Wall Township Public Schools	Board Approval Date:

Course Title: AP Physics 1

Course Description:
The AP Physics 1 course is designed to help students develop a deep understanding of the foundational principles that shape classical mechanics. By confronting complex physical situations or scenarios, the course is designed to enable students to develop the ability to reason about physical phenomena using important science practices, such as explaining relationships, applying and justifying the use of mathematical routines, designing experiments, analyzing data, and making connections across multiple topics within the course.

New Jersey Student Learning Standards - Science (Click here to skip below to a description about the Standards)

Course Sequence & Pacing

Unit Title	Estimated Number of Instructional Periods
Unit 1: Kinematics	13
Unit 2: Force and Translational Dynamics	20
Unit 3: Work, Energy, and Power	20
Unit 4: Linear Momentum	9

Unit 5: Torque and Rotational Dynamics	11
Unit 6: Rotational Energy and Momentum	7
Unit 7: Oscillations	5
Unit 8: Fluids	10
Unit 9: Review for the AP Exam	16
Unit 10: Utilizing our Physics Skills	11

Unit 1: Kinematics

Stage 1 Desired Results

Unit 1: Kinematics

Unit Summary: The world is made up of objects that are in a constant state of motion. To understand the relationships between objects, students must first understand movement. Unit 1 introduces students to the study of motion and serves as a foundation for all of AP Physics 1 by exploring the idea of acceleration and showing students how representations can be used to model and analyze scientific information as it relates to the motion of objects.

Unit 1 Learning Standards / Targets

NJSLS Science (PE):

- **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.

Unit Enduring Understandings:	**Unit Essential Questions:**

• Different observations occur because two observers are in different frames of reference. A frame of reference is a set of coordinates that can be used to determine positions and velocities of objects in that frame; different frames of reference move relative to one another. • Using kinematic equations, calculate the height of a building when given the time it takes an object to hit the ground measured by a stopwatch in seconds. • When the near objects are moving faster backward than the far object relative to the car and therefore, there is relative speed between the near object and the far object. Relative velocity is interpreted as the far object going in the direction of the car and the near objects in the opposite direction. • When speed is doubled, the time it takes to stop also doubles, but the stopping distance increases by a factor of four due to the quadratic relationship between distance and time in kinematics.	• How can the idea of frames of reference allow two people to tell the truth yet have conflicting reports? • How can we estimate the height of a very tall building with only a small rock and a stopwatch? • Why might it seem like you are moving backwards when a car passes you on the highway? • Why is the general rule for stopping your car "when you double your speed, you must give yourself four times as much distance to stop"?
Vocabulary: displacement, distance, velocity, speed, kinematics, acceleration, reference frame, relative velocity, gravitational acceleration, vector, scalar	
Interdisciplinary Connections	
Career Readiness, Life Literacies, & Key Skills *(CLKS)*: 9.4.12.IML.3: Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions (e.g., S-ID.B.6a., 8.1.12.DA.5, 7.1.IH.IPRET.8)	

Computer Science & Design Thinking (*CS & DT*):

8.2.12.ED.2: Create scaled engineering drawings for a new product or system and make modification to increase optimization based on feedback.

NJSLS Companion Standards - ELA

• 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), (HS-PS2-6)

• 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.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-PS2-6)

• WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-PS2-3), (HS-PS2-5)

• 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. (HS-PS2-5)

• WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS2-1), (HS-PS2-5)

Connections to NJSLS - Mathematics

• MP.2 Reason abstractly and quantitatively. (HS-PS2-1), (HS-PS2-2), (HS-PS2-4)

• MP.4 Model with mathematics. (HS-PS2-1), (HS-PS2-2), (HS-PS2-4)

• 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-PS2-5), (HS-PS2-6)

Unit 1 Stage 2 Assessment Evidence

Formative Assessments:

- Dueling buggies lab
- Quiz on motion graphs
- Yo-yo lab
- Quiz on 1D kinematics
- Spring launcher lab
- Quiz on 2D kinematics

Summative Assessments: (includes alternative assessments were applicable)

- Unit 1 Written Assessment– Test with questions from College Board
- Unit 1 Performance Assessment– Catapult (projectile motion)
    - In pairs, students will build a catapult and find a way to calculate the initial launch velocity. On the day of the assessment, the teacher will place the catapult at a random height. Students will have 5 minutes to calculate where to place a bullseye on the floor where they predict the marble will land.

***Common Benchmark Assessment**

Unit 1 Stage 3 Learning Plan

Potential Unit Launches

- Dueling Buggies Lab
- Which bullet hits the ground first– one that is shot, or one that is dropped?

Objectives

- Describe a scalar or vector quantity using magnitude and direction, as appropriate.
- Describe a change in an object's position.
- Describe the average velocity and acceleration of an object.
- Describe the position, velocity, and acceleration of an object using representations of that object's

motion.
- Describe the reference frame of a given observer.
- Describe the motion of objects as measured by observers in different inertial reference frames.
- Describe the perpendicular components of a vector.
- Describe the motion of an object moving in two dimensions.

Potential Supporting Lessons

- Desktop Experiment Task: Give each group a pull-back toy car. Ask students to lay out strips of paper 0.5m apart and take a video of the car as it is released, speeds up, and slows down. Using a frame-by-frame review app to get the time each strip is passed to get x versus t data, have students make v versus t data tables out of this, and graph both position as a function of time and velocity as a function of time.
- Desktop Experiment Task: Have students find the acceleration of a yo-yo as it falls and unwinds using only a meter stick and stopwatch. Then, have students draw (with correct shapes and scales) distance, speed, and acceleration versus time graphs.
- Changing Representations: Show a curvy x versus t graph, a v versus t graph made of connected straight-line segments, or an a versus t graph made of horizontal steps. Have students sketch the other two graphs and either walk them out along a line or move a cart on a track to demonstrate the motion (Note: The track can be tilted slightly to provide constant acceleration in either direction).
- Changing Representations: Have students throw/launch a ball from the second or third story of a building to the ground and measure the ball's initial height, horizontal distance, and time in the air. From this, ask students to calculate initial velocity components and draw (with scales) horizontal/vertical position/velocity/acceleration versus time graphs.
- Create a Plan: Give each group a spring-loaded ball launcher and a meter stick. Have students launch the ball horizontally from a known height and then predict where it will land on the floor when fired at a given angle from the floor. Then, ask students to write their own set of lab instructions for the procedure they just performed, articulating each subtask and calculations needed to obtain their prediction.

Potential Summative Assessments

- Unit 1 Written Assessment
- Unit 1 Performance Assessment– Catapult (described at the top)

Accommodations and Modifications: Students with Disabilities, English Language Learners, Students at Risk of Failure, Students with 504s, Gifted & Talented Students

Specific Strategies and Practices that Support Students with Disabilities:

Students receiving Special Education programming have specific goals and objectives, as well as accommodations and modifications outlined within their Individualized Education Plans (IEP) due to an identified disability and/or diagnosis. In addition to exposure to the general education curriculum, the instruction is differentiated based upon the student's needs. The IEP acts as a supplemental curriculum guide inclusive of instructional strategies that support each learner.

- Small group/One to one - Additional time - Review of directions - Student restates information - Space for movement or breaks - Extra visual and verbal cues and prompts - Preferential seating - Follow a routine/schedule - Rest breaks - Verbal and visual cues regarding directions and staying on task - Checklists - Immediate feedback

- Unit 1: Kinematics
  - Students will be provided with a written guide to organize their work and help them solve a projectile motion problem

Specific Strategies and Practices that Support English Language Learners

English language learner (ELL) is a national-origin-minority student who is limited-English-proficient. This term is often preferred over limited-English-proficient (LEP) as it highlights accomplishments rather than deficits.

- Pre-teaching of vocabulary and concepts - Personal Glossary - Extended Time - Simplified/Verbal Instructions - Frequent Breaks - Visual learning, including graphic organizers - Use of cognates to increase comprehension - Teacher modeling - Pairing students with beginning English language skills with students who have more advanced English language skills - Scaffolding - Word walls - Think-pair-share - Cooperative learning groups

Students at Risk of Failure

- Home/School Connection - Alternative Assessments - Learning Contracts - Homogenous Grouping - Supplemental Instruction - Think-Pair-Share by Readiness - Homework Options - Differentiated Online Practice - Leveled Rubrics - Tiered Level of Supports - Tiered Activities - Small Group Instruction - Work Alone Choice - Group Work Choice

Students with 504 Plans
Teachers are responsible for implementing designated services and strategies identified on a student's 504 Plan.
504 plans are formal plans that schools develop to give kids the support they need and covers any condition that limits daily activities in a major way. Students' accommodations are outlined in their individual 504 plan.

Specific Strategies and Practices that Support Gifted & Talented Students
It is critical that all teachers are able to recognize a high-ability student who may need more depth and complexity in instruction.

-Homogenous Grouping - Small Group In-Depth Instruction - Differentiated Online Practice - Alternative Assessments - Pre-Assess to provide Differentiated Instruction to Accelerate Learning

Unit 2: Force and Translational Dynamics

Stage 1 Desired Results

Unit 2: Force and Translational Dynamics

Unit Summary: In Unit 2, students are introduced to the concept of force, which is an interaction between two objects or systems of objects. Part of the larger study of dynamics, forces provide the context in which students analyze and come to understand a variety of physical phenomena. This understanding is accomplished by revisiting and building upon the models and representations presented in Unit 1—specifically through the introduction of the free body diagram. Students will further analyze the effect of forces on systems when they encounter Newton's second law in rotational form in Unit 5.

Unit 2 Learning Standards / Targets

NJSLS Science (PE):

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-PS2-4: Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.

Unit Enduring Understandings:	**Unit Essential Questions:**
• According to Newton's Universal Law of Gravitation, the gravitational attraction between two objects is stronger when the objects are more massive and closer together. Earth is much more massive than a pencil, so its gravitational pull on us is much stronger. • It's harder to stop a truck than a car at the same speed due to Newton's first law of motion, which requires a greater force to alter the larger mass and momentum of the truck. • Friction is a force that opposes motion when two surfaces are in contact. Ice is smooth, which reduces friction, making it easier for the foot to slide. • A delivery truck filled with birds sitting on the floor will weigh the same as a truck with the same birds flying around inside because the birds' lift cancels out their weight.	• Why do we feel pulled toward Earth but not towards a pencil? • Why is it more difficult to stop a fully loaded dump truck than a small passenger car? • Why is it difficult to walk on ice? • Why will a delivery truck filled with birds sitting on its floor be the same weight as a truck with the same birds flying around inside?

Vocabulary: Newton's Laws, inertia, balanced forces, normal force, kinetic friction, static friction, universal law of gravitation, gravitational constant, free body diagram, uniform circular motion, centripetal force

Interdisciplinary Connections

Career Readiness, Life Literacies, & Key Skills *(CLKS)*:

9.4.12.IML.3: Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions (e.g., S-ID.B.6a., 8.1.12.DA.5, 7.1.IH.IPRET.8)

Computer Science & Design Thinking ***(****CS & DT****)*:

N/A

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and data displays. (HS-PS2-1), (HS-PS2-2), (HS-PS2-4), (HS-PS2-5), (HS-PS2-6)

Unit 2 Stage 2 Assessment Evidence

Formative Assessments:

- Quiz– Conceptual questions on Newton's Laws
- Mu of your shoe lab
- Quiz on Free Body Diagrams
- Atwood machine lab
- Quiz on inclined planes
- Flying pig lab
- Quiz on centripetal force

Summative Assessments: (includes alternative assessments were applicable)

- Unit 2 Written Assessment– Test with questions from College Board
- Unit 2 Performance Assessment– Atwood Machine on an Inclined Plane
    - In groups, students will collect the data they need in order to calculate the acceleration of a block. Next, independently, students will calculate the acceleration of the system, and then use that acceleration to calculate the coefficient of friction of the block. After the student calculates the coefficient of friction, they will recalculate the acceleration of the system at a different angle (the force of friction will change).

***Common Benchmark Assessment**

Unit 2 Stage 3 Learning Plan

Potential Unit Launches

- The physics behind car crashes:
    - Why is it important to wear seatbelts?
    - Why is tailgating more DANGEROUS than annoying?

    - Why is it dangerous to drive in the rain?
    - How do police officers determine who's at fault in a car accident?
    - Why do jug handles have lower speed limits?
- How do rocket launches work?
- Why do shoes have different soles in different sports?
- If you have 100 lbs of gold on earth, and 100 lbs of gold on the moon, which pile makes you richer?

Objectives

- Describe the properties and interactions of a system.
- Describe the location of a system's center of mass with respect to the system's constituent parts.
- Describe a force as an interaction between two objects or systems.
- Describe the forces exerted on an object or system using a free-body diagram.
- Describe the interaction of two objects using Newton's third law and a representation of paired forces exerted on each object.
- Describe the conditions under which a system's velocity remains constant.
- Describe the conditions under which a system's velocity changes.
- Describe the gravitational interaction between two objects or systems with mass.
- Describe situations in which the gravitational force can be considered constant.
- Describe the conditions under which the magnitude of a system's apparent weight is different from the magnitude of the gravitational force exerted on that system.
- Describe inertial and gravitational mass.
- Describe kinetic friction between two surfaces.
- Describe static friction between two surfaces.
- Describe the force exerted on an object by an ideal spring
- Describe the motion of an object traveling in a circular path.
- Describe circular orbits using Kepler's third law.

Potential Supporting Lessons

- Changing Representations: Have students consider an accelerating two-object system from everyday life

(e.g., person pushes a shopping cart, car pulls a trailer). Have them draw the forces on one object, then on the other, and then the external forces exerted on the two-object system.

- Working Backward: Put students in pairs. Have student A write a Newton's second law equation either with symbols or plugged-in numbers including units. Then, have student B describe a situation that the equation applies to, including the object's velocity direction and how velocity is changing, a diagram, and a free-body diagram.
- What, If Anything, Is Wrong? Have students identify some force-related problem from their homework or textbook (that requires setting up Newton's second law and maybe more). Ask students to write out a detailed solution that has exactly one mistake in it (not a calculation error). Post everyone's problems/solutions, and then ask students to identify everyone else's errors. The last student to have their error found wins.
- Desktop Experiment Task: Have students measure the coefficient of static friction of their shoe on a wood plank or metal track. Level 1: Use a spring scale. Level 2: Use a pulley, a spring, a toy bucket, and an electronic balance. Level 3: Use a protractor.
- Desktop Experiment Task: Have students use the "My Solar System" PhET applet to create circular orbits of varying radii around the central star and record radius, period, and planet mass for various trials. Next, have them calculate the speed using $v = 2nr/T$ and force using $F = mv^2/r$. Using the data, have students show that gravitational force is directly proportional to the mass of each object and inversely proportional to the square of the radius.
- Construct an Argument: Ask students to consider two identical objects moving in circles (or parts of circles) of different radii. Then, ask them to think of a situation where the object with the smaller radius has a greater net force and another situation where the object with the larger radius has a greater net force.
- Changing Representations: Describe something a driver could be doing in a car (e.g., "turning the steering wheel to the right while pressing the brake"). Have students walk out the motion while holding out one arm representing the velocity vector and the other arm representing the acceleration vector.
- Predict and Explain: Attach an object of known weight (say, 2 N) to a force sensor and cause the object to

swing in a 180-degree arc. Ask students, "At the bottom, the object is neither speeding up nor slowing down, so what force is registered at the bottom?" Expect students to (incorrectly) answer, "2 N" and discuss, as a class, why this answer is incorrect.

Potential Summative Assessments

- Unit 2 Written Test
- Unit 2 Performance Assessment– Atwood machine (more details at the top)

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- Unit 2: Force and Translational Dynamics
  - Students will be provided with an organizer for force diagrams and setting up Newton's Second Law equations.

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Unit 3: Work, Energy, and Power

Stage 1 Desired Results

Unit 3: Work, Energy, and Power

Unit Summary: In Unit 3, students are introduced to the idea of conservation as a foundational principle of physics, along with the concept of work as the primary agent of change for energy. As in earlier units, students will once again utilize both familiar and new models and representations to analyze physical situations, now with force or energy as major components. Students will be encouraged to call upon their knowledge of content

and skills in Units 1 and 2 to determine the most appropriate technique for approaching a problem and will be challenged to understand the limiting factors of each technique.

Unit 3 Learning Standards / Targets

NJSLS Science (PE):

HS-PS3-1: Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.

HS-PS3-2: Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative position of particles (objects).

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.

Unit Enduring Understandings:

- By consistently recharging your cell phone at work (where your employer pays for electricity) instead of at home (where you pay for electricity), you save less than 50 cents a year.
- The law of conservation of energy states that, the energy can neither be created nor be destroyed. Rather, it can only be transformed from one form to another. So it is just converted from the form that we can use to a less usable form.
- It is possible that no energy transfer takes place even when a force is applied to a body. When the applied force on the body and the displacement of the body are perpendicular to each other, there is no work done which results in no energy transfer.

Unit Essential Questions:

- How much money can you save by charging your cell phone at school instead of at home?
- If energy is conserved, why are we running out of it?
- Does pushing an object always change its energy?
- Why does it seem easier to carry a large box up a ramp rather than up a set of stairs?

• Pushing the load up the ramp means that it moves along a distance that is double the vertical height. The payoff is that the effort required is only half that needed to lift the load vertically the same distance. The general rule is that a less steep slope means that the object moves further, but the effort is less.	
Vocabulary: work, gravitational potential energy, kinetic energy, thermal energy, conservation of energy, work, power, watt, joule	
Interdisciplinary Connections	
Career Readiness, Life Literacies, & Key Skills *(CLKS)*: 9.4.12.IML.3: Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions (e.g., S-ID.B.6a., 8.1.12.DA.5, 7.1.IH.IPRET.8)	
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Unit 3 Stage 2 Assessment Evidence

Formative Assessments:

- Spring launcher lab– analyze the relationship between launch height and compression distance
- Quiz on energy
- Ramp Lab– using energy and projectile motion to predict where a marble will land
- Boot camp– Power Lab
- Lab– Calculate the coefficient of friction on a block sliding down a ramp using both work and dynamics.
- Quiz on work and power

Summative Assessments: (includes alternative assessments were applicable)

- Unit 3 Written Assessment– Test with questions from College Board

- Unit 3 Performance Assessment– Roller Coasters
    - Alone or in pairs, students will build a mini roaster with a loop. First, they will use the height of the loop to calculate the minimum height needed to drop the marble from. They will test it. If the marble does not complete the loops successfully, they must experimentally determine the actual height they need to use to drop the marble from. Then, they will calculate the work done by friction on the coaster.

***Common Benchmark Assessment**

Unit 4 Stage 3 Learning Plan

Potential Unit Launches

- Roller Coasters!
    - Why does the roller coaster change speed throughout the course?
    - Why can't the roller coaster go up a higher hill than the one it started with?
    - How did the coaster get up the hill in the first place?
    - What does it take to complete a loop?
- How to: Be the most powerful person in the room

Objectives

- Describe the translational kinetic energy of an object in terms of the object's mass and velocity.
- Describe the work done on an object or system by a given force or collection of forces.
- Describe the potential energy of a system.
- Describe the energies present in a system.
- Describe the behavior of a system using conservation of mechanical energy principles.
- Describe how the selection of a system determines whether the energy of that system changes.
- Describe the transfer of energy into, out of, or within a system in terms of power.

Potential Supporting Lessons

- Concept-Oriented Demonstration: Release a low friction cart (mass m) from the top of a ramp, and have students time how long it takes to reach the bottom, as well as measure the release height h and track length L. Have students calculate the cart's velocity using $v = L/t$, and then calculate mgh and $\frac{1}{2} mv^2$. The

two speeds are different; discuss with students what incorrect assumptions lead to the difference in speeds.

- Desktop Experiment Task: Divide students into groups and give each group a spring-loaded ball launcher, scale, and meter stick. Ask students to determine the spring constant of the spring in the launcher.
- Four-Square Problem Solving: Have students create representations of scenarios related to work and conservation of energy. First square: Provide a description, in words, of an everyday situation (e.g., "a car goes downhill, speeding up even as the brakes are pressed") along with a diagram. Second square: Draw a free-body diagram with an arrow off to the side representing the object's displacement. Third square: Create energy bar charts (initial and final). Fourth square: For each force on the free-body diagram, state whether that force performs positive or negative work and what energy transformation that force is responsible for.
- Construct an Argument: Ask students to consider a cart that rolls from rest down a ramp and then around a vertical loop. Have students explain why it is the case, using energy and circular motion principles, that for the cart to complete the loop without falling out, the cart must be released at a height higher than the top of the loop.
- Working Backward: Put students in pairs. Have student A write a conservation of energy equation (either symbolically or with numbers and units plugged in). Then, have student B describe a situation that the equation could apply to, draw a diagram, and draw energy bar charts.

Potential Summative Assessments

- Unit 3 Written Test
- Unit 3 Performance Assessment– Roller Coasters (more details at the top)

Accommodations and Modifications: Students with Disabilities, English Language Learners, Students at Risk of Failure, Students with 504s, Gifted & Talented Students

Specific Strategies and Practices that Support Students with Disabilities:

Students receiving Special Education programming have specific goals and objectives, as well as accommodations and modifications outlined within their Individualized Education Plans (IEP) due to an identified disability and/or diagnosis. In addition to exposure to the general education curriculum, the instruction is differentiated based upon the student's needs. The IEP acts as a supplemental curriculum guide inclusive of instructional strategies that support each learner.

- Small group/One to one - Additional time - Review of directions - Student restates information - Space for movement or breaks - Extra visual and verbal cues and prompts - Preferential seating - Follow a routine/schedule - Rest breaks - Verbal and visual cues regarding directions and staying on task - Checklists - Immediate feedback

- Unit 3: Work, Energy, and Power
    - Students will be provided with an organizer for energy bar charts and steps to set up conservation of energy equations.

Specific Strategies and Practices that Support English Language Learners

English language learner (ELL) is a national-origin-minority student who is limited-English-proficient. This term is often preferred over limited-English-proficient (LEP) as it highlights accomplishments rather than deficits.

- Pre-teaching of vocabulary and concepts - Personal Glossary - Extended Time - Simplified/Verbal Instructions - Frequent Breaks - Visual learning, including graphic organizers - Use of cognates to increase comprehension - Teacher modeling - Pairing students with beginning English language skills with students who have more advanced English language skills - Scaffolding - Word walls - Think-pair-share - Cooperative learning groups

Students at Risk of Failure

- Home/School Connection - Alternative Assessments - Learning Contracts - Homogenous Grouping - Supplemental Instruction - Think-Pair-Share by Readiness - Homework Options - Differentiated Online Practice - Leveled Rubrics - Tiered Level of Supports - Tiered Activities - Small Group Instruction - Work Alone Choice - Group Work Choice

Students with 504 Plans

Teachers are responsible for implementing designated services and strategies identified on a student's 504 Plan.
504 plans are formal plans that schools develop to give kids the support they need and covers any condition that limits daily activities in a major way. Students' accommodations are outlined in their individual 504 plan.

Specific Strategies and Practices that Support Gifted & Talented Students

It is critical that all teachers are able to recognize a high-ability student who may need more depth and complexity in instruction.

-Homogenous Grouping - Small Group In-Depth Instruction - Differentiated Online Practice - Alternative Assessments - Pre-Assess to provide Differentiated Instruction to Accelerate Learning

Unit 4: Linear Momentum

Stage 1 Desired Results

Unit 4: Linear Momentum

Unit Summary: Unit 4 introduces students to the relationships between force, time, impulse, and linear momentum via calculations, data analysis, designing experiments, and making predictions. Students will learn how to use new models and representations to illustrate the law of conservation of linear momentum of objects and systems while gaining proficiency using previously studied representations. Using the law of conservation of linear momentum to analyze physical situations provides students with a more complete picture of forces and opportunities to revisit misconceptions surrounding Newton's third law. Students will also have the opportunity to make connections between momentum and kinetic energy of objects or systems and see under what conditions these quantities remain constant.

Unit 4 Learning Standards / Targets

NJSLS Science (PE):

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 science and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.

Unit Enduring Understandings:	**Unit Essential Questions:**

• Momentum is a mathematical quantity associated with “mass in motion”. It should not be confused with Newton’s Law of inertia • Increasing the time it takes to change an object’s momentum will decrease the force exerted on the object. • The total momentum of a system will always be conserved unless an outside force causes an impulse • While momentum may be conserved, kinetic energy may not. It depends on whether the collision is elastic or inelastic.	• How is the physics definition of momentum different from how momentum is used to describe things in everyday life? • Can a person on an elevator that breaks loose and falls to the ground avoid harm by jumping at the last second? • Why will a water balloon break when thrown on the pavement, but not break if caught carefully? • Why is it important that cars are designed to include crumple zones?
Vocabulary: momentum, impulse, velocity, mass, change, time, force, conservation	
Interdisciplinary Connections	
Career Readiness, Life Literacies, & Key Skills *(CLKS)*: 9.4.12.IML.3: Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions (e.g., S-ID.B.6a., 8.1.12.DA.5, 7.1.IH.IPRET.8)	
Computer Science & Design Thinking ***(****CS & DT****)*: N/A	
NJSLS Companion Standards - ELA • 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), (HS-PS2-6) • 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.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-PS2-6)	

• WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-PS2-3), (HS-PS2-5)

• 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. (HS-PS2-5)

• WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS2-1), (HS-PS2-5)

Connections to NJSLS - Mathematics

• MP.2 Reason abstractly and quantitatively. (HS-PS2-1), (HS-PS2-2), (HS-PS2-4)

• MP.4 Model with mathematics. (HS-PS2-1), (HS-PS2-2), (HS-PS2-4)

• 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-PS2-5), (HS-PS2-6)

Unit 4 Stage 2 Assessment Evidence

Formative Assessments:

- Impulse dart lab
- Quiz on momentum and impulse
- Car Crash lab on physics classroom
- Quiz on conservation of momentum

Summative Assessments: (includes alternative assessments were applicable)

- Unit 4 Written Assessment– Test with questions from College Board
- Unit 4 Performance Assessment– Car Crash

- In groups, students will collect data from before and after a car crash (using PASCO cars on a frictionless track). Independently, they will use their data to determine if momentum and kinetic energy was conserved in the different crashes.

***Common Benchmark Assessment**

Unit 4 Stage 3 Learning Plan

Potential Unit Launches

- Car Crashes!
  - What's the benefit of airbags and crumple zones?
  - Who is safer in a car crash– a person driving a smart car, or a person driving a tractor trailer?
- Heavy or light, which bat is right?
- Throwing an egg against the wall vs against a blanket

Objectives

- Describe the linear momentum of an object or system.
- Describe the impulse delivered to an object or system.
- Describe the relationship between the impulse exerted on an object or a system and the change in momentum of the object or system.
- Describe the behavior of a system using conservation of linear momentum.
- Describe how the selection of a system determines whether the momentum of that system changes.
- Describe whether an interaction between objects is elastic or inelastic.

Potential Supporting Lessons

- Conflicting Contentions: Ask students to imagine a pitcher throwing a baseball and a catcher catching it and have them debate who exerted more force on the ball (no way to know), who applied greater impulse (same for both), and who did a greater magnitude of net work on the ball (same). Repeat this process for a pitcher throwing the baseball and a batter hitting it back at the same speed.
- Desktop Experiment Task: Connect a spring-loaded lanyard between a cart and a force sensor, with a motion sensor on the other Side of the cart. Have students take force and motion versus time data as the

lanyard contracts and pulls, accelerating the cart. Show students that impulse applied to the cart equals the cart's change in momentum.

- Construct an Argument: Have students use momentum bar charts to explain why a dart bouncing off a cart makes the cart move faster than the dart sticking to the cart, passing through the cart, or stopping and dropping after colliding with the cart.
- Predict and Explain/Concept-Oriented Demonstration: Have a cart crash into a force sensor set to its highest setting in three different ways: cart sticks to sensor, cart bounces off the sensor on its hard side, and cart bounces off the sensor with its spring side. Have students predict in which case more force is registered and explain why.
- Desktop Experiment Task: Have two carts with different masses collide in a nonstick collision. Record the carts with a phone camera from above, with a meter stick next to the track. Have students use a frame-by-frame review app to determine the cart's initial and final speeds, whether momentum was conserved, and whether the collision was elastic.

Potential Summative Assessments

- Unit 4 Written Test
- Unit 4 Performance Assessment– Car Crash

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- Unit 4: Linear Momentum
    - Students will be provided with a graphic organizer to assist in organizing conservation of momentum equations.

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Unit 5: Torque and Rotational Dynamics

Stage 1 Desired Results

Unit 5: Torque and Rotational Dynamics

Unit Summary: Unit 5 reinforces the Unit 2 ideas of force and linear motion by introducing students to their rotational analogs—torque and rotational motion. Although these topics present more complex scenarios, the tools of analysis remain the same. The content and models explored in the first four units of the course set the foundation for Units 5 and 6. During their study of torque and rotational motion, students will be introduced to different ways of modeling forces. Throughout Units 5 and 6, students will compare and connect their understanding of linear and rotational motion, dynamics, energy, and momentum to develop holistic models to evaluate physical phenomena.

Unit 5 Learning Standards / Targets

NJSLS Science (PE):

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.

Unit Enduring Understandings:	**Unit Essential Questions:**
• The longer the lever arm, the less force required to exert a torque • In order for a structure to be in static equilibrium, all net force and net torques must be equal to zero. • The center of mass of any structure will exert a downwards torque.	• Why does it matter where a door handle is placed? • Why are long wrenches more effective? • What do mobiles have in common with the Grand Canyon Skywalk? • Why does a tightrope walker use a long pole?

• Any force located outside of the pivot point will exert a torque.	

Vocabulary: net torque, angular, radian, force, center of mass, equilibrium, pivot, theta, omega, alpha, lever, radius

Interdisciplinary Connections

Career Readiness, Life Literacies, & Key Skills *(CLKS)*:

9.4.12.TL.2: Generate data using formula-based calculations in a spreadsheet and draw conclusions about the data.

Computer Science & Design Thinking (*CS & DT***):**

8.2.12.ED.2: Create scaled engineering drawings for a new product or system and make modification to increase optimization based on feedback.

NJSLS Companion Standards - ELA

• 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), (HS-PS2-6)

• 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)

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Connections to NJSLS - Mathematics

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Unit 5 Stage 2 Assessment Evidence

Formative Assessments:

- Lab– find the mass of a meter stick without a scale!
- Quiz on calculating torque
- Lab– build a street sign in static equilibrium with varying weights

Summative Assessments: (includes alternative assessments were applicable)

- Combined Units 5-6 Assessment– Test with questions from College Board
- Unit 5-6 Performance Assessment– Kinetic Art Sculptures
    - Students will build their own mobile. They will bring in little sculptures, find the mass, and then work backwards to figure out the dimensions of their mobile. They must do calculations first in order to find radii, then they will mark their dowel rod where it has to be cut and where they are going to tie their sculptures. Once they are done building, the balance of their mobile will tell if they did the math right or not!

***Common Benchmark Assessment**

Unit 5 Stage 3 Learning Plan

Potential Unit Launches

- Try to open a door by pushing close to the hinge, then try to open it by using the door handle. Where is it easier and why?
- Daily tool/utensil challenge: Levers, wrenches, and jar openers. What's so special about them?

Objectives

- Describe the rotation of a system with respect to time using angular displacement, angular velocity, and angular acceleration.
- Describe the linear motion of a point on a rotating rigid system that corresponds to the rotational motion of that point, and vice versa.
- Identify the torques exerted on a rigid system.
- Describe the torques exerted on a rigid system.
- Describe the rotational inertia of a rigid system relative to a given axis of rotation.
- Describe the rotational inertia of a rigid system rotating about an axis that does not pass through the system's center of mass.
- Describe the conditions under which a system's angular velocity remains constant.
- Describe the conditions under which a system's angular velocity changes.

Potential Supporting Lessons

- Predict and Explain: Spin a bike wheel (preferably with the tire removed so that it will roll on its metal rims) and release it from rest on the floor or a long table. Have students predict what will happen to the wheel's linear velocity (it will increase) and its angular velocity (it will decrease) as the wheel "peels out." Then, explain why this happens using a force diagram.
- Create a Plan: Have students design a walkway (of given mass) that is to be suspended from a ceiling. Have them determine the amount of force the two supports (one on each end) must be able to provide as a person (of given mass) walks across the walkway.
- Desktop Experiment Task: Take a hard-boiled egg and a raw egg without identifying marks or labels. Give students the task to determine which one is which. To give them a starting point, have students place the eggs on a level surface and give each egg a spin. Once each egg is spinning lightly, have students touch each egg on the top to stop it. Students should conclude that the raw egg is noticeably more difficult to

start or stop.

- Desktop Experiment Task: Have students allow a yo-yo to fall and unroll. Then, have them use a meter stick and stopwatch to determine its downward acceleration. Next, have them measure its mass and the radius of its axle and use that information to determine the yo-yo's rotational inertia using rotational dynamics.
- Create a Plan: Have students complete the necessary research to determine the rotational inertia of a human body in different configurations (e.g., arms outstretched, arms pulled in). Then, obtain footage of an ice skater spinning and pulling in their arms. Have students analyze the footage to see if angular momentum is conserved.
- Desktop Experiment Task: Set a meter stick on a pivot that is not set at the center of mass of the meterstick. Hang two objects off the meter stick so that the two object—meterstick system is in equilibrium. Have students observe and collect data to allow them to determine the mass of the meter stick.

Potential Summative Assessments

- Combined Units 5-6 Test
- Unit 5-6 Performance Assessment– Kinetic Art Sculpture

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    - Students will be provided with an organizer for force diagrams and setting up torque equations.

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Unit 6: Rotational Energy and Momentum

Stage 1 Desired Results

Unit 6: Rotational Energy and Momentum

Unit Summary: In Unit 6, students will apply their knowledge of energy and momentum to rotating systems. Similar to the approach used for translational energy and momentum concepts in Units 3 and 4, it is important that students have conceptual understanding of how angular momentum and rotational energy change due to external torque(s) on a system. Additionally, articulating the conditions under which the rotational energy and/or angular momentum of a system remains constant is foundational to working through more complex scenarios. Students will use the content and skills presented in both Units 5 and 6 to further study the motion of orbiting satellites and rolling without slipping in this unit.

Unit 6 Learning Standards / Targets

NJSLS Science (PE):

HS-PS3-1: Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.

HS-PS3-2: Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative position of particles (objects).

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

Unit Enduring Understandings:	**Unit Essential Questions:**
• Any rotating object has angular momentum. Since momentum is conserved, the gyroscopic	• What keeps a bicycle balanced?

force (inertial force) will resist any external force acting against the object. • Angular momentum is conserved– decreasing the radius of a rotating body will increase the angular velocity of the rotating body	• Why do planets move faster when they travel closer to the sun? • What do satellites and projectiles have in common? • What do ice skaters do with their arms when they want to spin faster? Why?
Vocabulary: Angular momentum, inertial force, external force, radius, rotating body, angular velocity, projectile	
Interdisciplinary Connections	
Career Readiness, Life Literacies, & Key Skills *(CLKS)*: 9.4.12.TL.2: Generate data using formula-based calculations in a spreadsheet and draw conclusions about the data.	
Computer Science & Design Thinking (*CS & DT***):** 8.2.12.ED.2: Create scaled engineering drawings for a new product or system and make modification to increase optimization based on feedback.	
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Unit 6 Stage 2 Assessment Evidence

Formative Assessments:

- Quiz on energy conservation with rotational kinetic energy
- Lab– calculate the moment of inertia of a roll of tape using energy and projectile motion
- Quiz on calculating angular momentum

Summative Assessments: (includes alternative assessments were applicable)

- Unit 5/6 Assessment– Test with questions from College Board
- Unit 5/6 Performance Assessment– Kinetic Art Sculptures
    - Students will build their own mobile. They will bring in little sculptures, find the mass, and then work backwards to figure out the dimensions of their mobile. They must do calculations first in order to find radii, then they will mark their dowel rod where it has to be cut and where they are going to tie their sculptures. Once they are done building, the balance of their mobile will tell if they did the math right or not!

***Common Benchmark Assessment**

Unit 6 Stage 3 Learning Plan

Potential Unit Launches

- Bike wheel– explain why a person spins the opposite direction when sitting on a rotating plate and rotating a spinning bike wheel.
- Why does an ice skater spin faster when they pull their arms in?
- Why are spinning bullets more accurate?

Objectives

- Describe the rotational kinetic energy of a rigid system in terms of the rotational inertia and angular velocity of that rigid system.
- Describe the work done on a rigid system by a given torque or collection of torques.
- Describe the angular momentum of an object or rigid system.
- Describe the angular impulse delivered to an object or rigid system by a torque.
- Relate the change in angular momentum of an object or rigid system to the angular impulse given to that object or rigid system.
- Describe the behavior of a system using conservation of angular momentum.
- Describe how the selection of a system determines whether the angular momentum of that system changes.
- Describe the kinetic energy of a system that has translational and rotational motion.
- Describe the motion of a system that is rolling without slipping.
- Describe the motion of a system that is rolling while slipping.
- Describe the motions of a system consisting of two objects interacting only via gravitational forces.

Potential Supporting Lessons

- Desktop Experiment Task: Have students release a yo-yo from rest, calculate its acceleration from distance and time measurements, and then determine the yo-yo's rotational inertia (which requires the yo-yo's mass and the radius at which the string connects to the yo-yo). Next, have them roll the yo-yo down a ramp and use distance and time data to construct a conservation of energy equation that can be solved for the yo-yo's rotational inertia.

- Predict and Explain: Allow students to play with a set of fidget spinners. Ask them to explain why it is difficult to change the plane of rotation of a spinner while it is rotating.
- Concept-Oriented Demonstration: Obtain a ring and a disk of equal mass and radius and load up a low-friction cart with weights to make it the same mass. "Race" the three objects from rest down identical inclines to show students the cart wins, then the disk, and then the ring. Have students explain why the objects win in this order, with forces and then with energy.
- Ranking Tasks: Present students with the following scenario and its accompanying three cases: A wheel rolls down an incline from rest and across a flat surface. Case 1: Tracks are rough enough that there is no slipping. Case 2: Tracks have some friction, but there is slipping. Case 3: Tracks have negligible friction. Have students rank translational kinetic energies at the end, rotational kinetic energies at the end, and total mechanical energies of the wheel at the end as three separate tasks.
- Construct an Argument: Have students roll a hoop and a disk (of equal mass and radius) down identical ramps. Then have them explain why the disk reached the bottom in less time using energy bar charts
- and to-scale free-body diagrams.

Potential Summative Assessments

- Combined Units 5-6 Written Test
- Units 5-6 Performance Assessment– Kinetic Art Sculpture

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Students at Risk of Failure

- Home/School Connection - Alternative Assessments - Learning Contracts - Homogenous Grouping - Supplemental Instruction - Think-Pair-Share by Readiness - Homework Options - Differentiated Online Practice - Leveled Rubrics - Tiered Level of Supports - Tiered Activities - Small Group Instruction - Work Alone Choice - Group Work Choice

Students with 504 Plans

Teachers are responsible for implementing designated services and strategies identified on a student's 504 Plan.
504 plans are formal plans that schools develop to give kids the support they need and covers any condition that limits daily activities in a major way. Students' accommodations are outlined in their individual 504 plan.

Specific Strategies and Practices that Support Gifted & Talented Students

It is critical that all teachers are able to recognize a high-ability student who may need more depth and complexity in instruction.

-Homogenous Grouping - Small Group In-Depth Instruction - Differentiated Online Practice - Alternative Assessments - Pre-Assess to provide Differentiated Instruction to Accelerate Learning

Unit 7: Oscillations

Stage 1 Desired Results

Unit 7: Oscillations

Unit Summary: In Unit 7, students will apply previously-encountered models and methods of analysis to simple harmonic motion. They will also be reminded that, even in new situations, the fundamental laws of physics remain the same. Because this unit is the first in which students possess all the tools of force, energy, and momentum conservation—such as energy bar charts, free-body diagrams, and momentum diagrams—scaffolding lessons will enhance student understanding of fundamental physics principles and their limitations, as they relate to oscillating systems. Students will also use the skills and knowledge they have gained to make and justify claims, as well as connect new concepts with those learned in previous topics.

Unit 7 Learning Standards / Targets

NJSLS Science (PE):

HS-PS4-1 Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.

Unit Enduring Understandings:	**Unit Essential Questions:**
• Oscillations occur in a periodic motion, which is not affected by amplitude • With pendulums, only the length of the string and the acceleration due to gravity affects the period of the oscillation (not mass!) • With springs, only k and mass affect the period of the oscillation (not length!)	• How can oscillations be used to make our lives easier and more comfortable? • How can an astronaut be “weighed” in space? • How could you measure the length of a long string with a stopwatch? • What do a child on a swing, a beating heart, and a metronome have in common?

Vocabulary: Oscillation, periodic motion, amplitude, pendulum, acceleration, period, length, motion, elasticity, metronome

Interdisciplinary Connections

Career Readiness, Life Literacies, & Key Skills *(CLKS)*:

9.4.12.TL.2: Generate data using formula-based calculations in a spreadsheet and draw conclusions about the data.

Computer Science & Design Thinking ***(****CS & DT****)*****:**

N/A

NJSLS Companion Standards - ELA

• 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), (HS-PS2-6)

• 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.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-PS2-6)

• WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-PS2-3), (HS-PS2-5)

• 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. (HS-PS2-5)

• WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS2-1), (HS-PS2-5)

Connections to NJSLS - Mathematics

• MP.2 Reason abstractly and quantitatively. (HS-PS2-1), (HS-PS2-2), (HS-PS2-4)

• MP.4 Model with mathematics. (HS-PS2-1), (HS-PS2-2), (HS-PS2-4)
• 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-PS2-5), (HS-PS2-6)

Unit 7 Stage 2 Assessment Evidence

Formative Assessments:

- Lab– determining what affects the period of a pendulum
- Lab– creating graphs with an oscillating spring

Summative Assessments: (includes alternative assessments were applicable)

- Unit 7 Written Assessment– A quest (quiz/test)

***Common Benchmark Assessment**

Unit 7 Stage 3 Learning Plan

Potential Unit Launches

- Swing sets– who can swing the highest? what affects the time of a full swing
- Bungee jumping

Objectives

- Describe simple harmonic motion.
- Describe the frequency and period of an object exhibiting SHM.
- Describe the displacement, velocity, and acceleration of an object exhibiting SHM.
- Describe the mechanical energy of a system exhibiting SHM.

Potential Supporting Lessons

- Desktop Experiment Task: Have students determine the spring constant of a spring using (1) known masses and a meter stick only and then (2) known masses and a stopwatch only.
- Desktop Experiment Task : Have students use a pendulum to determine the acceleration due to gravity. Ask

them to refine the experiment from a single-trial calculation, to taking an average, to making a graph of linearized data.

- Predict and Explain: Have students make a pendulum bob oscillate with the other end of the string "clamped" between your fingers. While the bob oscillates, pull the string through your fingers so that the string length is shortened. Before doing this, ask students what will happen to the period of the oscillation and amplitude (measured in degrees), and then explain why the period decreases and the amplitude angle increases.
- Create a Plan: Have students choose a song and find its tempo (in beats per minute). Then, have them build a pendulum so that it swings back and forth on each beat. Next, give students a spring. Have them first find the spring's constant and then find the amount of mass necessary to make the spring-mass oscillate on each beat.
- Construct an Argument: A cart wiggles on a horizontal spring. A blob of clay is dropped on the cart and sticks (could be when the cart is at the center or at one end). Ask students to explain what happened to the period, total energy, amplitude of motion, and maximum speed.

Potential Summative Assessments

- Unit 7 Quest

Accommodations and Modifications: Students with Disabilities, English Language Learners, Students at Risk of Failure, Students with 504s, Gifted & Talented Students

Specific Strategies and Practices that Support Students with Disabilities:

Students receiving Special Education programming have specific goals and objectives, as well as accommodations and modifications outlined within their Individualized Education Plans (IEP) due to an identified disability and/or diagnosis. In addition to exposure to the general education curriculum, the instruction is differentiated based upon the student's needs. The IEP acts as a supplemental curriculum guide inclusive of instructional strategies that support each learner.

- Small group/One to one - Additional time - Review of directions - Student restates information - Space for movement or breaks - Extra visual and verbal cues and prompts - Preferential seating - Follow a routine/schedule - Rest breaks - Verbal and visual cues regarding directions and staying on task - Checklists - Immediate feedback

- Unit 7: Oscillations
    - Students will be provided with a graphic organizer on reading graphs for position vs time, velocity vs time, and acceleration vs time for an object undergoing simple harmonic motion

Specific Strategies and Practices that Support English Language Learners

English language learner (ELL) is a national-origin-minority student who is limited-English-proficient. This term is often preferred over limited-English-proficient (LEP) as it highlights accomplishments rather than deficits.

- Pre-teaching of vocabulary and concepts - Personal Glossary - Extended Time - Simplified/Verbal Instructions - Frequent Breaks - Visual learning, including graphic organizers - Use of cognates to increase comprehension - Teacher modeling - Pairing students with beginning English language skills with students who have more advanced English language skills - Scaffolding - Word walls - Think-pair-share - Cooperative learning groups

Students at Risk of Failure

- Home/School Connection - Alternative Assessments - Learning Contracts - Homogenous Grouping - Supplemental Instruction - Think-Pair-Share by Readiness - Homework Options - Differentiated Online Practice - Leveled Rubrics - Tiered Level of Supports - Tiered Activities - Small Group Instruction - Work Alone Choice - Group Work Choice

Students with 504 Plans

Teachers are responsible for implementing designated services and strategies identified on a student's 504 Plan.
504 plans are formal plans that schools develop to give kids the support they need and covers any condition that limits daily activities in a major way. Students' accommodations are outlined in their individual 504 plan.

Specific Strategies and Practices that Support Gifted & Talented Students

It is critical that all teachers are able to recognize a high-ability student who may need more depth and complexity in instruction.

-Homogenous Grouping - Small Group In-Depth Instruction - Differentiated Online Practice - Alternative Assessments - Pre-Assess to provide Differentiated Instruction to Accelerate Learning

Unit 8: Fluids

Stage 1 Desired Results

Unit 8: Fluids

Unit Summary: In Unit 8, students consider how the forces and conservation laws studied in Units 1 through 4 can be applied to the study of ideal fluids. Unit 8 ties together the thematic threads that have been woven throughout the course, including the interactions between systems and the conservation of fundamental quantities.

Unit 8 Learning Standards / Targets

NJSLS Science (PE):

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.

Unit Enduring Understandings:

- When the density of an object is greater than the density of the fluid it's in, the object will sink.
- Increasing fluid speed decreases the pressure.
- Our bodies are acclimated with an internal pressure to oppose the external atmospheric pressure.
- Law of Conservation of Matter contributes to the behavior of fluids.

Unit Essential Questions:

- Why do some objects float while others sink?
- Why is an object's ability to float an important characteristic?
- What implications to our lives would there be if nothing floated?
- Why don't we feel the miles of air above us pushing us down?

Vocabulary: Density, sink, float, speed, pressure, internal pressure, external atmospheric pressure, fluid, Law of Conservation of Matter

Interdisciplinary Connections

Career Readiness, Life Literacies, & Key Skills *(CLKS)*:

9.4.12.TL.2: Generate data using formula-based calculations in a spreadsheet and draw conclusions about the data.

Computer Science & Design Thinking ***(****CS & DT****)*****:**

8.2.12.NT.2: Redesign an existing product to improve form or function.

NJSLS Companion Standards - ELA

• 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), (HS-PS2-6)

• 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)

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• MP.4 Model with mathematics. (HS-PS2-1), (HS-PS2-2), (HS-PS2-4)
• 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-PS2-5), (HS-PS2-6)

Unit 8 Stage 2 Assessment Evidence

Formative Assessments:

- Buoyancy Lab– different metal objects– use a spring scale to determine the mass and density of the object
- Pressure Lab– students will determine the water pressure in different containers by examining the flow speed of water
- Quiz on Bernoulli's bar charts and graphs
- Syringe Lab– determine the force of a squirt gun by examining how far the water squirts out

Summative Assessments: (includes alternative assessments were applicable)

- Unit 8 Written Assessment– Test with questions from College Board

***Common Benchmark Assessment**

Unit 8 Stage 3 Learning Plan

Potential Unit Launches

- Paper Airplanes! What's the best design technique and why?
- What's the best way to drain a plastic water bottle and why?
- Why do our ears pop in higher altitudes?
- Pirates of the Caribbean– how do they "breathe underwater" with the boat?
- Why do you hear that terrible noise when only one window is open in a moving car?
- Bernuili's principle:
    - What happens when you put a ping pong ball over a hair dryer?
    - What happens when you blow air under a paper tent? Why?

Objectives

- Describe the properties of a fluid.
- Describe the pressure exerted on a surface by a given force.
- Describe the pressure exerted by a fluid.
- Describe the conditions under which a fluid's velocity changes.
- Describe the buoyant force exerted on an object interacting with a fluid.
- Describe the flow of an incompressible fluid through a cross-sectional area by using mass conservation.
- Describe the flow of a fluid as a result of a difference in energy between two locations within the fluid–Earth system.

Potential Supporting Lessons

- Construct an Argument: Search "pressure versus height graph" online and download a graph of air pressure as a function of elevation. Have students explain why the slope decreases with elevation (air gets less dense) and use the slope of the graph at one point to estimate the density of air at that elevation.
- Desktop Experiment Task: Divide students into groups. Give each group an irregularly shaped metal object (e.g., a small, inexpensive statue). Provide each group a spring scale and access to a deep sink. Have students use buoyancy principles to calculate the volume and density of the object.
- Graph and Switch: Have a student use a rope to raise an object 2 m from the bottom of a 3 m deep pool. Graph (with numerical scales) tension versus height of the bottom of the object above the floor of the pool for 0—4 m. Have another student determine the mass, volume, and density of the object. The shape of the graph from 1 to 3 m also determines whether the shape is a cube, sphere, or a cone pointing up or down. Ask students to switch graphs and discuss.
- Construct an Argument: Have students draw Bernoulli bar charts for two or more points in a flowing fluid situation. (Bars are for pressure, pgy, and —pv .) Examples: water leaking out of a hole in a container, water shooting out of a hose, and drinking from a straw. Have students make and defend a claim about the pressure in two different places in the container, hose, or straw, using the bar chart as evidence.
- Desktop Experiment Task: Divide students into groups. Obtain a syringe (no needle) or water squirter for each group. Have each group fill it with water and squirt the water horizontally. Then, have each group

determine how much pressure (for the water squirter) or force (for the syringe) was exerted to make the water come out.

Potential Summative Assessments

- Unit 8 Performance Assessment
- Unit 8 Test

Accommodations and Modifications: Students with Disabilities, English Language Learners, Students at Risk of Failure, Students with 504s, Gifted & Talented Students

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- Small group/One to one - Additional time - Review of directions - Student restates information - Space for movement or breaks - Extra visual and verbal cues and prompts - Preferential seating - Follow a routine/schedule - Rest breaks - Verbal and visual cues regarding directions and staying on task - Checklists - Immediate feedback

- Unit 1: Kinematics
  - Students will be provided with a written guide to organize their work and help them solve a projectile motion problem
- Unit 2: Force and Translational Dynamics
  - Students will be provided with an organizer for force diagrams and setting up Newton's Second Law equations.
- Unit 3: Work, Energy, and Power
  - Students will be provided with an organizer for energy bar charts and steps to set up conservation of energy equations.

- Unit 4: Linear Momentum
    - Students will be provided with a graphic organizer to assist in organizing conservation of momentum equations.
- Unit 5: Torque and Rotational Dynamics
    - Students will be provided with an organizer for force diagrams and setting up torque equations.
- Unit 6: Rotational Energy and Momentum
    - Students will be provided with an organizer for energy bar charts and steps to set up conservation of energy equations.
- Unit 7: Oscillations
    - Students will be provided with a graphic organizer on reading graphs for position vs time, velocity vs time, and acceleration vs time for an object undergoing simple harmonic motion
- Unit 8: Fluids
    - Students will be provided with an organizer with steps to set up Bernoulli's equation

Specific Strategies and Practices that Support English Language Learners

English language learner (ELL) is a national-origin-minority student who is limited-English-proficient. This term is often preferred over limited-English-proficient (LEP) as it highlights accomplishments rather than deficits.

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Unit 9: Review for the AP Exam

Stage 1 Desired Results

Unit 9: Review for the AP Exam

Unit Summary: In order to prepare for the Advanced Placement Exam in May, students will be provided AP level practice to review key concepts. Students will be encouraged to individualize their studying to focus on the units and/or topics that they personally need to improve.

Unit 9 Learning Standards / Targets

NJSLS Science (PE):

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 science 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.

HS-PS3-1: Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.

HS-PS3-2: Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative position of particles (objects).

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-PS4-1: Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.

Unit Enduring Understandings:	**Unit Essential Questions:**
• The format of the AP Exam is standard although the questions/topics that are emphasized may vary from year to year. • Creation of a study guide is a useful tool when taking important exams. • Study groups are useful for most students. • By showing a classmate how to answer a question you are demonstrating complete understanding.	• How does AP score the open ended questions? • What are the differences between the types of open ended questions? • Should you guess on the multiple choice and/or open ended questions? • What technology is acceptable and not acceptable on the AP test?

Vocabulary: Review, accuracy, study, self-assess, skills for success

Interdisciplinary Connections

Career Readiness, Life Literacies, & Key Skills *(CLKS)*:

9.4.12.TL.2: Generate data using formula-based calculations in a spreadsheet and draw conclusions about the data.

9.4.12.IML.3: Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions (e.g., S-ID.B.6a., 8.1.12.DA.5, 7.1.IH.IPRET.8)

Computer Science & Design Thinking (*CS & DT***):**

8.2.12.ED.2: Create scaled engineering drawings for a new product or system and make modification to increase optimization based on feedback.

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• 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. (HS-PS2-5)

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Unit 9 Stage 2 Assessment Evidence

Formative Assessments:

- Practice AP Exam
- Student Unit Presentations
- Student Created Study Guides

Summative Assessments: (includes alternative assessments were applicable)

- Practice AP Exam

***Common Benchmark Assessment**

Unit 9 Stage 3 Learning Plan

Potential Unit Launches

- Full length AP Practice Exam: Where are your strengths? Where are your weaknesses?

Objectives

- Create a study guide.
- Develop a glossary of terms.
- Design a spreadsheet of all hypothesis tests and confidence intervals.
- Answer a multitude of open ended questions from previous years.
- Take practice AP exams given previously and calculate score.
- Establish rules for answering questions based on scoring information.
- Establish a step by step procedure for taking the test and doing as well as possible.

Potential Supporting Lessons

- Student presentations for each unit
- AP Classroom Supplemental video
- AP Progress Checks

Potential Summative Assessments

- Practice AP Exam

Accommodations and Modifications:
Students with Disabilities, English Language Learners,
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- Units 9&10: Review and Post-AP Test
    - Students will be provided with a checklist to guide studying and review practices before the AP test

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-Homogenous Grouping - Small Group In-Depth Instruction - Differentiated Online Practice - Alternative Assessments - Pre-Assess to provide Differentiated Instruction to Accelerate Learning

Unit 10: Utilizing our Physics Skills

Stage 1 Desired Results

Unit 10: Utilizing our Physics Skills

Unit Summary: Students will be able to independently use their learning to conduct projects utilizing their physics skills.

Unit 10 Learning Standards / Targets

NJSLS Science (PE):

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 science 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.

HS-PS3-1: Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.

HS-PS3-2: Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative position of particles (objects).

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-PS4-1: Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.

Unit Enduring Understandings:	**Unit Essential Questions:**
• Basic physics principles are used to solve real-world problems. • Scientists use physics to explore and explain how the universe works.	• How is physics used to solve real world problems? • How is physics implemented in everyday societal technologies?

Vocabulary: Principles, explore, explain, technology, research

Interdisciplinary Connections

Career Readiness, Life Literacies, & Key Skills *(CLKS)*:

9.4.12.TL.2: Generate data using formula-based calculations in a spreadsheet and draw conclusions about the data.

9.4.12.IML.3: Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions (e.g., S-ID.B.6a., 8.1.12.DA.5, 7.1.IH.IPRET.8)

Computer Science & Design Thinking *(**CS & DT****)*:**

8.2.12.ED.2: Create scaled engineering drawings for a new product or system and make modification to increase optimization based on feedback.

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.

NJSLS Companion Standards - ELA

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• 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.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-PS2-6)

• WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-PS2-3), (HS-PS2-5)

• 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. (HS-PS2-5)

• WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS2-1), (HS-PS2-5)

Connections to NJSLS - Mathematics

• MP.2 Reason abstractly and quantitatively. (HS-PS2-1), (HS-PS2-2), (HS-PS2-4)

• MP.4 Model with mathematics. (HS-PS2-1), (HS-PS2-2), (HS-PS2-4)

• 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-PS2-5), (HS-PS2-6)

Unit 10 Stage 2 Assessment Evidence

Formative Assessments:

- Project Check-in #1
- Project Check-in #2
- Project Check-in #3

Summative Assessments: (includes alternative assessments were applicable)

- Physics Investigation Project (student choice)

***Common Benchmark Assessment**

Unit 10 Stage 3 Learning Plan

Potential Unit Launches

- Teacher will present an exemplary presentation of scientists who became famous because they had a question about a real-world phenomena. These scientists conducted their own investigations in order to find the answer.

  → Students will have to complete a project about a question they have regarding a real-world problem/phenomena. They have to conduct an investigation and create a 10 minute presentation to present to their peers.

Objectives

- Students will conduct an investigation to study a real-world problem.
- Students will use physics concepts to propose a solution to a real world problem.

Potential Supporting Lessons

- Actively listening to other students' presentations and submitting questions for the presenter(s).

Potential Summative Assessments

- Physics Investigation Project (student choice)

Core Instructional & Supplemental Materials

Texts, Readings, Online Platforms & Other Resources:

- College Physics a Strategic Approach 4th Edition. (2019) Knight, Jones & Field.
- PhysicsClassroom
- FlippingPhysics
- PhET Simulations
- AP Classroom

Accommodations and Modifications: Students with Disabilities, English Language Learners, Students at Risk of Failure, Students with 504s, Gifted & Talented Students

Specific Strategies and Practices that Support Students with Disabilities:

Students receiving Special Education programming have specific goals and objectives, as well as accommodations and modifications outlined within their Individualized Education Plans (IEP) due to an identified disability and/or diagnosis. In addition to exposure to the general education curriculum, the instruction is differentiated based upon the student's needs. The IEP acts as a supplemental curriculum guide inclusive of instructional strategies that support each learner.

- Small group/One to one - Additional time - Review of directions - Student restates information - Space for movement or breaks - Extra visual and verbal cues and prompts - Preferential seating - Follow a routine/schedule - Rest breaks - Verbal and visual cues regarding directions and staying on task - Checklists - Immediate feedback

- Units 9&10: Review and Post-AP Test
    - Students will be provided with a checklist to guide studying and review practices before the AP test

Specific Strategies and Practices that Support English Language Learners

English language learner (ELL) is a national-origin-minority student who is limited-English-proficient. This term is often preferred over limited-English-proficient (LEP) as it highlights accomplishments rather than deficits.

- Pre-teaching of vocabulary and concepts - Personal Glossary - Extended Time - Simplified/Verbal Instructions - Frequent Breaks - Visual learning, including graphic organizers - Use of cognates to increase comprehension - Teacher modeling -

Pairing students with beginning English language skills with students who have more advanced English language skills - Scaffolding - Word walls - Think-pair-share - Cooperative learning groups

Students at Risk of Failure

- Home/School Connection - Alternative Assessments - Learning Contracts - Homogenous Grouping - Supplemental Instruction - Think-Pair-Share by Readiness - Homework Options - Differentiated Online Practice - Leveled Rubrics - Tiered Level of Supports - Tiered Activities - Small Group Instruction - Work Alone Choice - Group Work Choice

Students with 504 Plans

Teachers are responsible for implementing designated services and strategies identified on a student's 504 Plan.
504 plans are formal plans that schools develop to give kids the support they need and covers any condition that limits daily activities in a major way. Students' accommodations are outlined in their individual 504 plan.

Specific Strategies and Practices that Support Gifted & Talented Students

It is critical that all teachers are able to recognize a high-ability student who may need more depth and complexity in instruction.

-Homogenous Grouping - Small Group In-Depth Instruction - Differentiated Online Practice - Alternative Assessments - Pre-Assess to provide Differentiated Instruction to Accelerate Learning

New Jersey Student Learning Standards - Science

Science

Scientific and technological advances have proliferated and now permeate most aspects of life in the 21st century. It is increasingly important that all members of our society develop an understanding of scientific and engineering concepts and processes. Learning how to construct scientific explanations and how to design evidence-based

solutions provides students with tools to think critically about personal and societal issues and needs. Students can then contribute meaningfully to decision-making processes, such as discussions about climate change, new approaches to health care, and innovative solutions to local and global problems.

Three Dimensions of NJSLS Science

Performance Expectations (PE) are student learning standards devised with the three dimensions or components described below. For detailed information regarding the research and design behind the standards click here.

Disciplinary Core Ideas (DCI)

The fundamental ideas that are necessary for understanding a given science discipline. The core ideas all have broad importance within or across science or engineering disciplines, provide a key tool for understanding or investigating complex ideas and solving problems, relate to societal or personal concerns, and can be taught over multiple grade levels at progressive levels of depth and complexity.

- Disciplinary Core Ideas in Physical Science (PS)
- Disciplinary Core Ideas in Life Science (LS)
- Disciplinary Core Ideas in Earth and Space Science (ESS)
- Disciplinary Core Ideas in Engineering, Technology, and the Application of Science (ETS)

Science and Engineering Practices (SEP)

The practices are what students DO to make sense of phenomena. They are both a set of skills and a set of knowledge to be internalized. The SEPs reflect the major practices that scientists and engineers use to investigate the world and design and build systems.

Crosscutting Concepts (CCC)

These are concepts that hold true across the natural and engineered world. Students can use them to make connections across seemingly disparate disciplines or situations, connect new learning to prior experiences, and more deeply engage with material across the other dimensions. The NGSS requires that students explicitly use their understanding of the CCCs to make sense of phenomena or solve problems.

Science and Engineering Practices (SEP)	**Crosscutting Concepts (CCC)**

• Asking Questions and Defining Problems • Planning and Carrying Out Investigations • Analyzing and Interpreting Data • Developing and Using Models • Constructing Explanations and Designing Solutions • Engaging in Argument from Evidence • Using Mathematics and Computational Thinking • Obtaining, Evaluating, and Communicating Information	• Patterns • Cause and Effect: Mechanism and Explanation • Scale, Proportion, and Quantity • Systems and System Models • Energy and Matter • Structure and Function • Stability and Change