| ORANGE PUBLIC SCHOOLS | | | |
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| **CONTENT AREA: Physics** | **GRADE: H.S.** | **UNIT #: 5** | **UNIT NAME: Electromagnetism** |

## SCOPE AND SEQUENCE

| OVERVIEW | | | | |
|---|---|---|---|---|
| Lesson | Topic | PE's and DCI's | Chapter | Suggested Pacing (Blocks) |
| 1 | Electricity and circuits | HS-PS3-5 | 17 | 1 |
| 2 | Resistance | HS-PS3-5 | 17 | 1 |
| 3 | Series and parallel circuits | HS-PS3-5 | 17 | 2 |
| 4 | House PBL | HS-PS3-5 | 17 | 5 |
| 5 | Magnetism | HS-PS3-5 | 18 | 1 |
| 6 | Electric Forces | HS-PS3-5<br>HS-PS2-4 | 18 | 1 |
| 7 | Electric Fields | HS-PS3-5 | 18 | 2 |
| 8 | Potential and capacitors | HS-PS2-4 | 18 | 1 |
| 9 | Magnetic fields and the electric motor | HS-PS3-5 | 19 | 3 |
| 10 | Induction and the generator | HS-PS2-5 | 19 | 2 |
| 11 | Magnetic Fields and moving charges | HS-PS3-5 | 19 | 2 |
| 12 | Electronics Project | HS-PS4-5 | 19 | 1 |

## CALENDAR- April 2017

| **M** | **T** | **W** | **R** | **F** |
|---|---|---|---|---|
| **5A**<br>Electricity and circuits | **6 B** | **7A**<br>Resistance | **8B** | **9A**<br>Series and parallel circuits |

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| | | | | |
|---|---|---|---|---|
| **12**B | **13A**<br>Series and parallel circuits | **14B** | **15A**<br>House PBL | **16B** |
| **19A**<br>House PBL | **20B** | **21A**<br>House PBL | **22B** | **23A**<br>House PBL |
| **26B** | **27A**<br>House PBL | **28B** | **29A**<br>Magnetism | **30**B |
| **1A**<br>Electric Forces | **2B** | **3A**<br>Electric Fields | **4B** | |

**CALENDAR- May 2017**

| **M** | **T** | **W** | **R** | **F** |
|---|---|---|---|---|
| **5A**<br>Electric Fields | **6 B** | **7A**<br>Potential and capacitors | **8B** | **9A**<br>Magnetic fields and the electric motor |
| **12**B | **13A** | **14B** | **15A** | **16B** |

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| **CONTENT AREA: Physics** | **GRADE: H.S.** | **UNIT #: 5** | **UNIT NAME: Electromagnetism** |

| | | | | |
|---|---|---|---|---|
| | Magnetic fields and the electric motor | | Magnetic fields and the electric motor | |
| **19A**<br>Induction and the generator | **20B** | **21A**<br>Induction and the generator | **22B** | **23A**<br>Magnetic Fields and moving charges |
| **26B** | **27A**<br>Magnetic Fields and moving charges | **28B** | **29A**<br>Electronics Project | **30**B |
| **1A** | **2B** | **3A** | **4B** | |

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***How is energy transferred and conserved (p.120, Framework)?***

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 (p. 118, Frameworks).

| # Blocks | STUDENT LEARNING OBJECTIVES | CORRESPONDING Pes and DCIs | CURRICULAR & SUPPLEMENTAL RESOURCES | ASSESSMENT |
|---|---|---|---|---|
| **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.** [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.*] | HS-PS3-5 | Charge Launcher Gizmos https://www.explorelearning.com/index.cfm?method=cResource.dspView&ResourceID=632 Electromagnetic Induction https://www.explorelearning.com/index.cfm?method=cResource.dspView&ResourceID=1044 Magnetic Induction https://www.explorelearning.com/index.cfm?method=cResource.dspView&ResourceID=611 Magnetism https://www.explorelearning.com/index.cfm?method=cResource.dspView&ResourceID=631 Pitch Ball Lab https://www.explorelearning.com/index.cf | Describe behavior of particles based off of the charge.<br><br>Explain how electric and magnetic forces are related. |

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| **CONTENT AREA: Physics** | **GRADE: H.S.** | **UNIT #: 5** | **UNIT NAME: Electromagnetism** |

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|---|---|---|---|---|
| | | | m?method=cResource.dspView&ResourceID=459<br>Discovery Textbook<br>https://app.discoveryeducation.com/techbook2:unit/view/unitGuid/7364F52A-EFB8-4905-90D4-69D4E6C48C81 | |
| **# Blocks** | **STUDENT LEARNING OBJECTIVES** | **CORRESPONDING Pes and DCIs** | **CURRICULAR & SUPPLEMENTAL RESOURCES** | **ASSESSMENT** |
| **1** | **Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.** [Clarification Statement: Emphasis is on both quantitative and conceptual descriptions of gravitational and electric fields.] [*Assessment Boundary: Assessment is limited to systems with two objects.*] | HS-PS2-4 | ***Coulomb Force (Static)***<br>***https://www.explorelearning.com/index.cfm?method=cResource.dspView&ResourceID=456***<br>Pitch Ball Lab<br>https://www.explorelearning.com/index.cfm?method=cResource.dspView&ResourceID=459<br>Discovery Textbook<br>https://app.discoveryeducation.com/techbook2:unit/view/unitGuid/7364F52A-EFB8-4905-90D4-69D4E6C48C81 | Calculate behavior using Coulomb's law. |

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| | | | | |
|---|---|---|---|---|
| | **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.** [*Assessment Boundary: Assessment is limited to designing and conducting investigations with provided materials and tools.*] | HS-PS2-5 | Electromagnetic Induction https://www.explorelearning.com/index.cfm?method=cResource.dspView&ResourceID=1044<br>Magnetic Induction https://www.explorelearning.com/index.cfm?method=cResource.dspView&ResourceID=611<br>Discovery Textbook https://app.discoveryeducation.com/techbook2:unit/view/unitGuid/7364F52A-EFB8-4905-90D4-69D4E6C48C81 | Use the right hand rule to describe the magnetic field and take measurements showing its existence. |
| | **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.*] | HS-PS4-5 | ***Phased Array*** ***https://www.explorelearning.com/index.cfm?method=cResource.dspView&ResourceID=590***<br>Discovery Textbook https://app.discoveryeducation.com/techbook2:unit/view/unitGuid/7364F52A-EFB8-4905-90D4-69D4E6C48C81 | Pick a device that uses this technology and create a presentation for the class. |

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| CONTENT AREA: Physics | GRADE: H.S. | UNIT #: 5 | UNIT NAME: Electromagnetism |
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The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

## 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)

**Analyzing and Interpreting Data**
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. (HS-PS2-1)

**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-PS2-2),(HS-PS2-4)

## Disciplinary Core Ideas

**PS2.A: Forces and Motion**

- Newton's second law accurately predicts changes in the motion of macroscopic objects. (HS-PS2-1)
- Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object. (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)

**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)

**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)*

**ETS1.A: Defining and Delimiting an Engineering Problem**

- 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)*

## 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-PS2-1), (HS-PS2-5)
- Systems can be designed to cause a desired effect. (HS-PS2-3)

**Systems and System Models**

- When investigating or describing a system, the boundaries and initial conditions of the system need to be defined. (HS-PS2-2)

| | | |
|---|---|---|
| **Constructing Explanations and Designing Solutions**<br>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.<br>• Apply scientific ideas to solve a design problem, taking into account possible unanticipated effects. (HS-PS2-3)<br>- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -<br>***Connections to Nature of Science***<br><br>**Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena**<br>• Theories and laws provide explanations in science. (HS-PS2-1),(HS-PS2-4)<br>• Laws are statements or descriptions of the relationships among observable phenomena. (HS-PS2-1),(HS-PS2-4) | **ETS1.C: Optimizing the Design Solution**<br>• 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. *(secondary to HS-PS2-3)* | |

*Connections to other DCIs in this grade-band:*
**HS.PS3.A** (HS-PS2-4),(HS-PS2-5); **HS.PS3.C** (HS-PS2-1); **HS.PS4.B** (HS-PS2-5); **HS.ESS1.A** (HS-PS2-1),(HS-PS2-2),(HS-PS2-4); **HS.ESS1.B** (HS-PS2-4); **HS.ESS1.C**(HS-PS2-1),(HS-PS2-2),(HS-PS2-4); **HS.ESS2.A** (HS-PS2-5); **HS.ESS2.C** (HS-PS2-1),(HS-PS2-4); **HS.ESS3.A** (HS-PS2-4),(HS-PS2-5)

*Articulation of DCIs across grade-bands:*
**MS.PS2.A** (HS-PS2-1),(HS-PS2-2),(HS-PS2-3); **MS.PS2.B** (HS-PS2-4),(HS-PS2-5); **MS.PS3.C** (HS-PS2-1),(HS-PS2-2),(HS-PS2-3); **MS.ESS1.B** (HS-PS2-4),(HS-PS2-5)**MS.PS3.B**

# ORANGE PUBLIC SCHOOLS

| CONTENT AREA: Physics | GRADE: H.S. | UNIT #: 5 | UNIT NAME: Electromagnetism |
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*Common Core State Standards Connections:*
*ELA/Literacy -*

**RST.11-12.1** Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. *(HS-PS2-1)*

**RST.11-12.7** Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-PS2-1)

**WHST.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. (HS-PS2-3),(HS-PS2-5)

**WHST.11-12.8** Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. *(HS-PS2-5)*

**WHST.11-12.9** Draw evidence from informational texts to support analysis, reflection, and research. *(HS-PS2-1),(HS-PS2-5)*

*Mathematics -*

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

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

**HSN.Q.A.1** Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS2-1),(HS-PS2-2),(HS-PS2-4),*(HS-PS2-5)*

**HSN.Q.A.2** Define appropriate quantities for the purpose of descriptive modeling. *(HS-PS2-1),(HS-PS2-2),(HS-PS2-4),(HS-PS2-5)*

**HSN.Q.A.3** Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS2-1),(HS-PS2-2),(HS-PS2-4),*(HS-PS2-5)*

**HSA.SSE.A.1** Interpret expressions that represent a quantity in terms of its context. (HS-PS2-1),(HS-PS2-4)

**HSA.SSE.B.3** Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression. (HS-PS2-1),(HS-PS2-4)

**HSA.CED.A.1** Create equations and inequalities in one variable and use them to solve problems. (HS-PS2-1),(HS-PS2-2)

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| Science and Engineering Practices | Disciplinary Core Ideas | Crosscutting Concepts |
|---|---|---|
| **Developing and Using Models**<br>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.<br>• Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-PS3-2), (HS-PS3-5)<br>**Planning and Carrying Out Investigations**<br>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.<br>• 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-PS3-4) | **PS3.A: Definitions of Energy**<br>• Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms. (HS-PS3-1), (HS-PS3-2)<br>• At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. (HS-PS3-2) (HS-PS3-3)<br>• These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as a combination of energy associated with the motion of particles and energy associated with the configuration (relative position of the particles). In some cases the relative position energy can be thought of as stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space. (HS-PS3-2) | **Cause and Effect**<br>• 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)<br>**Systems and System Models**<br>• 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. (HS-PS3-4)<br>• 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. (HS-PS3-1)<br>**Energy and Matter**<br>• 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. (HS-PS3-3)<br>• Energy cannot be created or destroyed—only moves between one place and another place, between objects and/or fields, or between systems. (HS-PS3-2) |

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**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.

- Create a computational model or simulation of a phenomenon, designed device, process, or system. (HS-PS3-1)

**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.

- Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-PS3-3)

**PS3.B: Conservation of Energy and Energy Transfer**

- Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system. (HS-PS3-1)
- Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. (HS-PS3-1),(HS-PS3-4)
- Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g. relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior. (HS-PS3-1)
- The availability of energy limits what can occur in any system. (HS-PS3-1)
- Uncontrolled systems always evolve toward more stable states—that is, toward more uniform energy distribution (e.g., water flows downhill, objects hotter than their surrounding environment cool down). (HS-PS3-4)

**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)

**PS3.D: Energy in Chemical Processes**

- Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment. (HS-PS3-3),(HS-PS3-4)

**ETS1.A: Defining and Delimiting an Engineering Problem**

- 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-PS3-3)*

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***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)

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***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)

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*Connections to other DCIs in this grade-band:*
**HS.PS1.A** (HS-PS3-2); **HS.PS1.B** (HS-PS3-1),(HS-PS3-2); **HS.PS2.B** (HS-PS3-2),(HS-PS3-5); **HS.LS2.B** (HS-PS3-1); **HS.ESS1.A** (HS-PS3-1),(HS-PS3-4) ; **HS.ESS2.A**(HS-PS3-1),(HS-PS3-2),(HS-PS3-4); **HS.ESS2.D** (HS-PS3-4); **HS.ESS3.A** (HS-PS3-3)

*Articulation of DCIs across grade-bands:*
**MS.PS1.A** (HS-PS3-2); **MS.PS2.B** (HS-PS3-2),(HS-PS3-5); **MS.PS3.A** (HS-PS3-1),(HS-PS3-2),(HS-PS3-3); **MS.PS3.B** (HS-PS3-1),(HS-PS3-3),(HS-PS3-4); **MS.PS3.C**(HS-PS3-2),(HS-PS3-5); **MS.ESS2.A** (HS-PS3-1),(HS-PS3-3)

*Common Core State Standards Connections:*
*ELA/Literacy -*

**RST.11-12.1** Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. *(HS-PS3-4)*

**WHST.9-12.7** Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. *(HS-PS3-3)*,(HS-PS3-4),*(HS-PS3-5)*

**WHST.11-12.8** Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. (HS-PS3-4),(HS-PS3-5)

**WHST.9-12.9** Draw evidence from informational texts to support analysis, reflection, and research. *(HS-PS3-4),(HS-PS3-5)*

**SL.11-12.5** Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. *(HS-PS3-1),(HS-PS3-2),(HS-PS3-5)*

*Mathematics -*

**MP.2** Reason abstractly and quantitatively. (HS-PS3-1),(HS-PS3-2),(HS-PS3-3),(HS-PS3-4),(HS-PS3-5)

**MP.4** Model with mathematics. (HS-PS3-1),(HS-PS3-2),(HS-PS3-3),*(HS-PS3-4)*,(HS-PS3-5)

**HSN.Q.A.1** Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS3-1),(HS-PS3-3)

**HSN.Q.A.2** Define appropriate quantities for the purpose of descriptive modeling. (HS-PS3-1),(HS-PS3-3)

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| **HSN.Q.A.3** | Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS3-1),(HS-PS3-3) |

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**Table: Component Ideas arranged into courses. The table uses the information in the NGSS foundation boxes to connect the high school NGSS performance expectations to the component ideas from the *Framework*.**