PH | Physics

PH | Unit 1 Measurement and Mathematics through Kinematics

RECOMMENDED TIME: 15 DAYS

Unit Overview:

Fundamental forces govern all the interactions of the universe. The interaction of masses is determined by the gravitational force; the interaction of charges is determined by the electro-weak force; the interaction between particles in the nucleus is controlled by the strong force. Changes in the motion of an object require a force. Newton's laws can be used to explain and predict the motion of an object.

Essential Question:
How can measurement be used to describe an action?

Key Ideas:

Key Idea 5: Energy and matter interact through forces that result in changes in motion.

NYS SCIENCE STANDARDS
http://www.p12.nysed.gov/ciai/mst/sci/documents/phycoresci.pdf

Major Understandings:

Quoted from the New York State Performance Indicators (5.1d)

- An object in linear motion may travel with a constant velocity* or with acceleration*. (5.1d)

(Note: Testing of acceleration will be limited to cases in which acceleration is constant.)

MST STANDARDS
http://www.p12.nysed.gov/ciai/mst/sci/documents/phycoresci.pdf

Standard 6: Interconnectedness: Common Themes

Key Idea 2: Models are simplified representations of objects, structures, or systems used in analysis, explanation, interpretation, or design.

Key Idea 3: The grouping of magnitudes of size, time, frequency, and pressures or other units of measurement into a series of relative order provides a useful way to deal with the immense range and the changes in scale that affect the behavior and design of systems.

Key Idea 5: Identifying patterns of change is necessary for making predictions about future behavior and conditions.

Key Idea 6: In order to arrive at the best solution that meets criteria within constraints, it is often necessary to make trade-offs.

continued

NGSS CROSS-CUTTING CONCEPTS
http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

Patterns:

Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.

- Patterns of performance of designed systems can be analyzed and interpreted to reengineer and improve the system.

Scale, Proportion, and Quantity:

In considering phenomena, it is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change.

- The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs.

continued

	MST STANDARDS http://www.p12.nysed.gov/ciai/mst/sci/documents/phycoresci.pdf	NGSS CROSS-CUTTING CONCEPTS http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf
	Standard 7: Interdisciplinary Problem Solving **Key Idea 1:** The knowledge and skills of mathematics, science, and technology are used together to make informed decisions and solve problems, especially those relating to issues of science/ technology/society, consumer decision making, design, and inquiry into phenomena. **Key Idea 2:** Solving interdisciplinary problems involves a variety of skills and strategies, including effective work habits; gathering and processing information; generating and analyzing ideas; realizing ideas; making connections among the common themes of mathematics, science, and technology; and presenting results.	▪ Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth). **Systems and System Models:** A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems. ▪ 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. ▪ 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. ▪ 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.

COMMON CORE STATE STANDARDS http://www.corestandards.org/wp-content/uploads/ELA_Standards.pdf http://www.corestandards.org/wp-content/uploads/Math_Standards.pdf	ENVIRONMENTAL GUIDELINES FOR LEARNING http://resources.spaces3.com/89c197bf-e630-42b0-ad9a-91f0bc55c72d.pdf	TABLES: REFERENCE TABLES FOR PHYSICAL SETTING/PHYSICS THAT ARE RELEVANT TO THE UNIT http://www.p12.nysed.gov/assessment/reftable/physics-rt/physics06tbl.pdf
ELA/Literacy **RST.11-12.3:** Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, analyze the specific results based on explanations in the text. **RST.11-12.4:** Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to Grades 11–12 texts and topics. **RST.11-12.8:** Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. **RST.11-12.9:** Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. **WHST.9–12.2:** Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes. **WHST.9–12.7:** Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. **WHST.9–12.9:** Draw evidence from informational texts to support analysis, reflection, and research. *continued*	**Strand 1: Questioning, Analysis, and Interpretation Skills** ▪ Guideline A—Questioning—Learners are able to develop, modify, clarify, and explain questions that guide environmental investigations of various types. They understand factors that influence the questions they pose. ▪ Guideline B—Designing investigations—Learners know how to design investigations to answer particular questions about the environment. They are able to develop approaches for investigating unfamiliar types of problems and phenomena. ▪ Guideline C—Collecting information—Learners are able to locate and collect reliable information for environmental investigations of many types. They know how to use sophisticated technology to collect information, including computer programs that access, gather, store, and display data. ▪ Guideline D—Evaluating accuracy and reliability—Learners can apply basic logic and reasoning skills to evaluate completeness and reliability in a variety of information sources. ▪ Guideline E—Organizing information—Learners are able to organize and display information in ways appropriate to different types of environmental investigations and purposes. ▪ Guideline F—Working with models and simulations—Learners are able to create, use, and evaluate models to understand environmental phenomena. *continued*	*[Refer To Appendix D – Reference Tables For Physical Setting/Physics]* Prefixes for Powers of 10 (p1) Geometry and Trigonometry (p5)

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Mathematics **HSN-Q.A.1:** Use units as a way to understand problems and to guide the solution of multistep problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. **HSN-Q.A.2:** Define appropriate quantities for the purpose of descriptive modeling. **HSN-Q.A.3:** Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. **HSA-CED.A.2:** Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. **HSA.CED.A.4:** Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. For example, rearrange Ohm's law V = IR to highlight resistance R. Represent and model with vector quantities. **HSN.VM.A.1:** Recognize vector quantities as having both magnitude and direction. Represent vector quantities by directed line segments, and use appropriate symbols for vectors and their magnitudes (e.g., v, |v|, ||v||, v). **HSN-VM.A.2:** Find the components of a vector by subtracting the coordinates of an initial point from the coordinates of a terminal point. **HSN-VM.A.2:** Solve problems involving velocity and other quantities that can be represented by vectors. **HSN-VM.A.4:** Add and subtract vectors. **HSN-VM.A.5:** Multiply a vector by a scalar.	▪ Guideline G—Drawing conclusions and developing explanations—Learners are able to use evidence and logic in developing proposed explanations that address their initial questions and hypotheses.	

PH | Unit 2 Mechanics

RECOMMENDED TIME: 40 DAYS

Unit Overview:

Fundamental forces govern all the interactions of the universe. The interaction of masses is determined by the gravitational force. Changes in the motion of an object require a force. Newton's laws can be used to explain and predict the motion of an object.

Essential Question:

How are Newton's laws of motion relevant to our lives?

Key Ideas:

Key Idea 1: The Earth and celestial phenomena can be described by principles of relative motion and perspective.

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/sci/documents/phycoresci.pdf

Major Understandings:

Quoted from the New York State Performance Indicators (4.1a, c, d, e, h, 5.1b-h, j, k, l, n-u)

- An object in linear motion may travel with a constant velocity* or with acceleration*. **(5.1d)**

(Note: Testing of acceleration will be limited to cases in which acceleration is constant.)

- A vector may be resolved into perpendicular components.* **(5.1b)**
- The resultant of two or more vectors, acting at any angle, is determined by vector addition. **(5.1c)**
- When the net force on a system is zero, the system is in equilibrium. **(5.1j)**
- An object in free fall accelerates due to the force of gravity.* Friction and other forces cause the actual motion of a falling object to deviate from its theoretical motion. **(5.1e)**

(Note: Initial velocities of objects in free fall may be in any direction.)

continued

MST STANDARDS

http://www.p12.nysed.gov/ciai/mst/sci/documents/phycoresci.pdf

Standard 2: Information Systems

Students will access, generate, process, and transfer information using appropriate technologies.

Key Idea 1: Information technology is used to retrieve, process, and communicate information as a tool to enhance learning.

Standard 6: Interconnectedness: Common Themes

Students will understand the relationships and common themes that connect mathematics, science, and technology and apply the themes to these and other areas of learning.

Key Idea 2: Models are simplified representations of objects, structures, or systems used in analysis, explanation, interpretation, or design.

continued

NGSS CROSS-CUTTING CONCEPTS

http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

Patterns:

Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.

- 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.
- Mathematical representations are needed to identify some patterns.

Scale, Proportion, and Quantity:

In considering phenomena, it is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change.

- The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs.

continued

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▪ According to Newton's First Law, the inertia of an object is directly proportional to its mass. An object remains at rest or moves with constant velocity, unless acted upon by an unbalanced force. **(5.1i)** ▪ According to Newton's Second Law, an unbalanced force causes a mass to accelerate*.**(5.1k)** ▪ According to Newton's Third Law, forces occur in action/reaction pairs. When one object exerts a force on a second, the second exerts a force on the first that is equal in magnitude and opposite in direction. **(5.1q)** ▪ The path of a projectile is the result of the simultaneous effect of the horizontal and vertical components of its motion; these components act independently. **(5.1f)** ▪ A projectile's time of flight is dependent upon the vertical component of its motion. **(5.1g)** ▪ The horizontal displacement of a projectile is dependent upon the horizontal component of its motion and its time of flight. **(5.1h)** ▪ Centripetal force* is the net force which produces centripetal acceleration.* In uniform circular motion, the centripetal force is perpendicular to the tangential velocity. **(5.1n)** ▪ Weight is the gravitational force with which a planet attracts a mass*. The mass of an object is independent of the gravitational field in which it is located. **(5.1l)** ▪ Field strength* and direction are determined using a suitable test particle. **(5.1s)** *(Notes: 1) Calculations are limited to electrostatic and gravitational fields. 2) The gravitational field near the surface of Earth and the electrical field between two oppositely charged parallel plates are treated as uniform.)* *continued*	**Key Idea 3:** The grouping of magnitudes of size, time, frequency, and pressures or other units of measurement into a series of relative order provides a useful way to deal with the immense range and the changes in scale that affect the behavior and design of systems. **Key Idea 4:** Equilibrium is a state of stability due either to a lack of change (static equilibrium) or a balance between opposing forces (dynamic equilibrium). **Key Idea 5:** Identifying patterns of change is necessary for making predictions about future behavior and conditions. **Standard 7: Interdisciplinary Problem Solving** Students will apply the knowledge and thinking skills of mathematics, science, and technology to address real-life problems and make informed decisions. **Key Idea 2:** Solving interdisciplinary problems involves a variety of skills and strategies, including effective work habits; gathering and processing information; generating and analyzing ideas; realizing ideas; making connections among the common themes of mathematics, science, and technology; and presenting results.	▪ Some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly. ▪ Patterns observable at one scale may not be observable or exist at other scales. **Systems and System Models:** A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems. ▪ 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. ▪ 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. **Structure and Function:** The way an object is shaped or structured determines many of its properties and functions. ▪ The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials.

NYS SCIENCE STANDARDS http://www.p12.nysed.gov/ciai/mst/sci/documents/phycoresci.pdf		
▪ Gravitational forces are only attractive, whereas electrical and magnetic forces can be attractive or repulsive. **(5.1t)** ▪ The inverse square law applies to electrical* and gravitational* fields produced by point sources. **(5.1u)** ▪ Work done against friction results in an increase in the internal energy of the system. **(4.1h)** ▪ Kinetic friction* is a force that opposes motion. **(5.1o)** ▪ The impulse* imparted to an object causes a change in its momentum.* **(5.1p)** ▪ Momentum is conserved in a closed system.* **(5.1r)** *(Note: Testing will be limited to momentum in one dimension.)* ▪ All energy transfers are governed by the law of conservation of energy.* **(4.1a)** ▪ Potential energy is the energy an object possesses by virtue of its position or condition. Types of potential energy include gravitational* and elastic.* **(4.1c)** ▪ Kinetic energy* is the energy an object possesses by virtue of its motion. **(4.1d)** ▪ In an ideal mechanical system, the sum of the macroscopic kinetic and potential energies (mechanical energy) is constant.* **(4.1e)** *(Note: Items with asterisks* require quantitative treatment per the Reference Table for Physics. Asterisks following individual words refer to the preceding word or phrase only; asterisks appearing after the final period of a sentence refer to all concepts or ideas presented in the sentence.)*		

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ELA/Literacy **RST.11-12.3:** Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text. **Craft and Structure:** **RST.11-12.4:** Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to Grades 11–12 texts and topics. **RST.11-12.8:** Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. **RST.11-12.9:** Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. **WHST.11-12.7:** Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. **WHST.11-12.9:** Draw evidence from informational texts to support analysis, reflection, and research. *continued*	**Strand 1: Questioning, Analysis, and Interpretation Skills** ▪ Guideline A—Questioning—Learners are able to develop, modify, clarify, and explain questions that guide environmental investigations of various types. They understand factors that influence the questions they pose. ▪ Guideline B—Designing investigations—Learners know how to design investigations to answer particular questions about the environment. They are able to develop approaches for investigating unfamiliar types of problems and phenomena. ▪ Guideline C—Collecting information—Learners are able to locate and collect reliable information for environmental investigations of many types. They know how to use sophisticated technology to collect information, including computer programs that access, gather, store, and display data. ▪ Guideline D—Evaluating accuracy and reliability—Learners can apply basic logic and reasoning skills to evaluate completeness and reliability in a variety of information sources. ▪ Guideline E—Organizing information—Learners are able to organize and display information in ways appropriate to different types of environmental investigations and purposes. ▪ Guideline F—Working with models and simulations—Learners are able to create, use, and evaluate models to understand environmental phenomena. *continued*	*[Refer To Appendix D – Reference Tables For Physical Setting/Physics]* List of Physical Constants (p1) Approximate Coefficients of Friction (p1) Mechanics (p6)

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Mathematics **HSN.Q.A.1:** Use units as a way to understand problems and to guide the solution of multistep problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. **HSN.Q.A.2:** Define appropriate quantities for the purpose of descriptive modeling. **HSN.Q.A.3:** Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. **HSA.CED.A.4:** Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. For example, rearrange Ohm's law V = IR to highlight resistance R. Represent and model with vector quantities. **HSN.VM.A.1:** Recognize vector quantities as having both magnitude and direction. Represent vector quantities by directed line segments, and use appropriate symbols for vectors and their magnitudes (e.g., v, |v|, ||v||, v). **HSN.VM.A.2:** Find the components of a vector by subtracting the coordinates of an initial point from the coordinates of a terminal point. **HSN.VM.A.3:** Solve problems involving velocity and other quantities that can be represented by vectors. Perform operations on vectors. **HSN.VM.B.4:** Add and subtract vectors.	▪ Guideline G—Drawing conclusions and developing explanations—Learners are able to use evidence and logic in developing proposed explanations that address their initial questions and hypotheses. **Strand 2: Knowledge of Environmental Processes and Systems** **Strand 2.1: The Earth as a Physical System** ▪ Guideline A—Processes that shape the Earth—Learners understand the major physical processes that shape the Earth. They can relate these processes, especially those that are large-scale and long-term, to characteristics of the Earth. **Strand 2.4: Environment and Society** ▪ Guideline D—Technology—Learners are able to examine the social and environmental impacts of various technologies and technological systems.	

PH | Unit 3 Energy

RECOMMENDED TIME: 15 DAYS

Unit Overview:

The law of conservation of energy provides one of the basic keys to understanding the universe. The fundamental tenet of this law is that the total mass-energy of the universe is constant; however, energy can be transferred in many ways. Historically, scientists have treated the law of conservation of matter and energy separately. All energy can be classified as either kinetic or potential. When work is done on or by a system, the energy of the system changes. This relationship is known as the work-energy theorem.

Essential Question:
How are work, power, and energy related?

Key Ideas:

Key Idea 4: Energy exists in many forms, and when these forms change, energy is conserved.

NYS SCIENCE STANDARDS
http://www.p12.nysed.gov/ciai/mst/sci/documents/phycoresci.pdf

Major Understandings:

Quoted from the New York State Performance Indicators (4.1a-j, 5.1m, 5.3 f, j)

- When work* is done on or by a system, there is a change in the total energy* of the system. **(4.1g)**
- Work done against friction results in an increase in the internal energy of the system. **(4.1h)**
- Energy may be stored in electric* or magnetic fields. This energy may be transferred through conductors or space and may be converted to other forms of energy. **(4.1j)**
- All energy transfers are governed by the law of conservation of energy.* **(4.1a)**
- Power* is the time-rate at which work is done or energy is expended. **(4.1i)**
- Among other things, mass-energy and charge are conserved at all levels (from subnuclear to cosmic). **(5.3f)**

continued

MST STANDARDS
http://www.p12.nysed.gov/ciai/mst/sci/documents/phycoresci.pdf

Standard 2: Information Systems

Key Idea 1: Information technology is used to retrieve, process, and communicate information as a tool to enhance learning.

Standard 6: Interconnectedness: Common Themes

Key Idea 1: Through systems thinking, people can recognize the commonalities that exist among all systems and how parts of a system interrelate and combine to perform specific functions.

Key Idea 2: Models are simplified representations of objects, structures, or systems used in analysis, explanation, interpretation, or design.

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NGSS CROSS-CUTTING CONCEPTS
http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

Scale, Proportion, and Quantity:

In considering phenomena, it is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change.

- The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs.
- Some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly.
- Patterns observable at one scale may not be observable or exist at other scales.
- Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale.

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▪ The fundamental source of all energy in the universe is the conversion of mass into energy.* **(5.3j)** ▪ Potential energy is the energy an object possesses by virtue of its position or condition. Types of potential energy include gravitational* and elastic.* **(4.1c)** ▪ The elongation or compression of a spring depends upon the nature of the spring (its spring constant) and the magnitude of the applied force.* **(5.1m)** ▪ Kinetic energy* is the energy an object possesses by virtue of its motion. **(4.1d)** ▪ Energy may be converted among mechanical, electromagnetic, nuclear, and thermal forms. **(4.1b)** ▪ In an ideal mechanical system, the sum of the macroscopic kinetic and potential energies (mechanical energy) is constant.* **(4.1e)** ▪ In a non-ideal mechanical system, as mechanical energy decreases there is a corresponding increase in other energies such as internal energy.* **(4.1f)** *(Note: Items with asterisks* require quantitative treatment per the Reference Table for Physics. Asterisks following individual words refer to the preceding word or phrase only; asterisks appearing after the final period of a sentence refer to all concepts or ideas presented in the sentence.)*	**Key Idea 3:** The grouping of magnitudes of size, time, frequency, and pressures or other units of measurement into a series of relative order provides a useful way to deal with the immense range and the changes in scale that affect the behavior and design of systems. **Key Idea 4:** Equilibrium is a state of stability due either to a lack of change (static equilibrium) or a balance between opposing forces (dynamic equilibrium). **Key Idea 6:** In order to arrive at the best solution that meets criteria within constraints, it is often necessary to make trade-offs. **Standard 7: Interdisciplinary Problem Solving** **Key Idea 1:** The knowledge and skills of mathematics, science, and technology are used together to make informed decisions and solve problems, especially those relating to issues of science/ technology/society, consumer decision making, design, and inquiry into phenomena. **Key Idea 2:** Solving interdisciplinary problems involves a variety of skills and strategies, including effective work habits; gathering and processing information; generating and analyzing ideas; realizing ideas; making connections among the common themes of mathematics, science, and technology; and presenting results.	▪ Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth). **Systems and System Models:** A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems. ▪ Systems can be designed to do specific tasks. ▪ 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. ▪ 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. ▪ 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: Flows, Cycles, and Conservation:** Tracking energy and matter flows into, out of, and within systems helps one understand their system's behavior. ▪ The total amount of energy and matter in closed systems is conserved. ▪ 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 moved between one place and another place, between objects and/or fields, or between systems. ▪ Energy drives the cycling of matter within and between systems.	

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ELA/Literacy **RST.11-12.3:** Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text. **RST.11-12.4:** Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to Grades 11-12 texts and topics. **RST.11-12.8:** Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. **RST.11-12.9:** Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. **Mathematics** **HSN.Q.A.1:** Use units as a way to understand problems and to guide the solution of multistep problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. **HSN.Q.A.2:** Define appropriate quantities for the purpose of descriptive modeling. **HSN.Q.A.3:** Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. **HSA.CED.A.2:** Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. *continued*	**Strand 1: Questioning, Analysis, and Interpretation Skills** ▪ Guideline A—Questioning—Learners are able to develop, modify, clarify, and explain questions that guide environmental investigations of various types. They understand factors that influence the questions they pose. ▪ Guideline B—Designing investigations—Learners know how to design investigations to answer particular questions about the environment. They are able to develop approaches for investigating unfamiliar types of problems and phenomena. ▪ Guideline C—Collecting information—Learners are able to locate and collect reliable information for environmental investigations of many types. They know how to use sophisticated technology to collect information, including computer programs that access, gather, store, and display data. ▪ Guideline D—Evaluating accuracy and reliability—Learners can apply basic logic and reasoning skills to evaluate completeness and reliability in a variety of information sources. ▪ Guideline E—Organizing information—Learners are able to organize and display information in ways appropriate to different types of environmental investigations and purposes. ▪ Guideline F—Working with models and simulations—Learners are able to create, use, and evaluate models to understand environmental phenomena. *continued*	*[Refer To Appendix D – Reference Tables For Physical Setting/Physics]* List of Physical Constants (p1) Approximate Coefficients of Friction (p1)

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HSA.CED.A.4: Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. For example, rearrange Ohm's law V = IR to highlight resistance R. Represent and model with vector quantities.	▪ Guideline G—Drawing conclusions and developing explanations—Learners are able to use evidence and logic in developing proposed explanations that address their initial questions and hypotheses. **Strand 2: Knowledge of Environmental Processes and Systems** **Strand 2.1: The Earth as a Physical System** ▪ Guideline A—Processes that shape the Earth—Learners understand the major physical processes that shape the Earth. They can relate these processes, especially those that are large-scale and long-term, to characteristics of the Earth. ▪ Guideline C—Energy—Learners apply their knowledge of energy and matter to understand phenomena in the world around them. **Strand 2.2: The Living Environment** ▪ Guideline D—Flow of matter and energy—Learners are able to account for environmental characteristics based on their knowledge of how matter and energy interact in living systems. **Strand 2.4: Environment and Society** ▪ Guideline A—Human/environment interactions—Learners understand that humans are able to alter the physical environment to meet their needs and that there are limits to the ability of the environment to absorb impacts or meet human needs. ▪ Guideline D—Technology—Learners are able to examine the social and environmental impacts of various technologies and technological systems. ▪ Guideline E—Environmental issues—Learners are familiar with a range of environmental issues at scales that range from local to national to global. They understand that these scales and issues are often linked.

PH | Unit 4 Electricity and Magnetism

RECOMMENDED TIME: 25 DAYS

Unit Overview:

The law of conservation of energy provides one of the basic keys to understanding the universe. The fundamental tenet of this law is that the total mass-energy of the universe is constant; however, energy can be transferred in many ways. Historically, scientists have treated the law of conservation of matter and energy separately. All energy can be classified as either kinetic or potential. When work is done on or by a system, the energy of the system changes. This relationship is known as the work-energy theorem. Energy may be transferred by matter or by waves. Waves transfer energy without transferring mass. Most of the information scientists gather about the universe is derived by detecting and analyzing waves. This process has been enhanced through the use of digital analysis. Types of waves include mechanical and electromagnetic. All waves have the same characteristics and exhibit certain behaviors, subject to the constraints of conservation of energy. Fundamental forces govern all the interactions of the universe. The interaction of charges is determined by the electro-weak force.

Essential Question:
How is electricity related to magnetism?

Key Ideas:

Key Idea 4: Energy exists in many forms, and when these forms change, energy is conserved.

Key Idea 5: Energy and matter interact through forces that result in changes in motion.

NYS SCIENCE STANDARDS
http://www.p12.nysed.gov/ciai/mst/sci/documents/phycoresci.pdf

Major Understandings:

Quoted from the New York State Performance Indicators (4.1a, b, j-p, 5.1s-u, 5.3b, f)

- Gravitational forces are only attractive, whereas electrical and magnetic forces can be attractive or repulsive. **(5.1t)**
- Charge is quantized on two levels. On the atomic level, charge is restricted to multiples of the elementary charge (charge on the electron or proton). On the subnuclear level, charge appears as fractional values of the elementary charge (quarks). **(5.3b)**

continued

MST STANDARDS
http://www.p12.nysed.gov/ciai/mst/sci/documents/phycoresci.pdf

Standard 2: Information Systems

Key Idea 1: Information technology is used to retrieve, process, and communicate information as a tool to enhance learning.

Standard 6: Interconnectedness: Common Themes

Key Idea 1: Through systems thinking, people can recognize the commonalities that exist among all systems and how parts of a system interrelate and combine to perform specific functions.

continued

NGSS CROSS-CUTTING CONCEPTS
http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

Patterns:

Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.

- 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.

continued

NYS SCIENCE STANDARDS http://www.p12.nysed.gov/ciai/mst/sci/documents/phycoresci.pdf	MST STANDARDS http://www.p12.nysed.gov/ciai/mst/sci/documents/phycoresci.pdf	NGSS CROSS-CUTTING CONCEPTS http://www.nextgenscience.org/next-generation-science-standards
▪ Among other things, mass-energy and charge are conserved at all levels (from subnuclear to cosmic). **(5.3f)** ▪ Field strength* and direction are determined using a suitable test particle. **(5.1s)** *(Notes: 1) Calculations are limited to electrostatic and gravitational fields. 2) The gravitational field near the surface of Earth and the electrical field between two oppositely charged parallel plates are treated as uniform.)* ▪ The inverse square law applies to electrical* and gravitational* fields produced by point sources. **(5.1u)** ▪ All materials display a range of conductivity. At constant temperature, common metallic conductors obey Ohm's Law*. **(4.1l)** ▪ A circuit is a closed path in which a current* can exist. **(4.1n)** *(Note: Use conventional current.)* ▪ All energy transfers are governed by the law of conservation of energy.* **(4.1a)** ▪ Energy may be converted among mechanical, electromagnetic, nuclear, and thermal forms. **(4.1b)** ▪ Energy may be stored in electric* or magnetic fields. This energy may be transferred through conductors or space and may be converted to other forms of energy. **(4.1j)** ▪ The factors affecting resistance in a conductor are length, cross-sectional area, temperature, and resistivity.* **(4.1m)** ▪ Circuit components may be connected in series* or in parallel*. Schematic diagrams are used to represent circuits and circuit elements. **(4.1o)** ▪ Electrical power* and energy* can be determined for electric circuits. **(4.1p)** *continued*	**Key Idea 2:** Models are simplified representations of objects, structures, or systems used in analysis, explanation, interpretation, or design. **Key Idea 3:** The grouping of magnitudes of size, time, frequency, and pressures or other units of measurement into a series of relative order provides a useful way to deal with the immense range and the changes in scale that affect the behavior and design of systems. **Key Idea 4:** Equilibrium is a state of stability due either to a lack of change (static equilibrium) or a balance between opposing forces (dynamic equilibrium). **Key Idea 5:** Identifying patterns of change is necessary for making predictions about future behavior and conditions. **Key Idea 6:** In order to arrive at the best solution that meets criteria within constraints, it is often necessary to make trade-offs. **Standard 7: Interdisciplinary Problem Solving** **Key Idea 1:** The knowledge and skills of mathematics, science, and technology are used together to make informed decisions and solve problems, especially those relating to issues of science/ technology/society, consumer decision making, design, and inquiry into phenomena. **Key Idea 2:** Solving interdisciplinary problems involves a variety of skills and strategies, including effective work habits; gathering and processing information; generating and analyzing ideas; realizing ideas; making connections among the common themes of mathematics, science, and technology; and presenting results.	▪ Classifications or explanations used at one scale may fail or need revision when information from smaller or larger scales is introduced; thus requiring improved investigations and experiments. ▪ Patterns of performance of designed systems can be analyzed and interpreted to reengineer and improve the system. ▪ Mathematical representations are needed to identify some patterns. ▪ Empirical evidence is needed to identify patterns. **Scale, Proportion, and Quantity:** In considering phenomena, it is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change. ▪ The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. ▪ Some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly. ▪ Patterns observable at one scale may not be observable or exist at other scales. ▪ Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale. ▪ Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth). *continued*

NYS SCIENCE STANDARDS http://www.p12.nysed.gov/ciai/mst/sci/documents/phycoresci.pdf	NGSS CROSS-CUTTING CONCEPTS http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf
▪ Moving electric charges produce magnetic fields. The relative motion between a conductor and a magnetic field may produce a potential difference in the conductor. **(4.1k)** *(Note: Items with asterisks* require quantitative treatment per the Reference Table for Physics. Asterisks following individual words refer to the preceding word or phrase only; asterisks appearing after the final period of a sentence refer to all concepts or ideas presented in the sentence.)*	**Systems and System Models:** A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems. ▪ Systems can be designed to do specific tasks. ▪ 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. ▪ 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. ▪ 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: Flows, Cycles, and Conservation:** Tracking energy and matter flows into, out of, and within systems helps one understand their system's behavior. ▪ The total amount of energy and matter in closed systems is conserved. ▪ 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 moved between one place and another place, between objects and/or fields, or between systems. ▪ Energy drives the cycling of matter within and between systems. ▪ In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. **Structure and Function:** The way an object is shaped or structured determines many of its properties and functions. ▪ 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. ▪ The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials.

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ELA/Literacy **RST.11-12.3:** Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, analyze the specific results based on explanations in the text. **RST.11-12.4:** Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to Grades 11–12 texts and topics. **RST.11-12.8:** Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. **RST.11-12.9:** Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. **WHST.9–12.2:** Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes. **WHST.9–12.7:** Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. **WHST.9–12.9:** Draw evidence from informational texts to support analysis, reflection, and research. *continued*	**Strand 1: Questioning, Analysis, And Interpretation Skills** ▪ Guideline A—Questioning—Learners are able to develop, modify, clarify, and explain questions that guide environmental investigations of various types. They understand factors that influence the questions they pose. ▪ Guideline B—Designing investigations—Learners know how to design investigations to answer particular questions about the environment. They are able to develop approaches for investigating unfamiliar types of problems and phenomena. ▪ Guideline C—Collecting information—Learners are able to locate and collect reliable information for environmental investigations of many types. They know how to use sophisticated technology to collect information, including computer programs that access, gather, store, and display data. ▪ Guideline D—Evaluating accuracy and reliability—Learners can apply basic logic and reasoning skills to evaluate completeness and reliability in a variety of information sources. ▪ Guideline E—Organizing information—Learners are able to organize and display information in ways appropriate to different types of environmental investigations and purposes. ▪ Guideline F—Working with models and simulations—Learners are able to create, use, and evaluate models to understand environmental phenomena. *continued*	*[Refer to Appendix D – Reference Tables for Physical Setting/Physics]* List of Physical Constants (p1) Electricity (p4) Circuit Symbols (p4) Resistivities at 20°C (p4)

COMMON CORE STATE STANDARDS

http://www.corestandards.org/wp-content/uploads/ELA_Standards.pdf
http://www.corestandards.org/wp-content/uploads/Math_Standards.pdf

Mathematics

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

HSN-Q.A.2: Define appropriate quantities for the purpose of descriptive modeling.

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

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

HSA.CED.A.4: Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. For example, rearrange Ohm's law V = IR to highlight resistance R. Represent and model with vector quantities.

HSN.VM.A.1: Recognize vector quantities as having both magnitude and direction. Represent vector quantities by directed line segments, and use appropriate symbols for vectors and their magnitudes (e.g., v, |v|, ||v||, v).

ENVIRONMENTAL GUIDELINES FOR LEARNING

http://resources.spaces3.com/89c197bf-e630-42b0-ad9a-91f0bc55c72d.pdf

- Guideline G—Drawing conclusions and developing explanations—Learners are able to use evidence and logic in developing proposed explanations that address their initial questions and hypotheses.

Strand 2: Knowledge of Environmental Processes and Systems

Strand 2.1: The Earth as a Physical System

- Guideline A—Processes that shape the Earth—Learners understand the major physical processes that shape the Earth. They can relate these processes, especially those that are large-scale and long-term, to characteristics of the Earth.
- Guideline C—Energy—Learners apply their knowledge of energy and matter to understand phenomena in the world around them.

Strand 2.4: Environment and Society

- Guideline A—Human/environment interactions—Learners understand that humans are able to alter the physical environment to meet their needs and that there are limits to the ability of the environment to absorb impacts or meet human needs.
- Guideline D—Technology—Learners are able to examine the social and environmental impacts of various technologies and technological systems.
- Guideline E—Environmental issues—Learners are familiar with a range of environmental issues at scales that range from local to national to global. They understand that these scales and issues are often linked.

Strand 3: Skills for Understanding and Addressing Environmental Issues

Strand 3.1: Skills for Analyzing and Investigating Environmental Issues

- Guideline A—Identifying and investigating issues—Learners apply their research and analytical skills to investigate environmental issues ranging from local issues to those that are regional or global in scope.
- Guideline B—Sorting out the consequences of issues—Learners are able to evaluate the consequences of specific environmental changes, conditions, and issues for human and ecological systems.
- Guideline C—Identifying and evaluating alternative solutions and courses of action—Learners are able to identify and propose action strategies that are likely to be effective in particular situations and for particular purposes.
- Guideline D—Working with flexibility, creativity, and openness—While environmental issues investigations can bring to the surface deeply held views, learners are able to engage each other in peer review conducted in the spirit of open inquiry.

PH | Unit 5 Waves

RECOMMENDED TIME: 25 DAYS

Unit Overview:

Energy may be transferred by matter or by waves. Waves transfer energy without transferring mass. Most of the information scientists gather about the universe is derived by detecting and analyzing waves. This process has been enhanced through the use of digital analysis. Types of waves include mechanical and electromagnetic. All waves have the same characteristics and exhibit certain behaviors, subject to the constraints of conservation of energy.

Essential Question:

How are waves used to model and explain physical phenomena?

Key Ideas:

Key Idea 4: Energy exists in many forms, and when these forms change, energy is conserved.

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/sci/documents/phycoresci.pdf

Major Understandings:

Quoted from the New York State Performance Indicators (4.1b, 4.3a-n)

- An oscillating system produces waves. The nature of the system determines the type of wave produced. **(4.3a)**
- Waves carry energy and information without transferring mass. This energy may be carried by pulses or periodic waves. **(4.3b)**
- The model of a wave incorporates the characteristics of amplitude, wavelength,* frequency*, period*, wave speed*, and phase. **(4.3c)**
- When a wave strikes a boundary between two media, reflection*, transmission, and absorption occur. A transmitted wave may be refracted. **(4.3h)**
- Mechanical waves require a material medium through which to travel. **(4.3d)**

continued

MST STANDARDS

http://www.p12.nysed.gov/ciai/mst/sci/documents/phycoresci.pdf

Standard 2: Information Systems

Key Idea 1: Information technology is used to retrieve, process, and communicate information as a tool to enhance learning.

Standard 6: Interconnectedness: Common Themes

Key Idea 2: Models are simplified representations of objects, structures, or systems used in analysis, explanation, interpretation, or design.

Key Idea 3: The grouping of magnitudes of size, time, frequency, and pressures or other units of measurement into a series of relative order provides a useful way to deal with the immense range and the changes in scale that affect the behavior and design of systems.

continued

NGSS CROSS-CUTTING CONCEPTS

http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

Patterns:

Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.

- Patterns of performance of designed systems can be analyzed and interpreted to reengineer and improve the system.
- Mathematical representations are needed to identify some patterns.
- Empirical evidence is needed to identify patterns.

Scale, Proportion, and Quantity:

In considering phenomena, it is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change.

continued

NYS SCIENCE STANDARDS http://www.p12.nysed.gov/ciai/mst/sci/documents/phycoresci.pdf	MST STANDARDS http://www.p12.nysed.gov/ciai/mst/sci/documents/phycoresci.pdf	NGSS CROSS-CUTTING CONCEPTS http://www.nextgenscience.org/next-generation-science-standards
▪ Waves are categorized by the direction in which particles in a medium vibrate about an equilibrium position relative to the direction of propagation of the wave, such as transverse and longitudinal waves. **(4.3e)** ▪ Resonance occurs when energy is transferred to a system at its natural frequency. **(4.3f)** ▪ When waves of a similar nature meet, the resulting interference may be explained using the principle of superposition. Standing waves are a special case of interference. **(4.3m)** ▪ When a wave source and an observer are in relative motion, the observed frequency of the waves traveling between them is shifted (Doppler effect). **(4.3n)** ▪ When a wave moves from one medium into another, the wave may refract due to a change in speed. The angle of refraction (measured with respect to the normal) depends on the angle of incidence and the properties of the media (indices of refraction).* **(4.3i)** ▪ The absolute index of refraction is inversely proportional to the speed of a wave.* **(4.3j)** ▪ Diffraction occurs when waves pass by obstacles or through openings. The wavelength of the incident wave and the size of the obstacle or opening affect how the wave spreads out. **(4.3l)**	**Standard 7: Interdisciplinary Problem Solving** **Key Idea 1:** The knowledge and skills of mathematics, science, and technology are used together to make informed decisions and solve problems, especially those relating to issues of science/ technology/society, consumer decision making, design, and inquiry into phenomena. **Key Idea 2:** Solving interdisciplinary problems involves a variety of skills and strategies, including effective work habits; gathering and processing information; generating and analyzing ideas; realizing ideas; making connections among the common themes of mathematics, science, and technology; and presenting results. ▪ Energy may be converted among mechanical, electromagnetic, nuclear, and thermal forms. **(4.1b)** ▪ Electromagnetic radiation exhibits wave characteristics. Electromagnetic waves can propagate through a vacuum. **(4.3g)** ▪ All frequencies of electromagnetic radiation travel at the same speed in a vacuum.* **(4.3k)** *(Note: Items with asterisks* require quantitative treatment per the Reference Table for Physics. Asterisks following individual words refer to the preceding word or phrase only; asterisks appearing after the final period of a sentence refer to all concepts or ideas presented in the sentence.)*	▪ The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. ▪ Some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly. ▪ Patterns observable at one scale may not be observable or exist at other scales. ▪ Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale. ▪ Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth). **Structure and Function:** The way an object is shaped or structured determines many of its properties and functions. ▪ 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. ▪ The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials.

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ELA/Literacy **RST.11-12.3:** Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, analyze the specific results based on explanations in the text. **RST.11-12.4:** Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to Grades 11–12 texts and topics. **RST.11-12.8:** Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. **RST.11-12.9:** Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. **WHST.9–12.2:** Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes. **WHST.9–12.7:** Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. **WHST.9–12.9:** Draw evidence from informational texts to support analysis, reflection, and research. *continued*	**Strand 1: Questioning, Analysis, and Interpretation Skills** ▪ Guideline A—Questioning—Learners are able to develop, modify, clarify, and explain questions that guide environmental investigations of various types. They understand factors that influence the questions they pose. ▪ Guideline B—Designing investigations—Learners know how to design investigations to answer particular questions about the environment. They are able to develop approaches for investigating unfamiliar types of problems and phenomena. ▪ Guideline C—Collecting information—Learners are able to locate and collect reliable information for environmental investigations of many types. They know how to use sophisticated technology to collect information, including computer programs that access, gather, store, and display data. ▪ Guideline D—Evaluating accuracy and reliability—Learners can apply basic logic and reasoning skills to evaluate completeness and reliability in a variety of information sources. ▪ Guideline E—Organizing information—Learners are able to organize and display information in ways appropriate to different types of environmental investigations and purposes. ▪ Guideline F—Working with models and simulations—Learners are able to create, use, and evaluate models to understand environmental phenomena. *continued*	*[Refer to Appendix D – Reference Tables for Physical Setting/Physics]* List of Physical Constants (p1) The Electromagnetic Spectrum (p2) Absolute Indices of Refraction (p2) Waves (p5)

COMMON CORE STATE STANDARDS http://www.corestandards.org/wp-content/uploads/ELA_Standards.pdf http://www.corestandards.org/wp-content/uploads/Math_Standards.pdf	ENVIRONMENTAL GUIDELINES FOR LEARNING http://resources.spaces3.com/89c197bf-e630-42b0-ad9a-91f0bc55c72d.pdf	
Mathematics **HSN-Q.A.1:** Use units as a way to understand problems and to guide the solution of multistep problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. **HSN-Q.A.2:** Define appropriate quantities for the purpose of descriptive modeling. **HSN-Q.A.3:** Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. **HSA.CED.A.2:** Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. **HSA.CED.A.4:** Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. For example, rearrange Ohm's law V = IR to highlight resistance R. Represent and model with vector quantities. **HSN.VM.A.1:** Recognize vector quantities as having both magnitude and direction. Represent vector quantities by directed line segments, and use appropriate symbols for vectors and their magnitudes (e.g., v, |v|, ||v||, v).	▪ Guideline G—Drawing conclusions and developing explanations—Learners are able to use evidence and logic in developing proposed explanations that address their initial questions and hypotheses. **Strand 2: Knowledge of Environmental Processes and Systems** **Strand 2.1: The Earth as a Physical System** ▪ Guideline A—Processes that shape the Earth—Learners understand the major physical processes that shape the Earth. They can relate these processes, especially those that are large-scale and long-term, to characteristics of the Earth. ▪ Guideline C—Energy—Learners apply their knowledge of energy and matter to understand phenomena in the world around them.	

PH | Unit 6 Modern Physics

RECOMMENDED TIME: 20 DAYS

Unit Overview:

Fundamental forces govern all the interactions of the universe. The interaction of masses is determined by the gravitational force; the interaction of charges is determined by the electro-weak force; the interaction between particles in the nucleus is controlled by the strong force. Changes in the motion of an object require a force. Newton's laws can be used to explain and predict the motion of an object. On the atomic level, the quantum nature of the fundamental forces becomes evident. Models of the atom have been developed to incorporate wave-particle duality, quantization, and the conservation laws. These models have been modified to reflect new observations; they continue to evolve. Everyday experiences are manifestations of patterns that repeat themselves, from the subnuclear to the cosmic level. Models that are used at each level reflect these patterns. The future development of physics is likely to be derived from these realms.

Essential Question:

How does our understanding of the atom change with new technologies?

Key Ideas:

Key Idea 5: Energy and matter interact through forces that result in changes in motion.

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/sci/documents/phycoresci.pdf

Major Understandings:

Quoted from the New York State Performance Indicators (4.1b, 5.3a-j)

- On the atomic level, energy and matter exhibit the characteristics of both waves and particles. **(5.3e)**
- States of matter and energy are restricted to discrete values (quantized). **(5.3a)**
- On the atomic level, energy is emitted or absorbed in discrete packets called photons.* **(5.3c)**
- The energy of a photon is proportional to its frequency.* **(5.3d)**

continued

MST STANDARDS

http://www.p12.nysed.gov/ciai/mst/sci/documents/phycoresci.pdf

Standard 2: Information Systems

Key Idea 1: Information technology is used to retrieve, process, and communicate information as a tool to enhance learning.

Standard 6: Interconnectedness: Common Themes

Key Idea 1: Through systems thinking, people can recognize the commonalities that exist among all systems and how parts of a system interrelate and combine to perform specific functions.

Key Idea 2: Models are simplified representations of objects, structures, or systems used in analysis, explanation, interpretation, or design.

continued

NGSS CROSS-CUTTING CONCEPTS

http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

Patterns:

Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.

- 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.
- Classifications or explanations used at one scale may fail or need revision when information from smaller or larger scales is introduced; thus requiring improved investigations and experiments.
- Patterns of performance of designed systems can be analyzed and interpreted to reengineer and improve the system.

continued

NYS SCIENCE STANDARDS http://www.p12.nysed.gov/ciai/mst/sci/documents/phycoresci.pdf	MST STANDARDS http://www.p12.nysed.gov/ciai/mst/sci/documents/phycoresci.pdf	NGSS CROSS-CUTTING CONCEPTS http://www.nextgenscience.org/next-generation-science-standards

▪ Behaviors and characteristics of matter, from the microscopic to the cosmic levels, are manifestations of its atomic structure. The macroscopic characteristics of matter, such as electrical and optical properties, are the result of microscopic interactions. **(5.3h)**
▪ Energy may be converted among mechanical, electromagnetic, nuclear, and thermal forms. **(4.1b)**
▪ Charge is quantized on two levels. On the atomic level, charge is restricted to multiples of the elementary charge (charge on the electron or proton). On the subnuclear level, charge appears as fractional values of the elementary charge (quarks). **(5.3b)**
▪ Among other things, mass-energy and charge are conserved at all levels (from subnuclear to cosmic). **(5.3f)**
▪ The Standard Model of Particle Physics has evolved from previous attempts to explain the nature of the atom and states that: **(5.3g)**
  ▪ atomic particles are composed of subnuclear particles
  ▪ the nucleus is a conglomeration of quarks which manifest themselves as protons and neutrons
  ▪ each elementary particle has a corresponding antiparticle
▪ The total of the fundamental interactions is responsible for the appearance and behavior of the objects in the universe. **(5.3i)**
▪ The fundamental source of all energy in the universe is the conversion of mass into energy.* **(5.3j)**
(Note: Items with asterisks require quantitative treatment per the Reference Table for Physics. Asterisks following individual words refer to the preceding word or phrase only; asterisks appearing after the final period of a sentence refer to all concepts or ideas presented in the sentence.)*
	Key Idea 3: The grouping of magnitudes of size, time, frequency, and pressures or other units of measurement into a series of relative order provides a useful way to deal with the immense range and the changes in scale that affect the behavior and design of systems.
	Key Idea 4: Equilibrium is a state of stability due either to a lack of change (static equilibrium) or a balance between opposing forces (dynamic equilibrium).
	Key Idea 5: Identifying patterns of change is necessary for making predictions about future behavior and conditions.
	Standard 7: Interdisciplinary Problem Solving
	Key Idea 1: The knowledge and skills of mathematics, science, and technology are used together to make informed decisions and solve problems, especially those relating to issues of science/ technology/society, consumer decision making, design, and inquiry into phenomena.
	Key Idea 2: Solving interdisciplinary problems involves a variety of skills and strategies, including effective work habits; gathering and processing information; generating and analyzing ideas; realizing ideas; making connections among the common themes of mathematics, science, and technology; and presenting results.
		▪ Mathematical representations are needed to identify some patterns.
		▪ Empirical evidence is needed to identify patterns.
		Systems and System Models:
		A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.
		▪ 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.
		▪ 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.
		▪ 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: Flows, Cycles, and Conservation:
		Tracking energy and matter flows into, out of, and within systems helps one understand their system's behavior.
		▪ The total amount of energy and matter in closed systems is conserved.
		▪ 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 moved between one place and another place, between objects and/or fields, or between systems.
		continued

		NGSS CROSS-CUTTING CONCEPTS http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf
		▪ Energy drives the cycling of matter within and between systems. ▪ In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. **Structure and Function:** The way an object is shaped or structured determines many of its properties and functions. ▪ 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. ▪ The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials. **Stability and Change:** For both designed and natural systems, conditions that affect stability and factors that control rates of change are critical elements to consider and understand. ▪ Much of science deals with constructing explanations of how things change and how they remain stable. ▪ Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.

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ELA/Literacy **RST.11-12.3:** Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, analyze the specific results based on explanations in the text. **RST.11-12.4:** Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to Grades 11–12 texts and topics. **RST.11-12.8:** Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. **RST.11-12.9:** Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. **WHST.9–12.2:** Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes. **WHST.9–12.7:** Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. **WHST.9–12.9:** Draw evidence from informational texts to support analysis, reflection, and research. *continued*	**Strand 1: Questioning, Analysis, and Interpretation Skills** ▪ Guideline A—Questioning—Learners are able to develop, modify, clarify, and explain questions that guide environmental investigations of various types. They understand factors that influence the questions they pose. ▪ Guideline B—Designing investigations—Learners know how to design investigations to answer particular questions about the environment. They are able to develop approaches for investigating unfamiliar types of problems and phenomena. ▪ Guideline F—Working with models and simulations—Learners are able to create, use, and evaluate models to understand environmental phenomena. ▪ Guideline G—Drawing conclusions and developing explanations—Learners are able to use evidence and logic in developing proposed explanations that address their initial questions and hypotheses. **Strand 2: Knowledge of Environmental Processes and Systems** **Strand 2.1: The Earth as a Physical System** ▪ Guideline B—Changes in matter—Learners apply their understanding of chemical reactions to round out their explanations of environmental characteristics and everyday phenomena. ▪ Guideline C—Energy—Learners apply their knowledge of energy and matter to understand phenomena in the world around them. *continued*	*[Refer to Appendix D – Reference Tables for Physical Setting/Physics]* List of Physical Constants (p1) Energy Level Diagrams (p3) Classification of Matter (p3) Particles of the Standard Model (p3) Modern Physics (p5)

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Mathematics **HSN-Q.A.1:** Use units as a way to understand problems and to guide the solution of multistep problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. **HSN-Q.A.2:** Define appropriate quantities for the purpose of descriptive modeling. **HSN-Q.A.3:** Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. **HSA.CED.A.2:** Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. **HSA.CED.A.4:** Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. For example, rearrange Ohm's law V = IR to highlight resistance R. Represent and model with vector quantities. **HSN.VM.A.1:** Recognize vector quantities as having both magnitude and direction. Represent vector quantities by directed line segments, and use appropriate symbols for vectors and their magnitudes (e.g., v, |v|, ||v||, v).	**Strand 2.2: The Living Environment** ▪ Guideline C—Systems and connections—Learners understand the living environment to be comprised of interrelated, dynamic systems. ▪ Guideline D—Flow of matter and energy—Learners are able to account for environmental characteristics based on their knowledge of how matter and energy interact in living systems. **Strand 2.3: Humans and Their Societies** ▪ Guideline D—Global connections—Learners are able to analyze global, social, cultural, political, economic, and environmental linkages. ▪ Guideline E—Change and conflict—Learners understand the functioning of public processes for promoting and managing change and conflict, and can analyze their effects on the environment. **Strand 2.4: Environment and Society** ▪ Guideline A—Human/environment interactions—Learners understand that humans are able to alter the physical environment to meet their needs and that there are limits to the ability of the environment to absorb impacts or meet human needs. ▪ Guideline C—Resources—Learners understand that the importance and use of resources change over time and vary under different economic and technological systems. ▪ Guideline D—Technology—Learners are able to examine the social and environmental impacts of various technologies and technological systems. **Strand 3: Skills for Understanding and Addressing Environmental Issues** **Strand 3.2: Decision-Making and Citizenship Skills** ▪ Guideline A—Forming and evaluating personal views—Learners are able to communicate, evaluate, and justify their own views on environmental issues and alternative ways to address them. ▪ Guideline D—Evaluating the results of actions—Learners are able to evaluate the effects of their own actions and actions taken by other individuals and groups, including possible intended and unintended consequences of actions.