car collisions - students will develop a lab illustrating 1-dimensional collisions and conservation of momentum. (T, EU1,2)

Pacing Guide

Unit #	*Title of Unit*	*Approximate # of teaching days*
1	Kinematics	40
2	Newton’s Laws & Forces	40
3	Energy	30
4	Electricity and Magnetism	40
5	Waves	30

Instructional Materials

A fully equipped physics lab

Accommodations

Special Education: The curriculum will be modified as per the Individualized Education Plan (IEP). Students will be accommodated based on specific accommodations listed in the IEP.
Students with 504 Plans: Students will be accommodated based on specific accommodations listed in the 504 Plan.
English Language Learners: Students will be accommodated based on individual need and in consultation with the ELL teacher.
Students at Risk of School Failure: Students will be accommodated based on individual need and provided various structural supports through their school.
Gifted and Talented Students: Students will be challenged to enhance their knowledge and skills through acceleration and additional independent research on the subject matter.