ESL
SCIENCE
BUSINESS
BILINGUAL
PRESCHOOL
MATHEMATICS
LIBRARY MEDIA
SOCIAL STUDIES
WORLD LANGUAGES
GIFTED & TALENTED
TECHNOLOGY EDUCATION
ENGLISH LANGUAGE ARTS
FINE & PERFORMING ARTS
FAMILY & CONSUMER SCIENCE
HEALTH & PHYSICAL EDUCATION

RAHWAY PUBLIC SCHOOLS

CURRICULUM & INSTRUCTION

Content Area: Science

Course: Physics

Grade Level: 11-12

This curriculum is part of the Educational Program of Studies of the Rahway Public Schools.

ACKNOWLEDGMENTS

Jeffery Kurczeski,

Program Supervisor of 7-12 Math & Science and 9-12 Business & Technology Education

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Julie Koft, Science Teacher

Mike Keat, Science Teacher

Dr. Tiffany A. Beer, Director of Curriculum and Instruction

Dr. Aleya Shoieb, Superintendent of Schools

Subject/Course Title:
Physics
Grades 11-12

Date of Board Adoption:
August 27, 2024

RAHWAY PUBLIC SCHOOLS CURRICULUM

Physics: Grades 11-12

PACING GUIDE

Unit	Title	Pacing
1	Kinematics	5 weeks
2	Dynamics	5 weeks
3	Momentum	5 weeks
4	Energy	6 weeks
5	Circular Motion and Universal Gravitation	6 weeks
6	Electricity and Magnetism	6 weeks
7	Wave Properties and Electromagnetic Radiation	4 weeks
8	The Physics of Stars and Climate	3 weeks

ACCOMMODATIONS

504 Accommodations:

- Provide scaffolded vocabulary and vocabulary lists.
- Provide extra visual and verbal cues and prompts.
- Provide adapted/alternate/excerpted versions of the text and/or modified supplementary materials.
- Provide links to audio files and utilize video clips.
- Provide graphic organizers and/or checklists.
- Provide modified rubrics.
- Provide a copy of teaching notes, especially any key terms, in advance.
- Allow additional time to complete assignments and/or assessments.
- Provide shorter writing assignments.
- Provide sentence starters.
- Utilize small group instruction.
- Utilize Think-Pair-Share structure.
- Check for understanding frequently.
- Have student restate information.
- Support auditory presentations with visuals.
- Weekly home-school communication tools (notebook, daily log, phone calls or email messages).
- Provide study sheets and teacher outlines prior to assessments.
- Quiet corner or room to calm down and relax when anxious.
- Reduction of distractions.
- Permit answers to be dictated.
- Hands-on activities.
- Use of manipulatives.
- Assign preferential seating.
- No penalty for spelling errors or sloppy handwriting.
- Follow a routine/schedule.
- Provide student with rest breaks.
- Use verbal and visual cues regarding directions and staying on task.
- Assist in maintaining agenda book.

IEP Accommodations:

- Provide scaffolded vocabulary and vocabulary lists.
- Differentiate reading levels of texts (e.g., Newsela).
- Provide adapted/alternate/excerpted versions of the text and/or modified supplementary materials.
- Provide extra visual and verbal cues and prompts.
- Provide links to audio files and utilize video clips.
- Provide graphic organizers and/or checklists.
- Provide modified rubrics.
- Provide a copy of teaching notes, especially any key terms, in advance.
- Provide students with additional information to supplement notes.
- Modify questioning techniques and provide a reduced number of questions or items on tests.
- Allow additional time to complete assignments and/or assessments.
- Provide shorter writing assignments.
- Provide sentence starters.
- Utilize small group instruction.
- Utilize Think-Pair-Share structure.
- Check for understanding frequently.
- Have student restate information.
- Support auditory presentations with visuals.
- Provide study sheets and teacher outlines prior to assessments.
- Use of manipulatives.
- Have students work with partners or in groups for reading, presentations, assignments, and analyses.
- Assign appropriate roles in collaborative work.
- Assign preferential seating.
- Follow a routine/schedule.

Gifted and Talented Accommodations:

- Differentiate reading levels of texts (e.g., Newsela).
- Offer students additional texts with higher lexile levels.
- Provide more challenging and/or more supplemental readings and/or activities to deepen understanding.
- Allow for independent reading, research, and projects.
- Accelerate or compact the curriculum.
- Offer higher-level thinking questions for deeper analysis.
- Offer more rigorous materials/tasks/prompts.
- Increase number and complexity of sources.
- Assign group research and presentations to teach the class.
- Assign/allow for leadership roles during collaborative work and in other learning activities.

ML Accommodations:

- Provide extended time.
- Assign preferential seating.
- Assign peer buddy who the student can work with.
- Check for understanding frequently.
- Provide language feedback often (such as grammar errors, tenses, subject-verb agreements, etc…).
- Have student repeat directions.
- Make vocabulary words available during classwork and exams.
- Use study guides/checklists to organize information.
- Repeat directions.
- Increase one-on-one conferencing.
- Allow student to listen to an audio version of the text.
- Give directions in small, distinct steps.
- Allow copying from paper/book.
- Give student a copy of the class notes.

	● Provide written and oral instructions. ● Differentiate reading levels of texts (e.g., Newsela). ● Shorten assignments. ● Read directions aloud to student. ● Give oral clues or prompts. ● Record or type assignments. ● Adapt worksheets/packets. ● Create alternate assignments. ● Have student enter written assignments in criterion, where they can use the planning maps to help get them started and receive feedback after it is submitted. ● Allow student to resubmit assignments. ● Use small group instruction. ● Simplify language. ● Provide scaffolded vocabulary and vocabulary lists. ● Demonstrate concepts possibly through the use of visuals. ● Use manipulatives. ● Emphasize critical information by highlighting it for the student. ● Use graphic organizers. ● Pre-teach or pre-view vocabulary. ● Provide student with a list of prompts or sentence starters that they can use when completing a written assignment. ● Provide audio versions of the textbooks. ● Highlight textbooks/study guides. ● Use supplementary materials. ● Give assistance in note taking ● Use adapted/modified textbooks. ● Allow use of computer/word processor. ● Allow student to answer orally, give extended time (time-and-a-half). ● Allow tests to be given in a separate location (with the ESL teacher). ● Allow additional time to complete assignments and/or assessments. ● Read question to student to clarify. ● Provide a definition or synonym for words on a test that do not impact the validity of the exam. ● Modify the format of assessments. ● Shorten test length or require only selected test items. ● Create alternative assessments. ● On an exam other than a spelling test, don’t take points off for spelling errors.

UNIT 1 OVERVIEW

Content Area: Science

Unit Title: Kinematics

Target Course/Grade Level: Physics/Grades 11-12

Unit Summary: In this unit of study, students are expected to plan and conduct investigations, analyze data to develop mathematical relationships and apply scientific ideas to solve design problems. In doing so, students will develop an understanding of ideas related to the mechanisms of motion and how moving objects interact. Students will also build an understanding of inertial reference frames according to Newton's Laws of Motion.

Approximate Length of Unit: 5 weeks

LEARNING TARGETS

NJ Student Learning 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-PS2-3 Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.

Science & Engineering Practices:

Analyzing and Interpreting Data

- Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.

Constructing Explanations and Designing Solutions

- Apply scientific ideas to solve a design problem, taking into account possible unanticipated effects.

Disciplinary Core Ideas:

HS-PS2.A

- Newton's second law accurately predicts changes in the motion of macroscopic objects.
- If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system.

Cross-Cutting Concepts:

Cause and Effect

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.
- Systems can be designed to cause a desired effect.

Career Readiness, Life Literacies, and Key Skills:

9.4.2.TL.7 Describe the benefits of collaborating with others to complete digital tasks or develop digital artifacts.
9.4.12.CI.2 Identify career pathways that highlight personal talents, skills, and abilities.
9.4.12.CI.3 Investigate new challenges and opportunities for personal growth, advancement, and transition.
9.4.12.CT.1 Identify problem-solving strategies used in the development of an innovative product or practice.
9.4.12.DC.7 Evaluate the influence of digital communities on the nature, content and responsibilities of careers, and other aspects of society.
9.4.12.GCA.1 Collaborate with individuals to analyze a variety of potential solutions to climate change effects and determine why some solutions (e.g., political. economic, cultural) may work better than others.
9.4.12.IML.3 Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions.
9.4.12.IML.5 Evaluate, synthesize, and apply information on climate change from various sources appropriately.
9.4.12.IML.7 Develop an argument to support a claim regarding a current workplace or societal/ethical issue such as climate change.
9.4.12.TL.1 Assess digital tools based on features such as accessibility options, capacities, and utility for accomplishing a specified task.
9.4.12.TL.2 Generate data using formula-based calculations in a spreadsheet and draw conclusions about the data.
9.4.12.TL.4 Collaborate in online learning communities or social networks or virtual worlds to analyze and propose a resolution to a real-world problem.

Interdisciplinary Connections and Standards:

ELA

RI.CR.11–12.1 Accurately cite a range of thorough textual evidence and make relevant connections to strongly support a comprehensive analysis of multiple aspects of what an informational text says explicitly and inferentially, as well as interpretations of the text.
RI.MF.11–12.6 Synthesize complex information across multiple sources and formats to develop ideas, resolve conflicting information, or develop an interpretation that goes beyond explicit text information (e.g., express a personal point of view, new interpretation of the concept).
W.AW.11–12.1 Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant and sufficient evidence.
W.SE.11–12.6 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 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.
SL.UM.11–12.5 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest.

Mathematics

N.Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
N.Q.A.2 Define appropriate quantities for the purpose of descriptive modeling.
N.Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
A.SSE.A.1 Interpret expressions that represent a quantity in terms of its context.
A.SSE.B.3 Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression.
A.CED.A.1 Create equations and inequalities in one variable and use them to solve problems.
A.CED.A.2 Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales.
A.CED.A.4 Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.

F.IF.C.7 Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases.
S.ID.A.1 Represent data with plots on the real number line (dot plots, histograms, and box plots).

Unit Understandings:
Students will understand…

- The general relationships between position, velocity, and acceleration.
- The special case of motion with constant acceleration.
- The relationship among words, equations, and graphs for motion in one dimension.

Unit Essential Questions:

- Why do objects move the way they do?
- How are vectors used to analyze motion?
- What is the difference between speed and velocity?
- What are the relationships between position, velocity, and acceleration?

Knowledge and Skills:
Students will know...

- Content Vocabulary: acceleration, constant velocity.
- Newton's first law.
- The general relationships among position, velocity, and acceleration.
- The special case of motion with constant acceleration.
- The relationship among words, equations, and graphs for motion in one dimension.

Students will be able to...

- Manipulate kinematics equations to solve for a desired variable of motion.
- Apply the qualitative definition of acceleration (speeding up, or slowing down, and/or changing
- direction) to determine if an object is accelerating.
- Organize data graphically using position vs time and velocity vs time graphs.
- Determine velocity by taking the slope of a position-time graph.
- Determine acceleration from the slope of a velocity-time graph, as well as the displacement by calculating the area under the curve.
- Correlate negative and positive slopes with positive and negative velocities and accelerations.

EVIDENCE OF LEARNING

Assessment:
What evidence will be collected and deemed acceptable to show that students truly "understand"?

- End of Unit Common Assessment - See folder for assessment links.
- Formative: warm-up activities, exploratory activities, class discussions, student participation, homework, and exit tickets.
- Summative: quizzes, tests, projects, and student lab reports.

Learning Activities:
What differentiated learning experiences and instruction will enable all students to achieve the desired results?

- The following PHET Colorado online simulations can be used to introduce students to the topic of force and motion: http://phet.colorado.edu/en/simulation/forces-and-motion-basics

- An Introduction to Free Body Diagrams: Students use the vector nature of forces to draw free body diagrams: http://betterlesson.com/lesson/630798/an-introduction-to-free-body-diagrams
- PUM Lessons: https://drive.google.com/a/southbergenjointure.org/file/d/0B_gIUgkOC7H3bURpa2NuYnl1a3c/view?usp=sharing

RESOURCES

Teacher Resources:

- https://www.nap.edu/read/13165/chapter/9#125

Equipment Needed:

- Computers
- Motion tracks and carts

UNIT 2 OVERVIEW

Content Area: Science

Unit Title: Dynamics

Target Course/Grade Level: Physics/Grades 11-12

Unit Summary: In this unit of study, students are expected to plan and conduct investigations, analyze data to develop mathematical relationships, and apply scientific ideas to solve design problems. In doing so, students will develop an understanding of ideas related to forces and Newton's Second Law. Students will also investigate the relationships between mass, acceleration, and component forces.

Approximate Length of Unit: 5 weeks

LEARNING TARGETS

NJ Student Learning 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-PS2-3 Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.

Science & Engineering Practices:

Analyzing and Interpreting Data

- Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.

Constructing Explanations and Designing Solutions

- Apply scientific ideas to solve a design problem, taking into account possible unanticipated effects.

Disciplinary Core Ideas:

HS-PS2.A

- Newton's second law accurately predicts changes in the motion of macroscopic objects.
- If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system.

Cross-Cutting Concepts:

Cause and Effect

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.
- Systems can be designed to cause a desired effect.

Career Readiness, Life Literacies, and Key Skills:

9.4.2.TL.7 Describe the benefits of collaborating with others to complete digital tasks or develop digital artifacts.
9.4.12.CI.2 Identify career pathways that highlight personal talents, skills, and abilities.
9.4.12.CI.3 Investigate new challenges and opportunities for personal growth, advancement, and transition.
9.4.12.CT.1 Identify problem-solving strategies used in the development of an innovative product or practice.
9.4.12.DC.7 Evaluate the influence of digital communities on the nature, content and responsibilities of careers, and other aspects of society.
9.4.12.GCA.1 Collaborate with individuals to analyze a variety of potential solutions to climate change effects and determine why some solutions (e.g., political. economic, cultural) may work better than others.
9.4.12.IML.3 Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions.
9.4.12.IML.5 Evaluate, synthesize, and apply information on climate change from various sources appropriately.
9.4.12.IML.7 Develop an argument to support a claim regarding a current workplace or societal/ethical issue such as climate change.
9.4.12.TL.1 Assess digital tools based on features such as accessibility options, capacities, and utility for accomplishing a specified task.
9.4.12.TL.2 Generate data using formula-based calculations in a spreadsheet and draw conclusions about the data.
9.4.12.TL.4 Collaborate in online learning communities or social networks or virtual worlds to analyze and propose a resolution to a real-world problem.

Interdisciplinary Connections and Standards:

ELA

RI.CR.11–12.1 Accurately cite a range of thorough textual evidence and make relevant connections to strongly support a comprehensive analysis of multiple aspects of what an informational text says explicitly and inferentially, as well as interpretations of the text.
RI.MF.11–12.6 Synthesize complex information across multiple sources and formats to develop ideas, resolve conflicting information, or develop an interpretation that goes beyond explicit text information (e.g., express a personal point of view, new interpretation of the concept).
W.AW.11–12.1 Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant and sufficient evidence.
W.SE.11–12.6 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 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.
SL.UM.11–12.5 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest.

Mathematics

N.Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
N.Q.A.2 Define appropriate quantities for the purpose of descriptive modeling.
N.Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
A.SSE.A.1 Interpret expressions that represent a quantity in terms of its context.
A.SSE.B.3 Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression.
A.CED.A.1 Create equations and inequalities in one variable and use them to solve problems.
A.CED.A.2 Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales.
A.CED.A.4 Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.

F.IF.C.7 Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases.
S.ID.A.1 Represent data with plots on the real number line (dot plots, histograms, and box plots).

Unit Understandings:
Students will understand…

- The general relationships between net force, mass, and acceleration.
- The relationships between vector component forces and the net force.
- How to create and interpret diagrams, graphs, and equations that describe the forces and motion of objects.
- The relationships between objects exerting forces on each other.

Unit Essential Questions:

- Why do objects move the way they do?
- How are vectors used to analyze motion?
- What causes an object to accelerate or stop accelerating?
- How do multiple forces in multiple directions impact the motion of an object?
- How do multiple objects interact?

Knowledge and Skills:
Students will know...

- Content Vocabulary: force, mass, acceleration, friction, free fall, air resistance, balanced/unbalanced forces, Newt.
- Newton's second law.
- Newton's third law.
- The relationships between objects exerting forces on each other.

Students will be able to...

- Create and interpret diagrams, graphs, and equations that describe the net force on an object and its acceleration.
- Analyze data to provide experimental evidence for Newton's second law.
- Manipulate the equation form of Newton's second law and kinematics equations to describe the forces and motion of an object.

EVIDENCE OF LEARNING

Assessment:
What evidence will be collected and deemed acceptable to show that students truly "understand"?

- End of Unit Common Assessment - See folder for assessment links.
- Formative: warm-up activities, exploratory activities, class discussions, student participation, homework, and exit tickets.
- Summative: quizzes, tests, projects, and student lab reports.

Learning Activities:

What differentiated learning experiences and instruction will enable all students to achieve the desired results?

- The following PHET Colorado online simulations can be used to introduce students to the topic of force and motion: http://phet.colorado.edu/en/simulation/forces-and-motion-basics
- Applying Newton's Second Law Quantitatively: http://betterlesson.com/lesson/635014/applyingnewton-s-second-law-quantitatively
- Combining Newton's Second Law and Kinematics In this lesson, students will solve a variety of
- problems with Newton's Second Law and the equations of motion: https://betterlesson.com/lesson/635295/combining-newton-s-second-law-and-kinematics
- Newton's Second Law in 1-D Motion In this lesson, students will be able to identify Newton's Second Law and apply it to 1-dimensional motion: https://betterlesson.com/lesson/631023/newton-s-second-law-in-1-d
- Newton's Second Law in 2-D Motion Students will be able to apply Newton's Second Law to 2-
- dimensional motions: https://betterlesson.com/lesson/631088/newton-s-second-law-in-2-d
- PUM Lessons: https://drive.google.com/a/southbergenjointure.org/file/d/0B_gIUgkOC7H3bURpa2NuYnl1a3c/view?usp=sharing

RESOURCES

Teacher Resources:

- https://www.nap.edu/read/13165/chapter/9#125

Equipment Needed:

- Computers
- Motion tracks and carts
- Scales and massed objects

UNIT 3 OVERVIEW

Content Area: Science

Unit Title: Momentum

Target Course/Grade Level: Physics/Grades 11-12

Unit Summary: In this unit of study, students are expected to plan and conduct investigations, analyze data to develop mathematical relationships and apply scientific ideas to solve design problems. In doing so, students will develop an understanding of ideas related to momentum. Students will also develop an understanding that the total momentum of a system of objects is conserved when there is no net force on the system.

Approximate Length of Unit: 5 weeks

LEARNING TARGETS

NJ Student Learning 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.

Science & Engineering Practices:

Analyzing and Interpreting Data

- Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.

Constructing Explanations and Designing Solutions

- Apply scientific ideas to solve a design problem, taking into account possible unanticipated effects.

Using Mathematics and Computational Thinking

- Use mathematical representations of phenomena to describe explanations.

Disciplinary Core Ideas:

HS-PS2.A

- Newton's second law accurately predicts changes in the motion of macroscopic objects.
- Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object.
- If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system.

- If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system.

Cross-Cutting Concepts:
Cause and Effect

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.
- Systems can be designed to cause a desired effect.

Systems and System Models

- When investigating or describing a system, the boundaries and initial conditions of the system need to be defined.

Career Readiness, Life Literacies, and Key Skills:
9.4.2.TL.7 Describe the benefits of collaborating with others to complete digital tasks or develop digital artifacts.
9.4.12.CI.2 Identify career pathways that highlight personal talents, skills, and abilities.
9.4.12.CI.3 Investigate new challenges and opportunities for personal growth, advancement, and transition.
9.4.12.CT.1 Identify problem-solving strategies used in the development of an innovative product or practice.
9.4.12.DC.7 Evaluate the influence of digital communities on the nature, content and responsibilities of careers, and other aspects of society.
9.4.12.GCA.1 Collaborate with individuals to analyze a variety of potential solutions to climate change effects and determine why some solutions (e.g., political. economic, cultural) may work better than others.
9.4.12.IML.3 Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions.
9.4.12.IML.5 Evaluate, synthesize, and apply information on climate change from various sources appropriately.
9.4.12.IML.7 Develop an argument to support a claim regarding a current workplace or societal/ethical issue such as climate change.
9.4.12.TL.1 Assess digital tools based on features such as accessibility options, capacities, and utility for accomplishing a specified task.
9.4.12.TL.2 Generate data using formula-based calculations in a spreadsheet and draw conclusions about the data.
9.4.12.TL.4 Collaborate in online learning communities or social networks or virtual worlds to analyze and propose a resolution to a real-world problem.

Interdisciplinary Connections and Standards:
ELA
RI.CR.11–12.1 Accurately cite a range of thorough textual evidence and make relevant connections to strongly support a comprehensive analysis of multiple aspects of what an informational text says explicitly and inferentially, as well as interpretations of the text.
RI.MF.11–12.6 Synthesize complex information across multiple sources and formats to develop ideas, resolve conflicting information, or develop an interpretation that goes beyond explicit text information (e.g., express a personal point of view, new interpretation of the concept).
W.AW.11–12.1 Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant and sufficient evidence.
W.SE.11–12.6 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 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.
SL.UM.11–12.5 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest.

Mathematics

N.Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

N.Q.A.2 Define appropriate quantities for the purpose of descriptive modeling.

N.Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

A.SSE.A.1 Interpret expressions that represent a quantity in terms of its context.

A.SSE.B.3 Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression.

A.CED.A.1 Create equations and inequalities in one variable and use them to solve problems.

A.CED.A.2 Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales.

A.CED.A.4 Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.

F.IF.C.7 Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases.

S.ID.A.1 Represent data with plots on the real number line (dot plots, histograms, and box plots).

Unit Understandings:

Students will understand…

- The general relationships between impulse and momentum.
- What it means for a physical quantity to be conserved.
- How to create and interpret diagrams, graphs, and equations that describe the forces, motion, and momentum of objects.
- The relationships between objects experiencing a collision.
- How to define a system and its initial/final states.

Unit Essential Questions:

- How do objects interact during a collision?
- What does it mean for a quantity to be conserved?
- How can we represent and track changes to conserved quantities in a system?
- What impacts the momentum of a system?
- How does a system interact with its surroundings?

Knowledge and Skills:

Students will know...

- Content Vocabulary: momentum, impulse, conservation, system.
- The relationships between objects experiencing a collision.
- The relationships between impulse and momentum.

Students will be able to...

- Create and interpret graphs and equations that describe the momentum and impulse of a system.
- Analyze data to provide experimental evidence for the conservation of momentum.
- Manipulate the equations for impulse, momentum, and kinematics to describe the momentum and motion of an object.

EVIDENCE OF LEARNING

Assessment:
What evidence will be collected and deemed acceptable to show that students truly "understand"?

- End of Unit Common Assessment - See folder for assessment links.
- Formative: warm-up activities, exploratory activities, class discussions, student participation, homework, and exit tickets.
- Summative: quizzes, tests, projects, and student lab reports.

Learning Activities:
What differentiated learning experiences and instruction will enable all students to achieve the desired results?

- The following PHET Colorado online simulations can be used to introduce students to the topic of collisions and momentum: https://phet.colorado.edu/en/simulation/collision-lab
- PUM Lessons: https://drive.google.com/a/southbergenjointure.org/file/d/0B_gIUgkOC7H3bURpa2NuYnl1a3c/view?usp=sharing

RESOURCES

Teacher Resources:

- https://www.nap.edu/read/13165/chapter/9#125

Equipment Needed:

- Computers
- Motion tracks and carts
- Scales and massed objects

UNIT 4 OVERVIEW

Content Area: Science

Unit Title: Energy

Target Course/Grade Level: Physics/Grades 11-12

Unit Summary: In this unit of study, students are expected to plan and conduct investigations, analyze data to develop mathematical relationships, and apply scientific ideas to solve design problems. In doing so, students will develop an understanding of ideas related to energy and its interactions with matter. Students will also develop an understanding of the conservation of energy and apply that understanding to engineering tasks.

Approximate Length of Unit: 6 weeks

LEARNING TARGETS

NJ Student Learning Standards:

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 positions 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.

Science & Engineering Practices:

Developing and Using Models

- Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system.

Constructing Explanations and Designing Solutions

- Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

Using Mathematics and Computational Thinking

- Create a computational model or simulation of a phenomenon, designed device, process, or system.

Disciplinary Core Ideas:

HS-PS3.A: Definitions of Energy

- Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the

fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms.
- At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy.
- These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as a combination of energy associated with the motion of particles and energy associated with the configuration (relative position of the particles). In some cases the relative position energy can be thought of as stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space.

HS-PS3.B: Conservation of Energy and Energy Transfer
- Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system.
- Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems.
- Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g. relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior.
- The availability of energy limits what can occur in any system.

HS-PS3.D: Energy in Chemical Processes
- Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment.

Cross-Cutting Concepts:

Systems and System Models
- Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models.

Energy and Matter
- Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system.
- Energy cannot be created or destroyed—only moves between one place and another place, between objects and/or fields, or between systems.

Career Readiness, Life Literacies, and Key Skills:

9.4.2.TL.7 Describe the benefits of collaborating with others to complete digital tasks or develop digital artifacts.
9.4.12.CI.2 Identify career pathways that highlight personal talents, skills, and abilities.
9.4.12.CI.3 Investigate new challenges and opportunities for personal growth, advancement, and transition.
9.4.12.CT.1 Identify problem-solving strategies used in the development of an innovative product or practice.
9.4.12.DC.7 Evaluate the influence of digital communities on the nature, content and responsibilities of careers, and other aspects of society.
9.4.12.GCA.1 Collaborate with individuals to analyze a variety of potential solutions to climate change effects and determine why some solutions (e.g., political. economic, cultural) may work better than others.
9.4.12.IML.3 Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions.
9.4.12.IML.5 Evaluate, synthesize, and apply information on climate change from various sources appropriately.
9.4.12.IML.7 Develop an argument to support a claim regarding a current workplace or societal/ethical issue such as climate change.
9.4.12.TL.1 Assess digital tools based on features such as accessibility options, capacities, and utility for accomplishing a specified task.
9.4.12.TL.2 Generate data using formula-based calculations in a spreadsheet and draw conclusions about the data.

9.4.12.TL.4 Collaborate in online learning communities or social networks or virtual worlds to analyze and propose a resolution to a real-world problem.

Interdisciplinary Connections and Standards:

ELA

RI.CR.11–12.1 Accurately cite a range of thorough textual evidence and make relevant connections to strongly support a comprehensive analysis of multiple aspects of what an informational text says explicitly and inferentially, as well as interpretations of the text.

RI.MF.11–12.6 Synthesize complex information across multiple sources and formats to develop ideas, resolve conflicting information, or develop an interpretation that goes beyond explicit text information (e.g., express a personal point of view, new interpretation of the concept).

W.AW.11–12.1 Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant and sufficient evidence.

W.SE.11–12.6 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 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.

SL.UM.11–12.5 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest.

Mathematics

N.Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

N.Q.A.2 Define appropriate quantities for the purpose of descriptive modeling.

N.Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

A.SSE.A.1 Interpret expressions that represent a quantity in terms of its context.

A.SSE.B.3 Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression.

A.CED.A.1 Create equations and inequalities in one variable and use them to solve problems.

A.CED.A.2 Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales.

A.CED.A.4 Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.

F.IF.C.7 Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases.

S.ID.A.1 Represent data with plots on the real number line (dot plots, histograms, and box plots).

Unit Understandings:

Students will understand…

- The total energy of a system is conserved.
- Conserved quantities are not necessarily constant quantities, depending on the choice of system.
- How to create and interpret diagrams, graphs, and equations that describe the energy, motion, and other properties of a system.
- How to define a system and its initial/final states.
- How to relate a macroscopic observation of temperature or sound to the motion of particles at the submicroscopic scale.

Unit Essential Questions:

- How do the different types of energy describe different aspects/states of a system?
- What does it mean for a quantity to be conserved?
- How can we represent and track changes to conserved quantities in a system?
- How does a system interact with its surroundings?
- How can energy be converted into forms that are advantageous to society?

Knowledge and Skills:

Students will know...

- Content Vocabulary: kinetic energy, internal energy, potential energy, conservation, system
- How to quantify energy with mathematical relationships.
- How to describe different states with different forms of energy.

Students will be able to...

- Create and interpret graphs and equations that describe the energy and net change of a system.
- Analyze data to provide experimental evidence for the conservation of energy.
- Develop a mathematical model to illustrate the energy changes in a system.
- Utilize an energy perspective to describe and predict an object's motion.

EVIDENCE OF LEARNING

Assessment:

What evidence will be collected and deemed acceptable to show that students truly "understand"?

- End of Unit Common Assessment - See folder for assessment links.
- Formative: warm-up activities, exploratory activities, class discussions, student participation, homework, and exit tickets.
- Summative: quizzes, tests, projects, and student lab reports.

Learning Activities:

What differentiated learning experiences and instruction will enable all students to achieve the desired results?

- The following PHET Colorado online simulations can be used to introduce students to the topic of energy: https://phet.colorado.edu/en/simulation/energy-skate-park
- Video: Energy Lost When a Ball Bounces: https://www.youtube.com/watch?v=ZSOxVwTv58Q
- Skatepark Energy: Explore a skateboard simulation: http://betterlesson.com/lesson/638233/skate-parkenergy
- Skatepark Energy Revisited: Students determine how friction and the shape of the ramp impact the transformation of potential into kinetic energy: http://betterlesson.com/lesson/638235/skate-park-energyrevisited
- Venn Diagram of Kinetic and Potential Energies: http://betterlesson.com/lesson/638234/venn-diagram-of-kinetic-and-potential-energies
- Simple Pendulum Lab: https://phet.colorado.edu/en/contributions/view/3591
- Swinging Pendulum: https://www.teachengineering.org/Activities/view/cub_energy_lesson03_activity2 http://www.ck12.org/ngss/high-school-physical-sciences/energy/
- PUM Lessons: https://drive.google.com/a/southbergenjointure.org/file/d/0B_gIUgkOC7H3bURpa2NuYnl1a3c/view?usp=sharing

RESOURCES

Teacher Resources:

- https://www.nap.edu/read/13165/chapter/9#125

Equipment Needed:

- Computers
- Scales and massed objects
- Timers

UNIT 5 OVERVIEW

Content Area: Science

Unit Title: Circular Motion and Universal Gravitation

Target Course/Grade Level: Physics/Grades 11-12

Unit Summary: In this unit of study, students are expected to plan and conduct investigations, analyze data to develop mathematical relationships and apply scientific ideas to solve design problems. In doing so, students will develop an understanding of ideas related to circular motion. Students will also build an understanding of Newton's Law of Gravitation and predict the gravitational forces exerted on one object by another.

Approximate Length of Unit: 6 weeks

LEARNING TARGETS

NJ Student Learning 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-PS2-4 Use mathematical representations of Newton's Law of Gravitation to describe and predict the gravitational forces between objects.

Science & Engineering Practices:

Analyzing and Interpreting Data

- Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.

Using Mathematics and Computational Thinking

- Use mathematical representations of phenomena to describe explanations.

Disciplinary Core Ideas:

HS-PS2.A: Forces and Motion

- Newton's second law accurately predicts changes in the motion of macroscopic objects.

HS-PS2.B: Types of Interactions

- Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects.
- Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields.

Cross-Cutting Concepts:

Patterns

- Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.

Cause and Effect

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

Career Readiness, Life Literacies, and Key Skills:

9.4.2.TL.7 Describe the benefits of collaborating with others to complete digital tasks or develop digital artifacts.
9.4.12.CI.2 Identify career pathways that highlight personal talents, skills, and abilities.
9.4.12.CI.3 Investigate new challenges and opportunities for personal growth, advancement, and transition.
9.4.12.CT.1 Identify problem-solving strategies used in the development of an innovative product or practice.
9.4.12.DC.7 Evaluate the influence of digital communities on the nature, content and responsibilities of careers, and other aspects of society.
9.4.12.GCA.1 Collaborate with individuals to analyze a variety of potential solutions to climate change effects and determine why some solutions (e.g., political. economic, cultural) may work better than others.
9.4.12.IML.3 Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions.
9.4.12.IML.5 Evaluate, synthesize, and apply information on climate change from various sources appropriately.
9.4.12.IML.7 Develop an argument to support a claim regarding a current workplace or societal/ethical issue such as climate change.
9.4.12.TL.1 Assess digital tools based on features such as accessibility options, capacities, and utility for accomplishing a specified task.
9.4.12.TL.2 Generate data using formula-based calculations in a spreadsheet and draw conclusions about the data.
9.4.12.TL.4 Collaborate in online learning communities or social networks or virtual worlds to analyze and propose a resolution to a real-world problem.

Interdisciplinary Connections and Standards:

ELA

RI.CR.11–12.1 Accurately cite a range of thorough textual evidence and make relevant connections to strongly support a comprehensive analysis of multiple aspects of what an informational text says explicitly and inferentially, as well as interpretations of the text.
RI.MF.11–12.6 Synthesize complex information across multiple sources and formats to develop ideas, resolve conflicting information, or develop an interpretation that goes beyond explicit text information (e.g., express a personal point of view, new interpretation of the concept).
W.AW.11–12.1 Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant and sufficient evidence.
W.SE.11–12.6 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 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.
SL.UM.11–12.5 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest.

Mathematics

N.Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
N.Q.A.2 Define appropriate quantities for the purpose of descriptive modeling.
N.Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
A.SSE.A.1 Interpret expressions that represent a quantity in terms of its context.
A.SSE.B.3 Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression.
A.CED.A.1 Create equations and inequalities in one variable and use them to solve problems.

A.CED.A.2 Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales.
A.CED.A.4 Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.
F.IF.C.7 Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases.
S.ID.A.1 Represent data with plots on the real number line (dot plots, histograms, and box plots).

Unit Understandings:
Students will understand…

- How Newton's laws apply to situations involving circular motion at constant speed.
- The direction of acceleration for an object experiencing circular motion at constant speed.
- How to apply Newton's third law pairs to the Law of Universal Gravitation.
- The relationships between mass, radius, and gravitational force.

Unit Essential Questions:

- What does it mean when we say something is 'weightless' in space?
- How do different points on a wheel move?
- How can water stay in a bucket while it's spun upside down?

Knowledge and Skills:
Students will know...

- Content Vocabulary: acceleration, radial acceleration, speed, velocity, circular motion, radius, period.
- The direction of acceleration and net force force of an object in circular motion at a constant speed.
- How to use the mathematical expression of Newton's second law for circular motion.
- How the radius and mass of each object impact the gravitational forces exerted on each.

Students will be able to...

- Gather experimental evidence to determine the direction of acceleration of an object experiencing circular motion at a constant speed.
- Use experimental data to determine the net force exerted on an object experiencing circular motion at a constant speed.
- Apply the mathematical expression of the Law of Universal Gravitation to describe planetary orbits.

EVIDENCE OF LEARNING

Assessment:
What evidence will be collected and deemed acceptable to show that students truly "understand"?

- End of Unit Common Assessment - See folder for assessment links.
- Formative: warm-up activities, exploratory activities, class discussions, student participation, homework, and exit tickets.
- Summative: quizzes, tests, projects, and student lab reports.

Learning Activities:

What differentiated learning experiences and instruction will enable all students to achieve the desired results?

- The following PHET Colorado online simulations can be used to introduce students to the topic of circular motion and universal gravitation: https://phet.colorado.edu/en/simulations/rotation and https://phet.colorado.edu/en/simulations/gravity-force-lab
- PUM Lessons: https://drive.google.com/a/southbergenjointure.org/file/d/0B_gIUgkOC7H3bURpa2NuYnl1a3c/view?usp=sharing

RESOURCES

Teacher Resources:

- https://www.nap.edu/read/13165/chapter/9#125

Equipment Needed:

- Computers
- massed objects and scales
- spinning platform
- flying pigs

UNIT 6 OVERVIEW

Content Area: Science

Unit Title: Electricity and Magnetism

Target Course/Grade Level: Physics/Grades 11-12

Unit Summary: In this unit of study, students are expected to plan and conduct investigations, analyze data to develop mathematical relationships, and apply scientific ideas to solve design problems. In doing so, students will develop an understanding of ideas related to electrostatics and magnetism. Students will also build an understanding of how objects interact with electrical and magnetic fields.

Approximate Length of Unit: 6 weeks

LEARNING TARGETS

NJ Student Learning Standards:

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-PS2-5 Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current.

HS-PS3-5 Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.

Science & Engineering Practices:

Using Mathematics and Computational Thinking

- Use mathematical representations of phenomena to describe explanations.

Planning and Carrying Out Investigations

- Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.

Developing and Using Models

- Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system.

Disciplinary Core Ideas:

HS-PS2.B: Types of Interactions

- Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects.
- Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields.

HS-PS3.A: Definitions of Energy

- "Electrical energy" may mean energy stored in a battery or energy transmitted by electric currents.

HS-PS3.C: Relationship Between Energy and Forces

- When two objects interacting through a field change relative position, the energy stored in the field is changed.

Cross-Cutting Concepts:

Patterns

- Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.

Cause and Effect

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.
- Cause and effect relationships can be suggested and predicted for complex natural and human-designed systems by examining what is known about smaller-scale mechanisms within the system.

Career Readiness, Life Literacies, and Key Skills:

9.4.2.TL.7 Describe the benefits of collaborating with others to complete digital tasks or develop digital artifacts.
9.4.12.CI.2 Identify career pathways that highlight personal talents, skills, and abilities.
9.4.12.CI.3 Investigate new challenges and opportunities for personal growth, advancement, and transition.
9.4.12.CT.1 Identify problem-solving strategies used in the development of an innovative product or practice.
9.4.12.DC.7 Evaluate the influence of digital communities on the nature, content and responsibilities of careers, and other aspects of society.
9.4.12.GCA.1 Collaborate with individuals to analyze a variety of potential solutions to climate change effects and determine why some solutions (e.g., political. economic, cultural) may work better than others.
9.4.12.IML.3 Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions.
9.4.12.IML.5 Evaluate, synthesize, and apply information on climate change from various sources appropriately.
9.4.12.IML.7 Develop an argument to support a claim regarding a current workplace or societal/ethical issue such as climate change.
9.4.12.TL.1 Assess digital tools based on features such as accessibility options, capacities, and utility for accomplishing a specified task.
9.4.12.TL.2 Generate data using formula-based calculations in a spreadsheet and draw conclusions about the data.
9.4.12.TL.4 Collaborate in online learning communities or social networks or virtual worlds to analyze and propose a resolution to a real-world problem.

Interdisciplinary Connections and Standards:

ELA

RI.CR.11–12.1 Accurately cite a range of thorough textual evidence and make relevant connections to strongly support a comprehensive analysis of multiple aspects of what an informational text says explicitly and inferentially, as well as interpretations of the text.
RI.MF.11–12.6 Synthesize complex information across multiple sources and formats to develop ideas, resolve conflicting information, or develop an interpretation that goes beyond explicit text information (e.g., express a personal point of view, new interpretation of the concept).
W.AW.11–12.1 Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant and sufficient evidence.
W.SE.11–12.6 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 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.

SL.UM.11–12.5 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest.

Mathematics

N.Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

N.Q.A.2 Define appropriate quantities for the purpose of descriptive modeling.

N.Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

A.SSE.A.1 Interpret expressions that represent a quantity in terms of its context.

A.SSE.B.3 Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression.

A.CED.A.1 Create equations and inequalities in one variable and use them to solve problems.

A.CED.A.2 Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales.

A.CED.A.4 Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.

F.IF.C.7 Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases.

S.ID.A.1 Represent data with plots on the real number line (dot plots, histograms, and box plots).

Unit Understandings:

Students will understand…

- That field interactions can be used to explain forces exerted at a distance.
- The difference between magnetic and electrostatic attraction.
- How field interactions impact the potential energy of a system.

Unit Essential Questions:

- What is electric charge?
- How are magnetic poles different from electric charges?
- What does it mean to ground something?
- Why is it safe to be in a car during a lightning strike?

Knowledge and Skills:

Students will know...

- Content Vocabulary: electric charge, electric force, magnetic pole, fields, Coulomb's Law, current.
- How electrical forces are described with charges.
- The relationships between charge, distance, and electrical force.
- How to use the right-hand rules to describe situations with magnetic fields.

Students will be able to...

- Describe the interactions of charged and neutral objects using charge distribution.
- Use diagrams, graphs, and mathematical expressions to describe the forces and potential energy of objects.
- Use the concept of fields to describe the concept of shielding.
- Compare and contrast electric and magnetic fields.
- Describe the experimental evidence that shows moving charged particles produce magnetic fields and vice versa.

EVIDENCE OF LEARNING

Assessment:
What evidence will be collected and deemed acceptable to show that students truly "understand"?

- End of Unit Common Assessment - See folder for assessment links.
- Formative: warm-up activities, exploratory activities, class discussions, student participation, homework, and exit tickets.
- Summative: quizzes, tests, projects, and student lab reports.

Learning Activities:
What differentiated learning experiences and instruction will enable all students to achieve the desired results?

- The following PHET Colorado online simulations can be used to introduce students to the topic of electromagnetic induction: https://phet.colorado.edu/en/simulations/faradays-electromagnetic-lab/about
- https://phet.colorado.edu/en/simulation/electric-hockey
- Universe and More electrostatics game: https://universeandmore.com/
- Understanding Electromagnetic Induction: https://www.youtube.com/watch?v=tC6E9J925pY
- DC Motor: How it Works: https://www.youtube.com/watch?v=LAtPHANEfQo
- Magnetic Field Investigation: In this lab you will investigate the properties of magnetic fields around a bar magnet:
- Magnetism and Electricity Lab: In this activity, students will be charged with building a better electromagnet.
- Explaining Electrical Conductivity in Neurons: Neurons are specialized to conduct electrical impulses using varied ion concentrations. https://www.youtube.com/watch?v=bS_N-nMiqnM
- PUM Lessons: https://drive.google.com/a/southbergenjointure.org/file/d/0B_gIUgkOC7H3bURpa2NuYnl1a3c/view?usp=sharing

RESOURCES

Teacher Resources:

- https://www.nap.edu/read/13165/chapter/9#125

Equipment Needed:

- Computers
- magnets
- electrostatics kits
- light bulbs

UNIT 7 OVERVIEW

Content Area: Science

Unit Title: Wave Properties and Electromagnetic Radiation

Target Course/Grade Level: Physics/Grades 11-12

Unit Summary: In this unit of study, students are expected to plan and conduct investigations, analyze data to develop mathematical relationships, and apply scientific ideas to solve design problems. In doing so, students will develop an understanding of electromagnetic waves and their properties. Students will also build an understanding of how electromagnetic waves are useful to society.

Approximate Length of Unit: 6 weeks

LEARNING TARGETS

NJ Student Learning Standards:

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

HS-PS4-2 Evaluate questions about the advantages of using a digital transmission and storage of information.

HS-PS4-3 Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other.

HS-PS4-5 Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.

Science & Engineering Practices:

Using Mathematics and Computational Thinking

- Use mathematical representations of phenomena or design solutions to describe and/or support claims and/or explanations

Asking Questions and Defining Problems

- Evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set, or the suitability of a design.

Engaging in Argument from Evidence

- Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments.

Obtaining, Evaluating, and Communicating Information

- Communicate technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).

Disciplinary Core Ideas:

HS-PS4.A: Wave Properties

- The wavelength and frequency of a wave are related to one another by the speed of travel of the wave, which depends on the type of wave and the medium through which it is passing.
- Information can be digitized (e.g., a picture stored as the values of an array of pixels); in this form, it can be stored reliably in computer memory and sent over long distances as a series of wave pulses.
- Waves can add or cancel one another as they cross, depending on their relative phase (i.e., relative position of peaks and troughs of the waves), but they emerge unaffected by each other.

HS-PS4.B: Electromagnetic Radiation

- Electromagnetic radiation (e.g., radio, microwaves, light) can be modeled as a wave of changing electric and magnetic fields or as particles called photons. The wave model is useful for explaining many features of electromagnetic radiation, and the particle model explains other features.
- Photoelectric materials emit electrons when they absorb light of a high enough frequency.

HS-PS4.C: Information Technologies and Instrumentation

- Multiple technologies based on the understanding of waves and their interactions with matter are part of everyday experiences in the modern world (e.g., medical imaging, communications, scanners) and in scientific research. They are essential tools for producing, transmitting, and capturing signals and for storing and interpreting the information contained in them.

Cross-Cutting Concepts:

Cause and Effect

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.
- Systems can be designed to cause a desired effect.

Stability and Change

- Systems can be designed for greater or lesser stability.

Systems and System Models

- Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales.

Career Readiness, Life Literacies, and Key Skills:

9.4.2.TL.7 Describe the benefits of collaborating with others to complete digital tasks or develop digital artifacts.
9.4.12.CI.2 Identify career pathways that highlight personal talents, skills, and abilities.
9.4.12.CI.3 Investigate new challenges and opportunities for personal growth, advancement, and transition.
9.4.12.CT.1 Identify problem-solving strategies used in the development of an innovative product or practice.
9.4.12.DC.7 Evaluate the influence of digital communities on the nature, content and responsibilities of careers, and other aspects of society.
9.4.12.GCA.1 Collaborate with individuals to analyze a variety of potential solutions to climate change effects and determine why some solutions (e.g., political. economic, cultural) may work better than others.
9.4.12.IML.3 Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions.
9.4.12.IML.5 Evaluate, synthesize, and apply information on climate change from various sources appropriately.
9.4.12.IML.7 Develop an argument to support a claim regarding a current workplace or societal/ethical issue such as climate change.
9.4.12.TL.1 Assess digital tools based on features such as accessibility options, capacities, and utility for accomplishing a specified task.
9.4.12.TL.2 Generate data using formula-based calculations in a spreadsheet and draw conclusions about the data.

9.4.12.TL.4 Collaborate in online learning communities or social networks or virtual worlds to analyze and propose a resolution to a real-world problem.

Interdisciplinary Connections and Standards:

ELA

RI.CR.11–12.1 Accurately cite a range of thorough textual evidence and make relevant connections to strongly support a comprehensive analysis of multiple aspects of what an informational text says explicitly and inferentially, as well as interpretations of the text.

RI.MF.11–12.6 Synthesize complex information across multiple sources and formats to develop ideas, resolve conflicting information, or develop an interpretation that goes beyond explicit text information (e.g., express a personal point of view, new interpretation of the concept).

W.AW.11–12.1 Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant and sufficient evidence.

W.SE.11–12.6 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 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.

SL.UM.11–12.5 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest.

Mathematics

N.Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

N.Q.A.2 Define appropriate quantities for the purpose of descriptive modeling.

N.Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

A.SSE.A.1 Interpret expressions that represent a quantity in terms of its context.

A.SSE.B.3 Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression.

A.CED.A.1 Create equations and inequalities in one variable and use them to solve problems.

A.CED.A.2 Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales.

A.CED.A.4 Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.

F.IF.C.7 Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases.

S.ID.A.1 Represent data with plots on the real number line (dot plots, histograms, and box plots).

Unit Understandings:

Students will understand…

- The relationships between frequency, speed, and wavelength of a wave.
- Electromagnetic radiation can be described by wave models or particle models.
- That visible light is a small part of the electromagnetic spectrum.

Unit Essential Questions:

- Why are multiple models used to describe electromagnetic radiation?
- How do solar cells produce electrical energy from light?
- How are radio and microwaves used for communication?

Knowledge and Skills:
Students will know...

- Content Vocabulary: electromagnetic radiation, light, frequency, wavelength, wave speed, photon, electron.
- The relationships between wavelength, frequency, and wave speed.
- How electromagnetic radiation impacts matter to create electrical currents.

Students will be able to...

- Use mathematical expressions to support claims regarding the wavelength and frequency of a wave.
- Explain the evidence that light acts as a wave and the evidence that light acts as a particle.
- Use experimental evidence and mathematical expressions to evaluate claims relating to electromagnetic radiation and matter.

EVIDENCE OF LEARNING

Assessment:
What evidence will be collected and deemed acceptable to show that students truly "understand"?

- End of Unit Common Assessment - See folder for assessment links.
- Formative: warm-up activities, exploratory activities, class discussions, student participation, homework, and exit tickets.
- Summative: quizzes, tests, projects, and student lab reports.

Learning Activities:
What differentiated learning experiences and instruction will enable all students to achieve the desired results?

- The following PHET Colorado online simulations can be used to introduce students to the topic of electromagnetic waves and the photoelectric effect: https://phet.colorado.edu/en/simulations/radio-waves and https://phet.colorado.edu/en/simulations/photoelectric
- GCSE Science Revision - Types of Waves: https://www.youtube.com/watch?v=w2s2fZr8sqQ
- Making Waves and Determining Mathematical Relationships: Students make waves and find an important relationship between variables: http://betterlesson.com/lesson/639696/making-waves-and-determiningmathematical-relationships
- Wave Lab Stations Day 1: Students participate in lab stations about the wave phenomena: http://betterlesson.com/lesson/639703/wave-lab-stations-day-1
- Wave Lab Stations Day 2: Students will be able to identify the wave phenomena occurring at each station in the lab: http://betterlesson.com/lesson/639704/wave-lab-stations-day-2
- Measuring the Speed of Sound: What is the speed of sound in our classroom? Today, students find out! http://betterlesson.com/lesson/640789/measuring-the-speed-of-sound
- Do Cellphones Cause Brain Tumors? https://www.youtube.com/watch?v=wU5XkhUGzBs
- Electromagnetic Investigations- Day 1: Students will apply this thinking to four big ideas in electromagnetics. http://betterlesson.com/lesson/636830/electromagnetic-investigations-day-1
- Electromagnetic Investigations- Day 2: http://betterlesson.com/lesson/636213/electromagneticinvestigations-day-2
- Electromagnetic Investigations- Day 3: Students will apply this thinking to four big ideas in electromagnetics. http://betterlesson.com/lesson/637306/electromagnetic-investigations-day-3

- A Closer Look at Photoelectric Effect Data from different metals show similarities and differences in the photoelectric effect, highlighting fundamental physics phenomena. http://betterlesson.com/lesson/638454/acloser-look-at-photoelectricity
- PUM Lessons: https://drive.google.com/a/southbergenjointure.org/file/d/0B_gIUgkOC7H3bURpa2NuYnl1a3c/view?usp=sharing

RESOURCES

Teacher Resources:

- https://www.nap.edu/read/13165/chapter/9#125

Equipment Needed:

- Computers

UNIT 8 OVERVIEW

Content Area: Science

Unit Title: Physics of Stars and Climate

Target Course/Grade Level: Physics/Grades 11-12

Unit Summary: In this unit of study, students are expected to plan and conduct investigations, analyze data to develop mathematical relationships, and apply scientific ideas to solve design problems. In doing so, students will develop an understanding of electromagnetic waves and their properties. Students will also build an understanding of how electromagnetic waves are useful to society.

Approximate Length of Unit: 6 weeks

LEARNING TARGETS

NJ Student Learning Standards:

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

HS-ESS1-2 Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe.

HS-ESS2-4 Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.

Science & Engineering Practices:

Using Mathematics and Computational Thinking

- Use mathematical representations of phenomena or design solutions to describe and/or support claims and/or explanations

Constructing Explanations and Designing Solutions

- Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.

Developing and Using Models

- Use a model to provide mechanistic accounts of phenomena.

Disciplinary Core Ideas:

HS-PS4.A: Wave Properties

- The wavelength and frequency of a wave are related to one another by the speed of travel of the wave, which depends on the type of wave and the medium through which it is passing.

HS-PS4.B: Electromagnetic Radiation

- Atoms of each element emit and absorb characteristic frequencies of light. These characteristics allow identification of the presence of an element, even in microscopic quantities.

HS-ESS1.A: The Universe and Its Stars

- The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth.
- The Big Bang theory is supported by observations of distant galaxies receding from our own, of the measured composition of stars and non-stellar gasses, and of the maps of spectra of the primordial radiation (cosmic microwave background) that still fills the universe.
- Other than the hydrogen and helium formed at the time of the Big Bang, nuclear fusion within stars produces all atomic nuclei lighter than and including iron, and the process releases electromagnetic energy. Heavier elements are produced when certain massive stars achieve a supernova stage and explode.

HS-ESS2.A: Earth Materials and Systems

- The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun's energy output or Earth's orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles.

HS-ESS2.D: Weather and Climate

- The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space.
- Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate.

Cross-Cutting Concepts:

Cause and Effect

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

Energy and Matter

- Energy cannot be created or destroyed–only moved between one place and another place, between objects and/or fields, or between systems.

Career Readiness, Life Literacies, and Key Skills:

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F.IF.C.7 Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases.

S.ID.A.1 Represent data with plots on the real number line (dot plots, histograms, and box plots).

Unit Understandings:

Students will understand…

- How the relationships between frequency, speed, and wavelength of a wave can be used to better understand the observable universe.
- How to interpret spectral data to obtain information about stars.
- How electromagnetic radiation impacts Earth's climate.
- Humans have impacted the processes that control Earth's climate.

Unit Essential Questions:

- How can we gather information from stars across the observable universe?
- How does the speed of light impact our observations of the observable universe?
- What is the greenhouse effect and how is CO_2 important?

Knowledge and Skills:
Students will know...

- Content Vocabulary: electromagnetic radiation, frequency, speed of light, Doppler effect, Cosmic Microwave Background, Big Bang theory, greenhouse effect, reflection, absorption, emission.
- How spectral data is used to determine information about the observable universe.
- How electromagnetic radiation impacts matter to create electrical currents.

Students will be able to...

- Interpret and explain the spectral data observations that support the Big Bang Theory, the expanding universe, and the composition of stars.
- Use physics concepts to explain how the absorption, reflection, and remission of electromagnetic radiation in the atmosphere impact Earth's climate.
- Interpret and explain the data that shows humans have impacted the composition of the atmosphere and reason how these changes impact the climate processes.

EVIDENCE OF LEARNING

Assessment:
What evidence will be collected and deemed acceptable to show that students truly "understand"?

- End of Unit Common Assessment - See folder for assessment links.
- Formative: warm-up activities, exploratory activities, class discussions, student participation, homework, and exit tickets.
- Summative: quizzes, tests, projects, and student lab reports.

Learning Activities:
What differentiated learning experiences and instruction will enable all students to achieve the desired results?

- The following PHET Colorado online simulations can be used to introduce students to the topic of spectral analysis and the greenhouse effect: https://phet.colorado.edu/en/simulations/discharge-lamps, https://phet.colorado.edu/en/simulations/blackbody-spectrum and https://phet.colorado.edu/en/simulations/greenhouse-effect/about
- PUM Lessons: https://drive.google.com/a/southbergenjointure.org/file/d/0B_gIUgkOC7H3bURpa2NuYnl1a3c/view?usp=sharing

RESOURCES

Teacher Resources:

- https://www.nap.edu/read/13165/chapter/9#125

Equipment Needed:

- Computers