Hillside Township School District

High School Science
Physics

Grade 9

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Board of Education Approved:
August 22, 2016

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District Mission Statement

The mission of the Hillside Public Schools is to ensure that all students at all grade levels achieve the Next Generation Science Standards and make connections to real-world success. We are committed to strong parent-community school partnerships, providing a safe, engaging, and effective learning environment, and supporting a comprehensive system of academic and developmental support that meets the unique needs of each individual.

Academic Area Overview

The Hillside Township School District is committed to excellence. We believe that all children are entitled to an education that will equip them to become productive citizens of the twenty-first century. We believe that an education grounded in the fundamental principles of science will provide students with the skills and content necessary to become our future leaders.

A sound science education is grounded in the principles of inquiry and rigor. Children are actively engaged in learning as they model real-world scientific behaviors to construct knowledge. They have ample opportunities to manipulate materials in ways that are developmentally appropriate to their age. They work in an environment that encourages them to take risks, think critically, and make models, note patterns and anomalies in those patterns. Children are encouraged to ask questions, not just the "how" and the "what" of observed phenomena, but also the "why".

Our program provides teachers with cost-effective science materials that are aligned to state and national standards, incorporate instructional strategies that are research-based, and provides teachers with a deep understanding of science and the pedagogical underpinnings of science. Our teachers receive quality professional development through a partnership with nearby districts. Our K-8 kit based program encourages "hands-on science" and is endorsed by the National Science Foundation.

Equality and Equity in Curriculum

The Hillside Township School District ensures that the district's curriculum and instruction are aligned to the Next Generation Science Standards and addresses the elimination of discrimination and the achievement gap, as identified by underperforming school-level AYP reports for State assessment, by providing equity in educational programs and by providing opportunities for students to interact positively with others regardless of race, creed, color, national origin, ancestry, age, marital status, affectional or sexual orientation, gender, religion, disability or socioeconomic status.

N.J.A.C. 6A:7-1.7(b): Section 504, Rehabilitation Act of 1973; N.J.S.A. 10:5; Title IX, Education Amendments of 1972

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Honors Curriculum

The content of an Honors course is organized to include more elaborate, complex, in-depth study of major ideas, problems and themes that integrate knowledge within a given academic subject. Emphasis is placed on higher-level thinking skills, creativity and excellence of performance. Students are selected for honors courses by state test data, previous course grades, and teacher recommendation. These students have been identified as being capable of above-average work. To maintain enrollment in Honor courses, students must maintain a marking period average of 'B' or above. In the event a marking period average falls under a 'B', a review process consisting of the student's counselor seeking input from the teacher regarding the placement of the student will take place. If removal from the Honor course is recommended, a parent conference with the student's counselor and teacher will be conducted.

All science department courses at Hillside High School prepare students with the knowledge and critical thinking skills necessary for study at the college level. The Honors Science courses are designed to support students seeking an additional challenge in their high school coursework, leading to the pursuit of STEM career paths. These honors courses stress the intellectual role of the student as they grapple with key concepts of science in increased depth. Emphasis will be on the analysis and application of data to make sense of major scientific concepts and principles. Students will learn by designing experiments, performing independent research, and working with models of systems at the nanoscopic, microscopic, and macroscopic levels.

To be successful in an Honors Science course, a student must be prepared to work both independently and cooperatively inside and outside of class. Students will also be required to apply more rigorous mathematical skills in Honors science, so it is recommended that students electing to take Honors Science courses have strong grades in their Math coursework. Students succeeding in Honors Science courses are prepared for success at the honors level the following year in the corresponding discipline.

- **In this document, the Honors Level components are indicated in bold purple text.**

Hillside Township School District

Science Department Lesson Plan Template

Lesson Information

Lesson Name: ___________________________
Unit: ___________________________________
Date: ___________________________________

Lesson Data

1. Essential Question:

2. NGSS:

3. DCI :

Students will know……

Students will be able to…..

4. Practices:

5. Crosscutting Concepts:

Students will apply…

6. Assessment:

Evidence of student learning:

7. Lesson Agenda:

Include in Lesson Outline:

- *Anticipated timing*
- *DO*
- *Activities and Investigations*
- *Discussion prompts*
- *Journal wNOW riting prompts*
- *Student uses of technology*
- *Safety precautions*
- *Materials*

8. Homework:

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UNIT 1:
Measurement and Communication in Physics

ENDURING UNDERSTANDINGS	ESSENTIAL QUESTIONS
● Science is the study and discovery of the world around us. ● Science requires the collection and use of evidence. ● Scientific knowledge varies in its level of certainty. ● Scientists work together in a community to share and critique ideas. ● Repeating experiments leads to more reliable and convincing data.	✓ How do we collect data/evidence? ✓ How do we communicate scientific evidence? ✓ How is scientific data represented and analyzed? ✓ How are math practices incorporated in physics?

Students Learning Objectives	**Disciplinary Core Ideas Students will know:**	**Practices of Science & Engineering & Additional Skills Students will be able to:**	**Cross Cutting Concepts Students will apply:**

	Disciplinary Core Ideas	Science and Engineering Practices	Crosscutting Concepts
CCSS.M.MP1 Make sense of problems and persevere while solving them. **CCSS.M.MP2** Reason abstractly and quantitatively. **CCSS.M.MP3** Construct viable arguments and critique the reasoning of others. **CCSS.M.MP4** Model with mathematics. **CCSS-M.MP5** Use appropriate tools strategically. **CCSS-M.MP6** Attend to precision. **HSN.Q.A.1** Use units a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose	**CCSS.M.MP1** • explain to themselves the meaning of a problem and looking for entry points to its solution. • analyze givens, constraints, relationships, and goals. • explain correspondences between equations, verbal descriptions, tables, and graphs. • draw diagrams of important features and relationships, graph data, and search for regularity or trends. • ask themselves, "Does this make sense?" • understand the approaches of others to solving complex problems **CCSS.M.MP2** • make sense of quantities and their relationships in problem situations. • use quantitative reasoning that entails creating a coherent representation of quantities, not just how to compute them • know and flexibly use different properties of operations and objects. **CCSS.M.MP3** • understand and use stated assumptions, definitions, and previously established results in constructing arguments. • make conjectures and build a logical progression of statements to explore the truth of their conjectures. • analyze situations by breaking them into cases • recognize and use counterexamples. • justify their conclusions, communicate them to others, and respond to the arguments of others. • reason inductively about data, making plausible arguments that take into account the context	● Asking questions (for science) and defining problems (for engineering) ○ Ask questions ■ that arise from careful observation of phenomena, or unexpected results, to clarify and/or seek additional information. ■ that arise from examining models or a theory, to clarify and/or seek additional information and relationships. ■ to determine relationships, including quantitative relationships, between independent and dependent variables. ■ to clarify and refine a model, an explanation, or an engineering problem. ● Developing and using models ○ Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system ○ Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems ● Planning and carrying out investigations ○ Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible confounding variables or effects	**Cause and Effect** (pp. 87-89, NRC, 2012) • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-PS2-1) • Systems can be designed to cause a desired effect. (HS-PS2-3) **Scale Proportion and Quantity** (pp. 89-91, NRC, 2012) • The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. **Systems and System Models** (pp. 91-94, NRC, 2012) • When investigating or describing a system, the boundaries and initial conditions of the system need to be defined. (HS-PS2-2) ***Connections to Nature of Science*** **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena** (pp. 96-101, Appendix H: NRC, 2013) • Theories and laws provide explanations in science. (HS-PS2-1) • Laws are statements or descriptions of the relationships among observable phenomena. (HS-PS2-1)

and interpret a scale and the origin in graphs and data displays. **HSA.CED.A.4** Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. **HSF.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	• compare the effectiveness of plausible arguments • distinguish correct logic or reasoning from that which is flawed • listen or read the arguments of others, decide whether they make sense, and ask useful questions **CCSS.M.MP4** • apply the mathematics they know to solve problems arising in everyday life, society, and the workplace. • simplify a complicated situation, realizing that these may need revision later. • identify important quantities in a practical situation • map their relationships using such tools as diagrams, two-way tables, graphs, flowcharts and formulas. • analyze those relationships mathematically to draw conclusions. • interpret their mathematical results in the context of the situation. • reflect on whether the results make sense, possibly improving the model if it has not served its purpose. **CCSS.M.MP5** • consider available tools when solving a mathematical problem. • are familiar with tools appropriate for their grade or course to make sound decisions about when each of these tools • detect possible errors by using estimations and other mathematical knowledge. • know that technology can enable them to visualize the results of varying assumptions, and explore consequences.	and evaluate the investigation's design to ensure variables are controlled. ○ Make directional hypotheses that specify what happens to a dependent variable when an independent variable is manipulated. ● **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. ○ Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible ● **Using mathematics and computational thinking** ○ Apply techniques of algebra and functions to represent and solve scientific and engineering problems ○ Apply ratios, rates, percentages, and unit conversions in the context of complicated measurement problems involving quantities with derived or compound units (such as mg/mL, kg/m3 , acre-feet, etc.). ● **Constructing explanations (for science) and designing solutions (for engineering)** ○ Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables. ○ Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that	

	• identify relevant mathematical resources and use them to pose or solve problems. • use technological tools to explore and deepen their understanding of concepts. **CCSS.M.MP6** • try to communicate precisely to others. • use clear definitions in discussion with others and in their own reasoning. • state the meaning of the symbols they choose, including using the equal sign consistently and appropriately. • specify units of measure and label axes to clarify the correspondence with quantities in a problem. • calculate accurately and efficiently, express numerical answers with a degree of precision appropriate for the context.	describe the natural world operate today as they did in the past and will continue to do so in the future. ○ Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. ○ Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion ● **Engaging in argument from evidence** ○ Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments. ○ Respectfully provide and/or receive critiques on scientific arguments by probing reasoning and evidence, challenging ideas and conclusions, responding thoughtfully to diverse perspectives, and determining additional information required to resolve contradictions. ○ Construct, use, and/or present an oral and written argument or counter-arguments based on data and evidence. ● **Obtaining, evaluating, and communicating information** ○ Compare, integrate and evaluate sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a scientific question or solve a problem ○ Communicate scientific and/or 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 (i.e., orally, graphically, textually, mathematically). **Additional Skills** ● Maintain a Lab Notebook ● Identify major laws and theories within the content area ● Distinguish between the type and amount of certainty expressed by scientific laws, theories, and hypotheses ● Apply scientific laws and theories to authentic situations ● Monitor one's own thinking as understandings of scientific concepts are refined	

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Pacing Chart
Unit 1: <u>Measurement and Communication</u>
Grade 9

TIME FRAME	TOPIC	PERFORMANCE TASKS ACTIVITIES/PROJECTS ASSESSMENTS	RESOURCES/INTERDISCIPLINARY CONNECTIONS
1-2 days	Introduction to Physics	Getting to Know You Bingo Lay of the Land - Classroom Procedures - Where are things in the room? Lab Activity Safety	Getting to Know You Bingo http://1.bp.blogspot.com/-9cb-C-G1C7M/UChXngB1QrI/AAAAAAAAAi4/3jS19deG7vo/s1600/GetToKnowYouBingo5th.jpg http://www.sdcda.org/office/girlsonlytoolkit/toolkit/got-02-getting-to-know-you.pdf Classroom Procedures https://www.dropbox.com/s/jombt3tb2jyyp3j/Classroom%20Procedures.docx?dl=0 Lab Safety https://www.dropbox.com/s/onwr74hlypi8l9r/Flinn%20Safety%20Contract.pdf?dl=0 Reaction Time: https://www.dropbox.com/s/5f8i6d55u1ahnpq/Reaction%20Time%20Lab.notebook?dl=0 http://www.humanbenchmark.com/ Active Physics Lesson https://www.youtube.com/watch?v=pEeEW9ZHx50 Unit Conversion: https://www.youtube.com/watch?v=XKCZn5MLKvk
2-3 days	Making Observations	Wood cylinder Activity Reaction time: - Measuring Reaction time of students grabbing a meter stick. - Measure distance to generate reaction time by reading free fall graph - Calculating Average Measurement Activity - Stations of Measurement (measuring objects with 6 in ruler, 1 foot ruler, and meter stick; measuring weight of individual; measuring item with electronic balance; measuring height of student; measuring "wing span"; measure length and width of table with 1 foot ruler and meter stick)	
	Application of Mathematics	Mathematics Diagnostic Basic Unit System: - Students make Reference Unit Table - Teacher models it on Unit Word Wall	

		- Matching Units Game Calculating average of data set - Calculating their own grade average - Processing the average of student reaction time data Unit Conversion - Metric to Metric - Metric to Standard; Standard to Metric - Converting data from Stations of Measurement - Mathematics Assessment Practical: Measuring length and width of room for wall-to-wall carpeting Graphing and graphical analysis - WIS/WIM - Small Group Activity & Gallery Walk: Student lab groups will receive a piece of graphing chart paper and a set of data to graph. Students will then perform a gallery walk to rate the graphs based on the graphing rubric. - Graphing rubric - Slope - **Mathematical Model** - **y = mx + b**	https://www.dropbox.com/s/4hb5fy7klim4zbb/Measurement%20Assessment%20Practical.docx?dl=0 Simplified for IEP students https://www.youtube.com/watch?v=ppaCtBbwISo https://www.youtube.com/watch?v=XKCZn5MLKvk https://www.youtube.com/watch?v=kkc5f7Gcj8s https://www.youtube.com/watch?v=iwrAvse-ONA https://www.youtube.com/watch?v=HHDmFCxCugc Mathematics Diagnostic: Problem Solving: http://cstephenmurray.com/Acrobatfiles/IPC/ch1and2/WordProblemprimer.pdf https://www.dropbox.com/s/e7h4xa7hh1x5u4s/Problem%20Solving%20Strategies%20for%20NB.JPG?dl=0 Graphing and graphical analysis Small Group Graphing Exercise and Gallery Walk https://www.dropbox.com/s/zt7820g904r1iod/Graphing%20Rubric%20-%20Classroom%20Version.doc?dl=0 http://cstephenmurray.com/Acrobatfiles/aphysics/NotesAndExamples/OneDimensionalMotion/howtofindslope.pdf **Visual Rep Graph Tutotial** https://www.youtube.com/watch?v=9BkbYeTC6Mo **Spreadsheet Graphing** https://www.youtube.com/watch?v=yvYvHU83_6Y **IEP Graphing** https://www.youtube.com/watch?v=GUYRMdcEs00

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UNIT 2 : Forces and Motion

ENDURING UNDERSTANDINGS	ESSENTIAL QUESTIONS
● The change of the position and the change in speed of an object determines its motion. ● In order for motion to change, an unbalanced force must be applied. ● All physical objects in the universe interact with one another. Each interaction happens as a result of some type of force. ● Newton's second law accurately predicts changes in the motion of macroscopic objects, but it requires revision for subatomic scales or for speeds close to the speed of light. Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object. In any system, total momentum is always conserved (p. 116, Framework).	✓ How can we describe motion in the world around us? ✓ How can one predict an object's continued motion, changes in motion, or stability? ✓ How can we describe force in the world around us? ✓ What is affect of forces on objects and an objects motion?

Student Learning Objectives	Disciplinary Core Ideas with Extended Knowledge Students will know:	Practices of Science & Engineering with Additional Skills Students will be able to:	Cross Cutting Concepts Students will apply:

	Disciplinary Core Ideas	Science and Engineering Practices	Crosscutting Concepts
1. Given a graph of position or velocity as a function of time, recognize in what time intervals the position, velocity and acceleration of an object are positive, negative, or zero and sketch a graph of each quantity as a function of time. **HS.PS2.A** *[Clarification Statement: Students should be able to accurately move from one representation of motion to another.]* 2. Represent forces in diagrams or mathematically using appropriately labeled vectors with magnitude, direction, and units during the analysis of a situation. **HS.PS2.A** 3. Understand and apply the relationship between the net force exerted on an object, its inertial mass, and its acceleration to a variety of situations. **HS.PS2.A** 4. 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-PS2-1** *[Clarification Statement: Examples of data could include tables or graphs of position or*	**PS2.A: Forces and Motion** (pp. 114-116, NRC, 2012) ● Newton's second law accurately predicts changes in the motion of macroscopic objects. (SLO 1, 2 & 3),(HS-PS2-1) ● Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object. (SLO 5),(HS-PS2-2) ● 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. (HS-PS2-2),(HS-PS2-3),(SLO 5) **ETS1.A: Defining and Delimiting an Engineering Problem** (pp. 204-206, NRC, 2012) ● Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. *(secondary to HS-PS2-3)* **ETS1.C: Optimizing the Design Solution** (pp. 208-210, NRC, 2012) ● Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed. (HS-PS2-3) **Knowledge**	**Planning and Carrying out Investigations** (pp. 59-61, NRC, 2012) Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models. ● 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. (HS-PS2-1),(HS-PS2-3) **Analyzing and Interpreting Data** (pp. 61-63, NRC, 2012) Analyzing data in 9–12 builds on K–8 and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze 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. (SLO 1, 2 & 3), (HS-PS2-1)	**Cause and Effect** (pp. 87-89, NRC, 2012) ● Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-PS2-1) ● Systems can be designed to cause a desired effect. (HS-PS2-3) **Systems and System Models** (pp. 91-94, NRC, 2012) ● When investigating or describing a system, the boundaries and initial conditions of the system need to be defined. (HS-PS2-2 ***Connections to Nature of Science*** **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena** (pp. 96-101, Appendix H: NRC, 2013) ● Theories and laws provide explanations in science. (HS-PS2-1) ● Laws are statements or descriptions of the relationships among observable phenomena. (HS-PS2-1)

velocity as a function of time for objects subject to a net unbalanced force, such as a falling object, an object rolling down a ramp, or a moving object being pulled by a constant force.] [Assessment Boundary: Assessment is limited to one-dimensional motion and to macroscopic objects moving at non-relativistic speeds.] 5. Predict the change in momentum of an object from the average force exerted on the object and the interval of time during which the force is exerted. **HS.PS2.A** 6. 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-PS2-2** *[Clarification Statement: Emphasis is on the quantitative conservation of momentum in interactions and the qualitative meaning of this principle.] [Assessment Boundary: Assessment is limited to systems of two macroscopic bodies moving in one dimension.]*	• Speed is defined as the distance traveled divided by the time it took to travel that distance and is measured in m/s. (v=d/t) • Velocity incorporates speed and the direction. • Acceleration is defined as the change in velocity divided by the time it took to change that velocity and is measured in m/s^2. (a = v/t) • Newton's first law of motion states that an object at rest will remain at rest or an object in motion will remain in motion unless an unbalanced force is applied. • Inertia is an object's natural tendency to remain in its current state (at rest or in motion) and is directly related to an object's mass. • Newton's Second Law of Motion states that object's acceleration is directly proportional to the force applied to it and inversely proportional to the mass of the object. • The direction of the acceleration is the same as the direction of the unbalanced force. (F=ma) • Friction is a force that opposes motion because of the types of surfaces interacting. • Mass is the amount of matter an object has and is measured in grams.	**Using Mathematics and Computational Thinking** (pp. 64-67, NRC, 2012)Mathematical and computational thinking at the 9–12 level builds on K–8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Use mathematical representations of phenomena to describe explanations. (SLO 1, 2 & 4), (HS-PS2-2) **Constructing Explanations and Designing Solutions** (pp. 67-71, NRC, 2012) Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Apply scientific ideas to solve a design problem, taking into account possible unanticipated effects. (HS-PS2-3)	

7. Make qualitative predictions about natural phenomena based on conservation of momentum and restoration of kinetic energy in elastic collisions. **HS.PS2.A** 8. Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.* **HS-PS2-3** *[Clarification Statement: Examples of evaluation and refinement could include determining the success of the device at protecting an object from damage and modifying the design to improve it. Examples of a device could include a football helmet or a parachute.] [Assessment Boundary: Assessment is limited to qualitative evaluations and/or algebraic manipulations.]*	• Weight is the amount of gravitational pull on an object. (F_w=mg) and is measured in Newtons. • All objects exert a gravitational pull on one another. This pull is relative to the mass of the objects and the distance between them. • Newton's Third Law of Motion states that every force has an equal and opposite reactive force. • Momentum is equal to the object's mass times the object's velocity. (p=mv) • The total momentum of a system remains constant unless an external force is exerted on the system. • Impulse is due to an object external to the system exerting a force on the system object for a given time interval. (I=FΔt)	**Additional Skills** • Create a graph of position vs. time • Interpret a graph of position vs. time • Make a prediction regarding motion based on graphs • Draw strobe photos to represent motion • Use v=d/t to calculate velocity, distance, or time • Apply understanding of speed and velocity to authentic situations • Create a graph of speed vs. time • Interpret a graph of speed vs. time • Make a prediction regarding motion based on graphs • Use a=v/t to calculate acceleration, velocity, or time • Compare the calculated and measured speed, average speed, and acceleration of an object in motion, and account for differences that may exist between calculated and measured values • Apply understanding of acceleration to authentic situations • Draw force diagrams	

		• Interpret force diagrams • Apply Newton's First Law to predict the motion of an object based on the forces applied • Compare the inertia of two objects • Create simple models to demonstrate the benefits of seatbelts using Newton's first law of motion • Apply understanding of inertia to authentic situations • Draw force diagrams • Interpret force diagrams • Use F=ma to explain Newton's Second Law • Use F=ma to calculate force, mass, or acceleration • Use F_w=mg to explain and distinguish between weight and mass • Measure and describe the relationship between the force acting on an object and the resulting acceleration • Compare an object's weight in different gravitational environments • Apply understanding of Newton's Second Law to authentic situations	

		• Draw force diagrams • Interpret force diagrams • Explain Newton's Third Law in student's words • Apply Newton's Third Law to authentic situations • Construct Momentum bar charts. • Identify initial and final states of system. • Learn to apply the ideas of impulse and momentum to the world around us. • Use p=mv to solve for momentum, mass, and velocity • Use I=FΔt to solve for impulse, force, and time interval • Use I=mΔv to solve for impulse, mass, and change in velocity	

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Pacing Chart
Unit 2:Forces and Motion
Grade 9

<table>
<tr><th>TIME FRAME</th><th>TOPIC</th><th>PERFORMANCE TASKS
ACTIVITIES/PROJECTS
ASSESSMENTS</th><th>RESOURCES/INTERDISCIPLINARY CONNECTIONS</th></tr>
<tr><td>3-4 days</td><td>Frames of Reference</td><td>Frames of Reference
- Watching videos on Frames of Reference.
- Observing pictures and determining origin and positive and negative directions within the picture and in real life.

I^2 Strategy of interpreting pictures and graphs
- Reviewing motion diagrams, dot diagrams, x-t graphs and v-t graphs.
- Using “What I See” and “What it means” to develop means of identification of what is in a graph or picture and develop a means of interpretation and making meaning based on what is identified.</td><td rowspan="2">Frames of Reference
YouTube playlist on frame of reference.

Interpreting Time-Distance Matching Activity

Motion/Dot Diagrams

Position-Time Graphs

Speed/Velocity

Connecting Motion/Dot Diagrams, Position-Time Graphs, Velocity-Time Graphs

Acceleration & Free Fall

Force Tutorial for52 IEP

https://www.youtube.com/watch?v=WwMiB30vh4o</td></tr>
<tr><td>4-5 days</td><td>Motion & Dot Diagrams</td><td>- Dot Diagrams
  - Car Oil Problem
    - same size spacing - constant motion
    - different size spacing - changing motion
    - Small Spacing - slow
    - Large Spacing - Fast
    - Changing Spaces -Slow Down & Velocity
- Constant Velocity Claim Evidence Reasoning - Buggie Lab with Sugar Packets/Markers
  - Lab Report on Google Doc & Sheets
  - Create graph using google sheets</td></tr>
</table>

3-4 days	Position-Time Graphing	- Graphing Assignment
		    - Qualitative view on slope
		    - Constant, changing, no slope
		- Graph interpretation Activity: Students will be given 10 cards with position-time graphs, position-time data tables, and motion stories where students will match the respective graph, data table and motion
		- Free Response Assignment: Students will create their own original motion story with corresponding graph and data table.
			Force Description
			https://www.youtube.com/watch?v=uoKo3DbfYZk
			Force Diagrams
			https://www.youtube.com/watch?v=2jYPcj5tQbI
			Free Body Diagrams
			https://www.youtube.com/watch?v=AfQEEymfzaI
			https://www.youtube.com/watch?v=91QYouih4bQ
			Constant Motion
			https://app.discoveryeducation.com/learn/videos/436655CD-DC1A-4039-BD73-51A30610F05A
			FearofPhysics.com

3-4 days	Speed/Velocity	- GUESS method for calculating Velocity, Displacement, & Time
		- Buggy Collision Lab
		    - students develop method for measuring speed
		    - use constant velocity and proportions to predict point of collision	

5-7 days	Connecting motion diagrams to position-time & velocity-time graphs	Multiple Representations Lessons/Activity:
		- Connect Dot Diagrams, x-t graphs, and slope to introduce v-t graphs
		- **Calculate vf, vi, a, and t using vf = vi + at using GUESS METHOD**
		- Toy Car Challenge
		    - students collect velocity data using Beespi velocimeter of Matchbox and Hot Wheels toy cars
		    - graph position-time and velocity-time data using Google Sheets to interpret the average velocity and acceleration of cars.	

7-10 days	Acceleration & Free Fall	Free Fall equation $\Delta x = \frac{1}{2}at^2$ - Hang Time - Students jump with a sticky note and calculate their hang time $t = \sqrt{2g/\Delta x}$ Discrepant Free Fall - Drop a Heavy Object and a Light Object - Students will have to make a prediction and test	

		- **Students will use kinematic equations to determine the acceleration due to gravity.** Soda Bottle Rocket Challenge - Engineering Design project where students will apply their knowledge of hang time to determine how high their rockets will travel. - **Students will complete data table with formulas to calculate time of flight to maximum height, take off speed, and maximum height.**	
30 days	Forces	Force As Interaction - Tennis Ball & Medicine Ball - Represent the forces on the two balls Free Body Diagrams - Make diagram of force on an object using PhET simulation (Force and Motion Basics). - Gallery walk on force diagrams and determining net force. - **Create your own force diagram for students to respond.** Calculating Force - Use of GUESS method to calculate net force and through using Newton's Second Law (F=ma) Newton's Laws of Motion - Identifying which law affects the motion of an object. Friction - Use of PhET Force Motion Basics to see the effects of mass, force, and friction on the acceleration of an object. - Mu of the shoe lab activity to determine the effect of the friction of different flooring to different shoes. Calculating Net Force - Use of force diagram and GUESS method to determine the forces on an object and the net force and acceleration on an object	

		Paper Bridge and Straw Bridge Engineering Design Challenges - Engineering design challenge for students to construct a bridge from 8 ½ x 11 sheets of paper and straws where students will apply their knowledge of forces.	
25 days	Momentum	Calculating impulse and momentum - Use of GUESS method to determine the impulse and momentum using the following: force x time = mass x velocity Law of Conservation of Momentum - Loosing my marble lab: Applying knowledge of momentum of marble collisions going down a ramp - "What happens when two things collide" simulation: Applying knowledge of collision of different vehicles traveling at different velocities. **Calculate and develop a data table of momentum of different vehicles.** Egg Car Crash Engineering Design Challenge - Develop and construct a car that will factor in the impulse-momentum theorem to prevent an egg from getting damaged in a car crash into a wall at the bottom of a ramp.	

UNIT 3: <u>Energy</u>

Hillside Township School District

ENDURING UNDERSTANDINGS	ESSENTIAL QUESTIONS
• Energy is always conserved; it is neither created nor destroyed. • Energy comes in different forms and can change from one form to another. • Energy is the ability of an object to do work.	✓ How can we represent energy in the world around us? ✓ Where does energy go?

NGSS Performance Expectation	Disciplinary Core Ideas Students will know:	Practices of Science & Engineering Students will be able to:	Cross Cutting Concepts Students will apply:
1. Identify and quantify the various types of energies within a system of objects in a well-defined state, such as elastic potential energy, gravitational potential energy, kinetic energy, and thermal energy and represent how these energies may change over time. **PS3.A, PS3.B**	**Disciplinary Core Ideas** **Work & Energy** • Energy is neither created nor destroyed and can change from one form to another. This is the Law of Conservation of Energy. • Potential Energy is energy stored and there are various forms: - Gravitational potential energy is the energy of position. This can be calculated by multiplying the height, mass, and gravitational constant. (GPE= mgh)	**Science and Engineering Practices** • Produce and identify electrically charged objects at the macroscopic scale • Use models and simulations to represent and study a nanoscopic process at a macroscopic scale and develop explanations • Use Coulomb's law to predict or determine the relative electrostatic force between two objects • Account for all charges being conserved in a closed system • Apply understanding of charges to authentic situations	**Crosscutting Concepts** **Cause and Effect** • 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. (HS-PS3-2) **Systems and System Models** • When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. (SLO 2) • Models can be used to predict the behavior of a system, but these predictions have limited precision and

	o Elastic potential energy is energy due to stretch or compression. This can be calculated using the amount of stretch and the spring constant. ($EPE=1/2\ kx^2$) ● Kinetic energy is energy of motion. ($KE= ½\ mv^2$) ● Energy can be transferred from one object to another. ● Energy can be used to do work. ● Work is the force supplied over a certain distance. ($W=Fd$) ● Power is the amount of work done in a certain time. ($P=W/t$) Key Terms: elastic potential energy, energy, gravitational potential energy, kinetic energy, Law of Conservation of Energy, potential energy, power, work		reliability due to the assumptions and approximations inherent in models. (SLO 1 & 2), (HS-PS3-1), (HS-PS3-2) **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. (SLO 2), (HS-PS3-3) ● Energy cannot be created or destroyed—only moves between one place and another place, between objects and/or fields, or between systems. (SLO 2),(HS-PS3-1),(HS-PS3-2) - ***Connections to Engineering, Technology, and Applications of Science*** **Influence of Science, Engineering and Technology on Society and the Natural World** ● Modern civilization depends on major technological systems. Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks. (HS-PS3-3) ***Connections to Nature of Science*** **Scientific Knowledge Assumes an Order and Consistency in Natural Systems**

			• Science assumes the universe is a vast single system in which basic laws are consistent. (HS-PS3-1)
2. Calculate changes in kinetic energy and gravitational potential energy of a system using representations of that system. **PS3.A**			
3. Construct an explanation, using atomic-scale interactions and probability, of how a closed system approaches thermal equilibrium after energy is transferred to it or from it in a thermal process.**PS3.A**			

4. 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-PS3-2** *[Clarification Statement: Examples of phenomena at the macroscopic scale could include the conversion of kinetic energy to thermal energy, the energy stored due to position of an object above the earth, and the energy stored between two electrically-charged plates. Examples of models could include diagrams, drawings, descriptions, and computer simulations.]*			

5. 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-PS3-1***[Clarification Statement: Emphasis is on explaining the meaning of mathematical expressions used in the model.] [Assessment Boundary: Assessment is limited to basic algebraic expressions or computations; to systems of two or three components; and to thermal energy, kinetic energy, and/or the energies in gravitational fields.]*			

Hillside Township School District

Pacing Chart
Unit 3: Energy
Grade 9

TIME FRAME	TOPIC	PERFORMANCE TASKS ACTIVITIES/PROJECTS ASSESSMENTS	RESOURCES/INTERDISCIPLINARY CONNECTIONS
3-4 days	Work and Force	Does the direction of force affect the amount of energy imparted upon an object? - To develop concept that work is related to the magnitude and direction of force. What factors affect the energy of an object and its ability to do work? - Compare factors of height of drop and mass of objects to the size and depth of craters in the sand	Work-Power Lab Work-Power POGIL KE and PE of Marble Collisions KE and PE of Pendulums Car Ramps and Total Mechanical Energy Roller Coaster Physics Energy Skate Park - PhET The Spring of Things - Hooke's Law Lab Catapult Engineering Design Challenge Playlist on Catapults
3-4 days	Kinetic Energy Potential Energy (Gravitational Potential Energy & Elastic Potential)	Use of GUESS method to calculate kinetic energy ($KE = \frac{1}{2} mv^2$) and potential energy (mgh)	
7-10 days	Work and Power	- Use GUESS method to calculate and relate work and power.	

		- Work-Power Lab: Collecting time data on how long it takes to complete certain tasks to determine the amount of work and power is exerted. - Work-Power Processed Oriented Guided Inquiry Lesson (POGIL): Use of models and examples to further reinforce relationship of work, power, and time.	
15-20 days	Law of Conservation of Energy Total Mechanical Energy	KE and PE of Marble Collisions KE and PE of Pendulums Car Ramps and Total Mechanical Energy - Applicaiton of calculating KE and PE change in a system. - Comparing data using Google Sheets to compare changes in KE and PE within a system. Roller Coaster Physics - POGIL exercise using video on Roller Coasters and examples to determine changes in total mechanical energy Using GUESS method to determine KE, PE, and TME within a system Energy Skate Park - PhET simulation to show and model the changes in KE, PE, and TME of a skater on a half-pipe. The Spring of Things - Application of elastic potential energy varying the mass of objects on a spring to determine the spring constant.	
7 days	Engineering Design Challenge: Catapults	Application and synthesis of topics dealing with energy in constructing a siege weapon.	

Hillside Township School District

UNIT 4: Electricity and Magentism

ENDURING UNDERSTANDINGS	ESSENTIAL QUESTIONS
● Forces at a distance are explained by fields permeating space that can transfer energy through space. ● Magnets or changing electric fields cause magnetic fields; electric charges or changing magnetic fields cause electric fields ● Some materials are attracted to each other while other are not ● Both magnets or electric currents cause magnetic fields ● Charges or changing magnetic fields cause electric fields	✓ How do charges interact with electric and magnetic fields? ✓ How can one explain and predict the interactions between objects and within a system of objects?

NGSS Performance Expectation	**Disciplinary Core Ideas Students will know:**	**Practices of Science & Engineering Students will be able to:**	**Cross Cutting Concepts Students will apply:**

1.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. **HS-PS3-5** *[Clarification Statement: Examples of models could include drawings, diagrams, and texts, such as drawings of what happens when two charges of opposite polarity are near each other.] [Assessment Boundary: Assessment is limited to systems containing two objects.]* 2. Use mathematical representations of Coulomb's Law to describe and predict the electrostatic forces between objects. **HS-PS2-4** *[Clarification Statement: Emphasis is on both quantitative and conceptual descriptions of electric fields.]* [Assessment Boundary: Assessment is limited to systems with two objects.*]*	**Disciplinary Core Ideas** **PS2.B: Types of Interactions** ● Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects. (HS-PS2-4) ● Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields. (HS-PS2-4),(HS-PS2-5) ● Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects. (HS-PS2-6) **PS3.A: Definitions of Energy** ● "Electrical energy" may mean energy stored in a battery or energy transmitted by electric currents. *(secondary to HS-PS2-5)* **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. (HS-PS3-5) Knowledge	**Science and Engineering Practices** **Planning and Carrying Out Investigations** Planning and carrying out investigations to answer questions or test solutions to problems in 9–12 builds on K–8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical and empirical models. ● 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. (HS-PS2-5) **Using Mathematics and Computational Thinking** Mathematical and computational thinking at the 9–12 level builds on K–8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. ● Use mathematical representations of phenomena to describe explanations. (HS-PS2-4)	**Crosscutting 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. (HS-PS2-4) **Cause and Effect** ● Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-PS2-5) ● 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. (HS-PS3-5) **Structure and Function** ● Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem. (HS-PS2-6) - ***Connections to Nature of Science*** **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena**

3. Make predictions about the sign and relative quantity of net charge of objects or systems after various charging processes. **PS2.B** 4. Construct an explanation of a model of electric charge, and make a qualitative prediction about the distribution of positive and negative electric charges within neutral systems as they undergo various processes. **PS2.B** *[Clarification Statement: The focus is on the mechanisms that explain conductors and insulators.]* 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-PS2-5***[Assessment Boundary: Assessment is limited to designing and conducting investigations with provided materials and tools.]* 6. Communicate scientific and technical information about why the	• 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. • “Electrical energy” may mean energy stored in a battery or energy transmitted by electric currents. • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. • When two objects interacting through a field change relative position, the energy stored in the field is changed. • Cause-and-effect relationships between electrical and magnetic fields can be predicted through an understanding of inter- and intra-molecular forces (protons and electrons). **Charges** ● Matter is made up of particles at the nanoscopic scale. ● Charges make particles either attract or repel one another. ● There is a special type of electrical force that exists between charged particles. ● Electrostatic forces depend on charge and distance between objects (Coulomb’s Law). This is analogous to the gravitational force that depends on the mass and distance between objects.	**Obtaining, Evaluating, and Communicating Information** Obtaining, evaluating, and communicating information in 9–12 builds on K–8 and progresses to evaluating the validity and reliability of the claims, methods, and designs. ● Communicate scientific and technical information (e.g. about the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). (HS-PS2-6) **Developing and Using Models** Modeling in 9–12 builds on K–8 and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds. ● Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-PS3-5) **Skills** ● Produce and identify electrically charged objects at the macroscopic scale ● Use models and simulations to represent and study a nanoscopic process at a macroscopic scale and develop explanations	● Theories and laws provide explanations in science. (HS-PS2-4) ● Laws are statements or descriptions of the relationships among observable phenomena. (HS-PS2-4)

molecular-level structure is important in the functioning of designed materials.* **HS-PS2-6** *[Clarification Statement: Emphasis is on the attractive and repulsive forces that determine the functioning of the material. Examples could include why electrically conductive materials are often made of metal] [Assessment Boundary: Assessment is limited to provided molecular structures of specific designed materials.]* *[Teacher Note: The emphasis in this unit is on the electrical properties of materials.]* 7. **Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.*** *[Clarification Statement: Emphasis is on both qualitative and quantitative evaluations of devices. Examples of devices could include Rube Goldberg devices, wind turbines, solar cells, solar ovens, and generators.*	• Charge is conserved in a closed system and distributes out to reach equilibrium. Key Terms: charge, closed system, conservation of charge, Coulomb's law, electrostatic force, equilibrium, matter, nanoscopic **Electric Circuits** • Electricity is the movement of charge. • Charges moves through a circuit depending on voltage, current, and number of resistors. • Voltage is the energy in Joules for each Coulomb of charge. • Current is the rate of flow of charge. When charges are flowing, this is kinetic energy. It is measured in amps. • A resistor controls the flow of current. • An electrical circuit is a route along which electricity can flow. In a closed circuit, electricity flows continuously. • In a series circuit, there is only one path the charge can follow. • In a parallel circuit, the charge can take multiple paths. Key Terms: amps, current, closed circuit, Coulomb, electrical circuit, electricity, Joule, resistors, series circuit, open circuit, parallel circuit, voltage	• Use Coulomb's law to predict or determine the relative electrostatic force between two objects • Account for all charges being conserved in a closed system • Apply understanding of charges to authentic situations • Design and create functional electrical systems using circuits • Use electricity equations: V=IR to calculate, voltage, resistance, and current • Compare the utility of parallel and series circuits in an authentic scenario • Plan and conduct an investigation individually and collaboratively to produce data that can serve as the basis for evidence that an electric current can produce a magnetic field. • Plan and conduct an investigation individually and collaboratively to produce data that can serve as the basis for evidence that a changing magnetic field can produce an electric current. • In experimental design, decide on the types, amounts, and accuracy of data needed to produce reliable measurements, consider limitations on the precision of the data, and refine the design accordingly. • Collect empirical evidence to support the claim that an electric current can produce a magnetic field. • Collect empirical evidence to support the claim that a changing magnetic field can produce an electric current.	

Examples of constraints could include use of renewable energy forms and efficiency.] [Assessment Boundary: Assessment for quantitative evaluations is limited to total output for a given input. Assessment is limited to devices constructed with materials provided to students.]		• Develop and use an evidence-based 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. • Suggest and predict cause-and-effect relationships for two objects interacting through electric or magnetic fields.	

Hillside Township School District

Pacing Chart
Unit 4: Electricity and Magnetism
Grade 9

TIME FRAME	TOPIC	PERFORMANCE TASKS ACTIVITIES/PROJECTS ASSESSMENTS	RESOURCES/INTERDISCIPLINARY CONNECTIONS
2 ½ to 3 Weeks	Current Electricity Series and Parallel Circuits Ohm's Law	CER - Making a light bulb turn on: Guided inquiry activity where students will document how to make a bulb light up with a bulb, battery and wire. Use of Direct Current Interactive from physicsclassroom.com to understand how current, voltage and resistance affect each other in both series and parallel circuits both virtual and hands-on. GUESS method to calculate voltage, current, and resistance in a circuit.	John Travoltage Zoom Static Electricity Types of Charging Electrostatics Lab http://www.physicsclassroom.com/Physics-Interactives/Static-Electricity http://www.physicsclassroom.com/Physics-Interactives/Electric-Circuits http://www.physicsclassroom.com/Physics-Interactives/Magnetism https://phet.colorado.edu/en/simulations/category/physics/electricity-magnets-and-circuits NOVA Energy Lab

Hillside Township School District

UNIT 5: Waves and Their Applications

<table>
<tr><th colspan="2">ENDURING UNDERSTANDINGS</th><th colspan="2">ESSENTIAL QUESTIONS</th></tr>
<tr><td colspan="2">● The wavelength and frequency of a wave 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.
● Empirical evidence is required to differentiate between cause and correlation and to make a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.</td><td colspan="2">✓ How are waves used to transfer energy and send and store information?
✓ Why has the digital technology replace the analog technology?</td></tr>
<tr><th>NGSS
Performance Expectation</th><th>Disciplinary Core Ideas
Students will know:</th><th>Practices of Science & Engineering
Students will be able to:</th><th>Cross Cutting Concepts
Students will apply:</th></tr>
<tr><td>1. HS-PS4-1
Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media. [Clarification Statement: Examples of data could include electromagnetic radiation traveling in a vacuum and glass, sound waves traveling through air and water, and seismic waves traveling through the Earth.] [Assessment</td><td>Disciplinary Core Ideas
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-PS4-1)
● 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. (HS-PS4-2),(HS-PS4-5)
PS4.B: Electromagnetic Radiation</td><td>Science and Engineering Practices
Asking Questions and Defining Problems
Asking questions and defining problems in grades 9–12 builds from grades K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations.
● Evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set, or the suitability of a design. (HS-PS4-2)
Using Mathematics and Computational Thinking</td><td>Crosscutting Concepts
Cause and Effect
● Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-PS4-1)
● Systems can be designed to cause a desired effect. (HS-PS4-5)
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</td></tr>
</table>

Boundary: Assessment is limited to algebraic relationships and describing those relationships qualitatively.]	● Photoelectric materials emit electrons when they absorb light of a high-enough frequency. (HS-PS4-5) **Knowledge** • 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. • 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. • Solar cells are human-made devices that capture the sun's energy and produce electrical energy. • 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. • Photoelectric materials emit electrons when they absorb light of a high enough frequency. • 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.	Mathematical and computational thinking at the 9-12 level builds on K-8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. ● Use mathematical representations of phenomena or design solutions to describe and/or support claims and/or explanations. (HS-PS4-1) **Engaging in Argument from Evidence** Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about natural and designed worlds. Arguments may also come from current scientific or historical episodes in science. ● Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments. (HS-PS4-3) **Obtaining, Evaluating, and Communicating Information**	between systems at different scales. (HS-PS4-3) **Stability and Change** ● Systems can be designed for greater or lesser stability. (HS-PS4-2) **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. (HS-ESS1-2) - ***Connections to Engineering, Technology, and Applications of Science*** **Interdependence of Science, Engineering, and Technology** ● Science and engineering complement each other in the cycle known as research and development (R&D). (HS-PS4-5) **Influence of Engineering, Technology, and Science on Society and the Natural World** ● Modern civilization depends on major technological systems. (HS-PS4-2),(HS-PS4-5) ● Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks. (HS-PS4-2)

	• Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. • 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. • Systems for transmission and storage of information can be designed for greater or lesser stability. • Modern civilization depends on systems for transmission and storage of information. • Engineers continuously modify these technological systems for transmission and storage of information by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks.	Obtaining, evaluating, and communicating information in 9–12 builds on K–8 and progresses to evaluating the validity and reliability of the claims, methods, and designs. ● Evaluate the validity and reliability of multiple claims that appear in scientific and technical texts or media reports, verifying the data when possible. (HS-PS4-4) ● 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). (HS-PS4-5) **Constructing Explanations and Designing Solutions** Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. ● 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	- ***Connections to Engineering, Technology, and Applications of Science*** **Interdependence of Science, Engineering, and Technology** ● Science and engineering complement each other in the cycle known as research and development (R&D). Many R&D projects may involve scientists, engineers, and others with wide ranges of expertise. (HS-ESS1-2) - ***Connections to Nature of Science*** **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena** ● A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment and the science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence. (HS-PS4-3) **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** ● Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and they

		laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-ESS1-2) **Skills (Students will be able to)** ● Identify and describe the characteristics of waves, including crests, troughs, speed, frequency, and amplitude ● Identify nodes and antinodes ● Use mathematical representations to show relationships among frequency, wavelength, and speed of waves using or, equivalently. ● Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media. ● Use algebraic relationships to quantitatively describe relationships among the frequency, wavelength, and speed of waves traveling in various media. ● Communicate qualitative 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.	will continue to do so in the future. (HS-ESS1-2) ● Science assumes the universe is a vast single system in which basic laws are consistent. (HS-ESS1-2)

		• Communicate technical information or ideas about technological devices that use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy in multiple formats (including orally, graphically, textually, and mathematically). • Analyze technological devices that use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy by specifying criteria and constraints for successful solutions. • Evaluate a solution offered by technological devices that use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. • Evaluate questions about the advantages of using digital transmission and storage of information by challenging the premise of the advantages of digital transmission and storage of information, interpreting data, and considering the suitability of	

		digital transmission and storage of information. ● Consider advantages and disadvantages in the use of digital transmission and storage of information.	
2 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.*** *[Clarification Statement: Examples could include solar cells capturing light and converting it to electricity; medical imaging; and communications technology.]* [Assessment Boundary: Assessments are limited to qualitative information. Assessments do not include band theory.]			

3 [HS-PS4-2](HS-PS4-2) **Evaluate questions about the advantages of using a digital transmission and storage of information.** *[Clarification Statement: Examples of advantages could include that digital information is stable because it can be stored reliably in computer memory, transferred easily, and copied and shared rapidly. Disadvantages could include issues of easy deletion, security, and theft.]*			

Pacing Chart
Unit 5: Waves and Their Applications
Grade 9

TIME FRAME	TOPIC	PERFORMANCE TASKS ACTIVITIES/PROJECTS ASSESSMENTS	RESOURCES/INTERDISCIPLINARY CONNECTIONS
1 Week	Anatomy of Waves	Students will explore the basics of wave properties. - Amplitude, Period, Wavelength, Frequency, Velocity - Node, AntiNode, Crest, Trough, Guess Method: T = 1/f f = 1/T v = f (λ) **E ~ A^2**	http://theuniverseandmore.com/wp-content/uploads/2015/07/WaveTest_secure.swf

			https://phet.colorado.edu/en/simulations/category/physics/sound-and-waves https://www.youtube.com/watch?v=TdnB6IY1soE
2-3 Days	Wave Addition	Wave interference—A wave tank or computer simulation could be used to illustrate interference. - Constructive & destructive interfrence. - **Standing Waves** - **Tacoma Bridge**	
1-5	Solar Cells	Students will use a solar cell to reason the power of wave energy and its transfer to electricity. - **Extension Solar Cell Car Race**	
1-3 days	Data Transmission	Students will explore the digital tramission of bits.	

Hillside Township School District

Modifications

Teacher Note: Teachers identify the modifications that they will use in the unit. ● Teachers will incorporate the appropriate modifications based on student individualized education plan, IEP, and/or 504 accomodations included but not solely limited to this modification and accomodation list. ● Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA) ● Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community. ● Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling). ● Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies). ● Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences). ● Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings. ● Use project-based science learning to connect science with observable phenomena. ● Structure the learning around explaining or solving a social or community-based issue. ● Provide ELL students with multiple literacy strategies. ● Collaborate with after-school programs or clubs to extend learning opportunities.

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NGSS Resources

(Click on the following to access the following resources.)

High School Physical Sciences, specifically HS.Forces and Interactions, HS.Energy, HS.Waves and Electromagnetic Radiation

Appendix F Science & Engineering Practices

Appendix G Crosscutting Concepts

Appendix I Engineering Design in NGSS

Appendix L Connections to CCCS - Mathematics

Appendix M Connections to CCCS - Literacy in Science and Technical Subjects.