Overview:

Unit 1: Fundamental Review (15 days)
Unit 2: Structure and Properties of Matter (20 days)
Unit 3: Chemical Reactions (25 days)
Unit 4: Thermal energy (30 days)
Unit 5: Forces and motions (25 days)
Unit 6: Electromagnetic spectrum (20 days)
Unit 7: Types of interactions (25 days)
Unit 8: Relationships among forms of energy (20 days)

Throughout the year students will behave like scientists/engineers by:

- Asking questions
- Planning and carrying out investigations
- Engaging in arguments from evidence
- Constructing explanations
- Developing and using models
- Analyzing and interpreting data
- Defining problems and designing solutions
- Evaluating findings
- Communicating information
- Using scientific and engineering practices
Big Idea -

How do you create a functioning chair?

How do scientists and engineers work in the 21st century to discover problems and create solutions that improve society?

How do scientist think and operate?

What is the engineering and design process?

Unit Summary

In this unit the students will work on exploring the fundamentals of the design and engineering process by having to create a chair out of cardboard scraps.

Ultimate “project” - Create a functional chair out of cardboard

End Goals

Students will behave like scientists/engineers by:

- Researching and observing static forces
- Researching different designs and solutions
- Designing and engineering a chair that is made out of cardboard and is functional
- Collaborating with their partner to work on the chair
- Communicating with their partner and the class

Student Learning Objectives

Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions. MS-ETS1-1.

Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem. MS-ETS1-2.

Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success. MS-ETS1-3.

Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved. MS-ETS1-4.
What does this look like in the classroom? Use Webb’s DoK and provide specifics when appropriate.

**Activity 1 - Build a chair - Level 4 DOK:**

**Phenomena/Big Question -** How can design and engineering be used to create a functional chair? How do we scientifically test and measure results? How are forces measured?

The students will work in cooperative pairs to create a chair out of pieces of cardboard. The constraints of the project are: the chair will be able to hold the student’s weight, the seat will need to be taller than the student’s knee height, and the chair will need to have more than five functional parts.

**Engage** - Show the students PBS Design Squad videos on designing and engineering furniture from cardboard  
**Explore** - Allow the students in cooperative groups to explore different chair designs  
**Explain** - The students will have to explain how their chair works and the forces acting upon on their chair  
**Elaborate** - The students will test their designs and make improvements as necessary  
**Evaluate** - The students will present their final findings to the rest of the class for evaluation

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**Unit 2 Structure and Properties of Matter**

**Big Idea** -
How is it that everything is made of stardust?
What is the universe made of?

Unit Summary

Students build understandings of what occurs at the atomic and molecular scale. Students apply their understanding that pure substances have characteristic properties and are made from a single type of atom or molecule. They also provide a molecular level accounts to explain states of matter and changes between states. The crosscutting concepts of cause and effect, scale, proportion and quantity, structure and function, interdependence of science, engineering, and technology, and the influence of science, engineering and technology on society and the natural world provide a framework for understanding the disciplinary core ideas. Students demonstrate grade appropriate proficiency in developing and using models, and obtaining, evaluating, and communicating information. Students are also expected to use the scientific and engineering practices to demonstrate understanding of the core ideas.

End goals

Students will behave like scientists/engineers by:
- Creating an atomic model
- Creating models of molecules
- Investigating atomic and molecular simulations
- Investigating physical and chemical changes

Student Learning Objectives

Develop models to describe the atomic composition of simple molecules and extended structures. [Clarification Statement: Emphasis is on developing models of molecules that vary in complexity. Examples of simple molecules could include ammonia and methanol. Examples of extended structures could include sodium chloride or diamonds. Examples of molecular-level models could include drawings, 3D ball and stick structures, or computer representations showing different molecules with different types of atoms. The substructure of atoms and the periodic table are learned in high school chemistry.] [Assessment Boundary: Assessment does not include valence electrons and bonding energy, discussing the ionic nature of subunits of complex structures, or a complete depiction of all individual atoms in a complex molecule or extended structure.] (MS-PS1-1)

Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred. [Clarification Statement: Examples of reactions could include burning sugar or steel wool, fat reacting with sodium hydroxide, and mixing zinc with hydrogen chloride.] [Assessment Boundary: Assessment is limited to analysis
of the following properties: density, melting point, boiling point, solubility, flammability, and odor.] (MS-PS1-2)

**Part A: If the universe is not made of Legos®, then what is it made of?**

<table>
<thead>
<tr>
<th>Concepts</th>
<th>Formative Assessment</th>
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<tbody>
<tr>
<td>- Substances are made from different types of atoms.</td>
<td>Students who understand the concepts are able to:</td>
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<tr>
<td>- Atoms are the basic units of matter.</td>
<td>- Develop a model of a simple molecule.</td>
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<td>- Substances combine with one another in various ways.</td>
<td>- Use the model of the simple molecule to describe its atomic composition.</td>
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<tr>
<td>- Molecules are two or more atoms joined together.</td>
<td>- Develop a model of an extended structure.</td>
</tr>
<tr>
<td>- Atoms form molecules that range in size from two to thousands of atoms.</td>
<td>- Use the model of the extended structure to describe its repeating subunits.</td>
</tr>
<tr>
<td>- Molecules can be simple or very complex.</td>
<td>[Boundary: The substructure of atoms and the periodic table are learned in high school chemistry.]</td>
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<tr>
<td>- Solids may be formed from molecules, or they may be extended structures with repeating subunits (e.g., crystals).</td>
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**Part B: Is it possible to tell if two substances mixed or if they reacted with each other?**

<table>
<thead>
<tr>
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<tr>
<td>- Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it.</td>
<td>Students who understand the concepts are able to:</td>
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<tr>
<td>- Substances react chemically in characteristic ways.</td>
<td>- Analyze and interpret data to determine similarities and differences from results of chemical reactions between substances before and after they undergo a chemical process.</td>
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<tr>
<td>- In a chemical process, the atoms that make up the original substances are regrouped into different molecules; these new substances have different</td>
<td>- Analyze and interpret data on the properties of substances before and after they undergo a chemical process.</td>
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</table>
properties from those of the reactants.

- The analysis of data on the properties of products and reactants can be used to determine whether a chemical process has occurred.
- Density, melting point, boiling point, solubility, flammability, and odor are characteristic properties that can be used to identify a pure substance.
- Macroscopic patterns are related to the nature of the atomic-level structure of a substance.

- Identify and describe possible correlation and causation relationships evidenced in chemical reactions.
- Make logical and conceptual connections between evidence that chemical reactions have occurred and explanations of the properties of substances before and after they undergo a chemical process.

What does this look like in the classroom? Use Webb’s DoK and provide specifics when appropriate.

**Activity 1 - Atom and compound models - Level 3 DOK:**

**Phenomena/Big Question** - What is the universe made of? What does the atom look like? What does a compound look like?

The students will create a model of an atom, a model of a common compound (ex. Water, salt, carbon dioxide, sugar, etc.), and a model of a polymer.

**Engage** - Ask the students the big question of what is the universe made of? Watch the following video for further discussion:

https://www.ted.com/talks/just_how_small_is_an_atom

**Explore** - In small groups the students will explore the structure of the atom, the structure of common compounds, and the structure of polymers using web resources.

**Explain** - The students will create a model of the atom, a models of a common compound, and a model of a polymer.

**Elaborate** - The students provide detailed descriptions of the models. For example the atom will include proton #, electron #, and neutron #. The compound model will include descriptions of the elements in the compound. The polymer will include a description of how the subunit repeats.

**Evaluate** - The students will present their final models and descriptions to the rest of the class.

**Activity 2 - Atom and molecule simulations - Level 2 DOK**
Phenomena/Big Question - What is the universe made of? What does the atom look like? What does a compound look like?

The students will continue their investigation of atoms and compounds by using the following simulations:

- Build an atom
  https://phet.colorado.edu/en/simulation/build-an-atom
- Build a molecule
  https://phet.colorado.edu/en/simulation/legacy/build-a-molecule
- Molecule shapes
  https://phet.colorado.edu/en/simulation/molecule-shapes-basics

**Engage** - Demonstrate the simulations to the students
**Explore** - Allow the students to explore the simulations
**Explain** - The students will explain what the different simulations are demonstrating
**Elaborate** - The students will do further research on the models that they observed
**Evaluate** - The students will compare and evaluate the simulations in relation to the models from activity one.

Activity 3 - Physical vs. Chemical Changes - Level 2 DOK:
Phenomena/Big Question - What happens when two different chemicals are mixed? What is a physical change vs. a chemical change?

Students will perform the following lab investigations and will then analyze if a physical or chemical change is occurring: burning sugar, burning steel wool, mixing fat with sodium hydroxide, mixing zinc with hydrogen chloride, vinegar and an old penny, ripping up a piece of a paper, crumpling up a piece of aluminum foil, and melting ice and then refreezing it into a different shape.

**Engage** - Mixing baking soda and vinegar, as a demonstration in front of the students, and then ask the students what happened.
**Explore** - The students will work in pairs to perform the physical and chemical change investigations listed above. The investigation can be done at stations with the students rotating.
**Explain** - The student will create a chart that summarizes each investigation (whether it is a physical or chemical change)
**Elaborate** - The students will elaborate on what are the telltale signs of a physical and a chemical change.
**Evaluate** - The students will present their final models and descriptions to the rest of the class
Unit 3 Chemical Reactions

Big Idea -
How do substances combine or change (react) to make new substances?

Unit Summary

Students provide molecular-level accounts of states of matters and changes between states, of how chemical reactions involve regrouping of atoms to form new substances, and of how atoms rearrange during chemical reactions. Students also apply their understanding of optimization design and process in engineering to chemical reaction systems. The crosscutting concept of energy and matter provides a framework for understanding the disciplinary core ideas. Students are expected to demonstrate proficiency in developing and using models, analyzing and interpreting data, designing solutions, and obtaining, evaluating, and communicating information. Students are also expected to use these science and engineering practices to demonstrate understanding of the disciplinary core ideas.

End Goals

Students will behave like scientists/engineers by:

- Mathematical modeling chemical equations
- Investigating exothermic and endothermic processes

Student Learning Objectives

Develop and use a model to describe how the total number of atoms does not change in a chemical reaction and thus mass is conserved. [Clarification Statement: Emphasis is on law of conservation of matter and on physical models or drawings, including digital forms, that represent atoms.] [Assessment Boundary: Assessment does not include the use of atomic masses, balancing symbolic equations, or intermolecular forces.] (MS-PS1-5)

Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes.* [Clarification Statement: Emphasis is on the design, controlling the transfer of energy to the environment, and modification of a device using factors such as type and concentration of a substance. Examples of designs could involve chemical reactions such as dissolving ammonium chloride or calcium chloride.] [Assessment Boundary: Assessment is limited to the criteria of amount, time, and temperature of substance in testing the device.] (MS-PS1-6)
Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success. (MS-ETS1-3)

### Unit Sequence Part A: What happens to the atoms when I bake a cake?

<table>
<thead>
<tr>
<th>Concepts</th>
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</table>
| • Substances react chemically in characteristic ways.  
• In a chemical process, the atoms that make up the original substances are regrouped into different molecules.  
• New substances created in a chemical process have different properties from those of the reactants.  
• The total number of each type of atom in a chemical process is conserved, and thus the mass does not change (the law of conservation of matter).  
• Matter is conserved because atoms are conserved in physical and chemical processes.  
• The law of conservation of mass is a mathematical description of natural phenomena. | Students who understand the concepts are able to:  
• Use physical models or drawings, including digital forms, to represent atoms in a chemical process.  
• Use mathematical descriptions to show that the number of atoms before and after a chemical process is the same. |

### Unit Sequence Part B: How can a device be designed, constructed, tested, and modified that either releases or absorbs thermal energy by chemical processes?

<table>
<thead>
<tr>
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</thead>
</table>
| • Some chemical reactions release energy, while others store energy.  
• The transfer of thermal energy can be tracked as energy flows through a designed or natural system.  
• Models of all kinds are important for testing solutions. | Students who understand the concepts are able to:  
• Undertake a design project, engaging in the design cycle, to construct, test, and modify a device that either releases or absorbs |
- There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem.
- The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution.
- A solution needs to be tested and then modified on the basis of the test results in order to for it to be improved.
- Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process.
- Some of the characteristics identified as having the best performance may be incorporated into the new design.

- thermal energy by chemical processes.
- Specific criteria are limited to amount, time, and temperature of a substance.
- Analyze and interpret data for the amount, time, and temperature of a substance in testing a device that either releases or absorbs thermal energy by chemical processes to determine similarities and differences in findings.
- Develop a model to generate data for testing a device that either releases or absorbs thermal energy by chemical processes, including those representing inputs and outputs of thermal energy.
- Track the transfer of thermal energy as energy flows through a designed system that either releases or absorbs thermal energy by chemical processes.

What does this look like in the classroom? Use Webb’s DoK and provide specifics when appropriate.

**Activity 1 - Balancing Chemical Equations - Level 2 DOK**

**Phenomena/Big Question - What happens to the atoms when I bake a cake?**

The students will work on mathematical modeling of chemical reactions,

**Engage** - Show the students the Colorado Phet simulator:

Balancing chemical equations

https://phet.colorado.edu/en/simulation/balancing-chemical-equations

**Explore** - The students will work in pairs to balance the chemical equations

**Explain** - The student will create summary models/diagrams of the balanced chemical
reactions

**Elaborate** - The students will elaborate by finding images of the chemicals involved in the chemical reactions

**Evaluate** - The students will present their final models and descriptions to the rest of the class

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**Activity 2 - Exothermic and Endothermic - Level 4 DOK**

**Phenomena/Big Question** - How can a device be designed, constructed, tested, and modified that either releases or absorbs thermal energy by chemical processes?

The following lab investigations will be performed:

1. Calcium chloride will be mixed with distilled water. A temperature probe will be used to measure the exothermic process.

2. Aluminum chloride in water to observe and endothermic reaction. A temperature probe will be used to measure the endothermic process.

**Engage** - Demonstrate an ice pack to the students and ask them to explain how it works

**Explore** - The students will work in pairs to perform the lab investigations described above.

**Explain** - The student will create a chart that summarizes each investigation (whether it is an exothermic or endothermic reaction). The students will design, construct, test or modify a device that either releases or absorbs thermal energy by chemical processes.

**Elaborate** - The students will elaborate on what are the telltale signs of an exothermic and endothermic reaction.

**Evaluate** - The students will present their final models and descriptions to the rest of the class

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<tr>
<th>Unit 4 Thermal Energy</th>
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**Big Idea** -

How can a standard thermometer be used to tell you how particles are behaving?

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**Unit Summary**

In this unit, students *ask questions, plan and carry out investigations, engage in argument from evidence, analyze and interpret data, construct explanations, define problems and*
Students ask questions, plan and carry out investigations, engage in argument from evidence, analyze and interpret data, construct explanations, define problems and design solutions. Students are also expected to use these practices to demonstrate understanding of the core ideas.

This unit is based on MS-PS3-3, MS-PS3-4, MS-ETS1-1, MS-ETS1-2, MS-ETS1-3, and MS-ETS1-4.

**End Goals**

Students will behave like scientists/engineers by:

- Investigating states of matter
- Designing an investigation for thermal energy transfer
- Constructing a device that utilizes heat transfer principles

**Student Learning Objectives**

Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer. [Clarification Statement: Examples of devices could include an insulated box, a solar cooker, and a Styrofoam cup.] [Assessment Boundary: Assessment does not include calculating the total amount of thermal energy transferred.] (MS-PS3-3)

Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample. [Clarification Statement: Examples of experiments could include comparing final water temperatures after different masses of ice melted in the same volume of water with the same initial temperature, the temperature change of samples of different materials with the same mass as they cool or heat in the environment, or the same material with different masses when a specific amount of energy is added.] [Assessment Boundary: Assessment does not include calculating the total amount of thermal energy transferred.] (MS-PS3-4)

Define the criteria and constraints of a design problem with sufficient precision to ensure a
successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions. (MS-ETS1-1)

Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem. (MS-ETS1-2)

Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success. (MS-ETS1-3)

Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved. (MSETS1-4)

Part A: How can a standard thermometer be used to tell you how particles are behaving?

<table>
<thead>
<tr>
<th>Concepts</th>
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</thead>
<tbody>
<tr>
<td>• There are relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of particles as measured by the temperature of the sample.</td>
<td>• Individually and collaboratively plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of particles as measured by the temperature of the sample.</td>
</tr>
<tr>
<td>• Temperature is a measure of the average kinetic energy of particles of matter. • The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present.</td>
<td>• As part of a planned investigation, identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim.</td>
</tr>
<tr>
<td>• The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the environment.</td>
<td>• Make logical and conceptual connections between evidence and explanations.</td>
</tr>
<tr>
<td>• Proportional relationships among the amount of energy transferred, the mass, and the change in the average kinetic energy of particles as measured by temperature of the sample provide information about the magnitude of properties and processes.</td>
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</tbody>
</table>
What does this look like in the classroom? Use Webb’s DoK and provide specifics when appropriate.

Activity 1 - States of Matter - Level 2 DOK:  
Phenomena/Big Question - How can a standard thermometer be used to tell you how particles are behaving?

The students will use the states of matter simulator on Colorado Phet to investigate how temperature is a measure of the amount of kinetic energy in a system.

https://phet.colorado.edu/en/simulation/legacy/states-of-matter-basics

Engage - Ask the students what is temperature? What is heat? What is cold?  
Explore - Individually have the students work on the states of matter simulator on Colorado Phet  
Explain - The students will explain how the different states of matter are occurring, the relationship between kinetic energy and temperature, and when phase changes occur.  
Elaborate - The students will create a model of how kinetic energy is related to temperature and how it determines states of matter.  
Evaluate - The students will present their final models and descriptions to the rest of the class.

Activity 2 - Energy Transfer Investigation - Level 4 DOK:  
Phenomena/Big Question - What are the relationships among energy transfer?

The students will plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample. Examples of experiments could include comparing final water temperatures after different masses of ice melted in the same volume of water with the same initial temperature, the temperature change of samples of different materials with the same mass as they cool or heat in the environment, or the same material with different masses when a specific amount of energy is added. [Assessment Boundary: Assessment does not include calculating the total amount of thermal energy transferred.] (MS-PS3-4)

Engage - Ask the students to design an investigation that analyzes thermal energy transfer.
Explore - Allow the students to explore their thermal investigation.
Explain - The students will explain their findings and the mechanics of thermal energy transfer.
Elaborate - The students will elaborate on how thermal transfer is related to their thermal transfer investigation.
Evaluate - The students will present their final findings of their investigation to the rest of the class.

Activity 3 - Construct a device that utilizes heat transfer principles - Level 4 DOK
Phenomena/Big Question - How can the principles of heat transfer be used for a human benefit?

The students will design, construct, and test a device that either minimizes or maximizes thermal energy transfer. [Clarification Statement: Examples of devices could include an insulated box, a solar cooker, and a Styrofoam cup.]

Engage - Show the students examples of devices that use the laws of thermodynamics for an engineered purpose (ex. Solar cooker)
Explore - The students will work in small groups to research whether they want to create a device that absorbs or releases heat.
Explain - The students will construct their device and explain how the device works.
Elaborate - The students will elaborate on how heat is transferred in the device and to the surrounding environment.
Evaluate - The students will present their final models and descriptions to the rest of the class.

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**Unit 5 Forces and motion**

Big Idea -

How can we predict the motion of an object?

**Unit Summary**

Students use *system and system models* and *stability and change* to understanding ideas related to why some objects will keep moving and why objects fall to the ground. Students apply Newton's third law of motion to related forces to explain the motion of objects. Students
also apply an engineering practice and concept to solve a problem caused when objects collide. The crosscutting concepts of *system and system models* and *stability and change* provide a framework for understanding the disciplinary core ideas. Students demonstrate proficiency in *asking questions, planning and carrying out investigations, designing solutions, engaging in argument from evidence, developing and using models, and constructing explanations and designing solutions*. Students are also expected to use these practices to demonstrate understanding of the core ideas.

This unit is based on MS-PS2-1, MS-PS2-2, MS-ETS1-1, MS-ETS1-2, MS-ETS1-3, and MS-ETS1-4.

### End Goals

Students will behave like scientists/engineers by:

- Designing a collision investigation
- Constructing a functional sailboat and analyzing the forces that operate on the sailboat

### Student Learning Objectives

Apply Newton’s Third Law to design a solution to a problem involving the motion of two colliding objects. * [Clarification Statement: Examples of practical problems could include the impact of collisions between two cars, between a car and stationary objects, and between a meteor and a space vehicle.] [Assessment Boundary: Assessment is limited to vertical or horizontal interactions in one dimension.] (MS-PS2-1)

Plan an investigation to provide evidence that the change in an object’s motion depends on the sum of the forces on the object and the mass of the object. [Clarification Statement: Emphasis is on balanced (Newton’s First Law) and unbalanced forces in a system, qualitative comparisons of forces, mass and changes in motion (Newton’s Second Law), frame of reference, and specification of units.] [Assessment Boundary: Assessment is limited to forces and changes in motion in one dimension in an inertial reference frame and to change in one variable at a time. Assessment does not include the use of trigonometry.] (MS-PS2-2)

Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions. (MS-ETS1-1)

Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem. (MS-ETS1-2)

Analyze data from tests to determine similarities and differences among several design
solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success. (MS-ETS1-3)

Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved. (MSET1S1-4)

Part A: How does a sailboat work?

<table>
<thead>
<tr>
<th>Concepts</th>
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</table>
| • For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first, but in the opposite direction (Newton’s third law).  
• Models can be used to represent the motion of objects in colliding systems and their interactions, such as inputs, processes, and outputs, as well as energy and matter flows within systems.  
• The uses of technologies and any limitations on their use are driven by individual or societal needs, desires, and values, by the findings of scientific research and by differences in such factors as climate, natural resources, and economic conditions.  
• The more precisely a design task’s criteria and constraints can be defined, the more likely it is that the designed solution will be successful.  
• Specification of constraints includes consideration of scientific principles and other relevant knowledge, which are likely to limit possible solutions. | Students who understand the concepts are able to:  
• Apply Newton’s third law to design a solution to a problem involving the motion of two colliding objects.  
• Define a design problem involving the motion of two colliding objects that can be solved through the development of an object, tool, process, or system and that includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions.  
• Evaluate competing design solutions involving the motion of two colliding objects based on jointly developed and agreed-upon design criteria.  
• Develop a model to generate data to test ideas about designed systems, including those representing inputs and outputs.  
• Analyze and interpret data to determine similarities and differences in findings. |

Part B: Who can build the fastest sailboat?
Concepts

- The change in an object’s motion depends on balanced (Newton’s first law) and unbalanced forces in a system. Evidence that the change in an object’s motion depends on the sum of the forces on the object and the mass of the object includes qualitative comparisons of forces, mass, and changes in motion (Newton’s second law); frame of reference; and specification of units.
- The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change.
- The greater the mass of the object, the greater the force needed to achieve the same change in motion.
- For any given object, a larger force causes a larger change in motion.
- Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales.

Formative Assessment

- Students who understand the concepts are able to:
  - Plan an investigation individually and collaboratively to provide evidence that the change in an object’s motion depends on the sum of the forces on the object and the mass of the object.
  - Design an investigation and identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim.
  - Make logical and conceptual connections between evidence and explanations.
  - Examine the changes over time and forces at different scales to explain the stability and change in designed systems.

What does this look like in the classroom? Use Webb’s DoK and provide specifics when appropriate.

Activity 1 - Collision Lab (Newton’s Third Law) - Level 4 DOK

Phenomena/Big Question - What happens during a collision?

Apply Newton’s Third Law to design a solution to a problem involving the motion of two colliding objects. * [Clarification Statement: Examples of practical problems could include the impact of collisions between two cars, between a car and stationary objects, and between a meteor and a space vehicle.] [Assessment Boundary: Assessment is limited to vertical or horizontal interactions in one dimension.] (MS-PS2-1)
**Engage** - Demonstrate the Colorado Phet collision lab:  
https://phet.colorado.edu/en/simulation/legacy/collision-lab

**Explore** - Ask the students to design an investigation that models the motion of two colliding objects. This investigation should include a collision between two physical objects. The objects should be safe to use in the classroom (ex. Ping pong balls or model cars).

**Explain** - The students will explain the forces involved in the collision.

**Elaborate** - The students will show the direction and magnitude of the forces

**Evaluate** - The students will present their models to the rest of the class

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**Activity 2 - How does a sailboat work? Who can build the fastest sailboat? - Level 4 DOK**

**Phenomena/Big Questions - What makes a sailboat work? How do forces sum together to influence motion?**

The students will work in small groups to create a working sailboat. The sailboat will be placed in a large plastic container that is filled with water. An artificial wind source will be used to propel the sailboat (ex. Hair dryer or fan).

**Engage** - Show the students the following Colorado Phet simulations Motion in 2D and Forces and Motion Basics

https://phet.colorado.edu/en/simulation/legacy/motion-2d  
https://phet.colorado.edu/en/simulation/forces-and-motion-basics

**Explore** - Allow the students to research how a sailboat works and different sailboat designs. After exploring different sailboat designs the students will create their own sailboat.

**Explain** - The students will have to explain how their sailboat works.

**Elaborate** - The students will create a diagram of the forces acting on the sailboat.

**Evaluate** - The students will present the summarization of their findings to the rest of the class.

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**Unit 6 Electromagnetic spectrum**

**Big Idea -**

How do cell phones work?
### Unit Summary

In this unit of study, students develop and use models, use mathematical thinking, and obtain, evaluate, and communicate information in order to describe and predict characteristic properties and behaviors of waves. Students also apply their understanding of waves as a means of sending digital information. The crosscutting concepts of patterns and structure and function are used as organizing concepts for these disciplinary core ideas. Students develop and use models, use mathematical thinking, and obtain, evaluate, and communicate information. Students are also expected to use these practices to demonstrate understanding of the core ideas.

This unit is based on MS-PS4-1, MS-PS4-2, and MS-PS4-3.

Ultimate “project” - Arduino microcontroller that wirelessly transmits data

### End Goals

Students will behave like scientists/engineers by

- Create a model of a physical wave.
- Investigate light/sound waves using reflection, refraction, absorption, and transmission.
- Create a device that transmits digital signals wirelessly.

### Student Learning Objectives

Use mathematical representations to describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave. [Clarification Statement: Emphasis is on describing waves with both qualitative and quantitative thinking.] [Assessment Boundary: Assessment does not include electromagnetic waves and is limited to standard repeating waves.] (MS-PS4-1)

Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials. [Clarification Statement: Emphasis is on both light and mechanical waves. Examples of models could include drawings, simulations, and written descriptions.] [Assessment Boundary: Assessment is limited to qualitative applications pertaining to light and mechanical waves.] (MS-PS4-2)

Integrate qualitative scientific and technical information to support the claim that digitized signals are a more reliable way to encode and transmit information than analog signals. [Clarification Statement: Emphasis is on a basic understanding that waves can be used for
communication purposes. Examples could include using fiber optic cable to transmit light pulses, radio wave pulses in wifi devices, and conversion of stored binary patterns to make sound or text on a computer screen.] [Assessment Boundary: Assessment does not include binary counting. Assessment does not include the specific mechanism of any given device.] (MS-PS4-3)

### Part A: Why do surfers love physicists?

<table>
<thead>
<tr>
<th>Concepts</th>
<th>Formative Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>• A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude.</td>
<td>Students who understand the concepts can:</td>
</tr>
<tr>
<td>• Describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave.</td>
<td>• Use mathematical representations to describe and/or support scientific conclusions about how the amplitude of a wave is related to the energy in a wave.</td>
</tr>
<tr>
<td>• Graphs and charts can be used to identify patterns in data.</td>
<td>• Use mathematical representations to describe a simple model.</td>
</tr>
<tr>
<td>• Waves can be described with both qualitative and quantitative thinking.</td>
<td></td>
</tr>
</tbody>
</table>

### Part B: How do the light and sound system in the auditorium work?

<table>
<thead>
<tr>
<th>Concepts</th>
<th>Formative Assessment</th>
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</thead>
<tbody>
<tr>
<td>• When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object’s material and the frequency (color) of the light.</td>
<td>Students who understand the concepts can:</td>
</tr>
<tr>
<td>• The path that light travels can be traced as straight lines, except at surfaces between different transparent materials (e.g., air and water, air and glass) where the light path bends.</td>
<td>• Develop and use models to describe the movement of waves in various materials.</td>
</tr>
<tr>
<td>• A wave model of light is useful for explaining brightness, color, and</td>
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</tr>
</tbody>
</table>
the frequency-dependent bending of light at a surface between media.

- Waves are reflected, absorbed, or transmitted through various materials.
- A sound wave needs a medium through which it is transmitted. Because light can travel through space, it cannot be a matter wave, like sound or water waves.
- The structure of a wave can be modified to serve particular functions by taking into account properties of different materials and how materials can be shaped and used.

Part C: If rotary phones worked for my grandparents, why did they invent cell phones?

<table>
<thead>
<tr>
<th>Concepts</th>
<th>Formative Assessment</th>
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<tbody>
<tr>
<td>- Structures can be designed to use properties of waves to serve particular functions.</td>
<td>Students who understand the concepts can:</td>
</tr>
<tr>
<td>- Waves can be used for communication purposes.</td>
<td>- Integrate qualitative scientific and technical information in written text with that contained in media and visual displays to clarify claims that digitized signals are a more reliable way to encode and transmit information than analog signals are.</td>
</tr>
<tr>
<td>- Digitized signals (sent as wave pulses) are a more reliable way to encode and transmit information than are analog signals.</td>
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</tr>
<tr>
<td>- Wave-related technologies extend the measurement, exploration, modeling, and computational capacity of scientific investigations.</td>
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</tbody>
</table>
Activity 1 - Wave Model - Level 3 DOK
Phenomena/Big Question - How is a wave created?
The students will design an investigation that analyzes how the amplitude of a wave effects its energy level. The students will be asked to describe a wave quantitatively and qualitatively. Wavelength, frequency, and amplitude will all be addressed.

Engage - Use the Colorado Phet wave on a string simulation to engage the students:  
https://phet.colorado.edu/en/simulation/wave-on-a-string
Explore - Allow the students, in small cooperative groups, to investigate how a wave works and what are the major parts of the wave through their creation of a wave model. The students are open to create the model using whatever school appropriate materials/method that they desire.
Explain - The students will explain how their wave model works
Elaborate - The students will extend the explanation of their model to other wave analogies
Evaluate - The students will present their findings to the rest of the class for peer review.

Activity 2 - Light and sound - Level DOK
Phenomena/Big Question - What is sound? What is light? What do they have in common? How are they different?

The students will conduct an investigation of light/sound waves using reflection, refraction, absorption, and transmission.

Engage - Show the students the following simulation on Colorado Phet:  
https://phet.colorado.edu/en/simulation/legacy/sound
Explore - The students can work in cooperative groups to explore the different properties of waves.
Explain - The students will be asked to create an investigation that incorporates wave reflection, refraction, absorption, and transmission. The students will then be asked to explain how each of these are occurring.
Elaborate - The students can elaborate on waves by explaining applications of reflection, refraction, absorption, and transmission.
Evaluate - The students will present their findings to the rest of the class for evaluation.

Activity 3 - Wireless digital data communication - Level 4 DOK

In this lab activity the students will build a microcontroller that is able to send and receive digital data. The following websites provide examples for the teacher:

https://www.youtube.com/watch?v=e8RhXtst7ME
**Engage** - Show and explain to the students the history of wireless communication

**Explore** - Allow the students in groups to explore how a microcontroller can be used to transmit information wirelessly. Different approaches to accomplishing the task, of wirelessly transmitting the data with the microcontroller, will be encouraged. The data can be transmitted from a laptop to the microcontroller device or from one group’s microcontroller to another.

**Explain** - The students will explain how their device, and the wireless transmission of data works

**Elaborate** - The students will elaborate on how this project could be furthered if given more time and resources.

**Evaluate** - The students will present their findings to the rest of the class.

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### Unit 7: Types of interactions

**Big Idea** -

Is it possible to exert force on an object without touching it?

### Unit Summary

Students use *cause and effect; system and system models; and stability and change* to understand ideas that explain why some materials are attracted to each other while others are not. Students apply ideas about gravitational, electrical, and magnetic forces to explain a variety of phenomena including beginning ideas about why some materials attract each other while others repel. In particular, students develop understandings that gravitational interactions are always attractive but that electrical and magnetic forces can be both attractive and negative. Students also develop ideas that objects can exert forces on each other even though the objects are not in contact, through fields. Students are expected to consider the influence of science, engineering, and technology on society and the natural world. Students
are expected to demonstrate proficiency in asking questions, planning and carrying out investigations, designing solutions, and engaging in argument. Students are also expected to use these practices to demonstrate understanding of the core ideas. This unit is based on MS-PS2-3, MS-PS2-4, and MS-PS2-5.

Ultimate “project” - Create an electromagnet

End Goals

Students will behave like scientists/engineers by

- Investigate electromagnetic waves using a simulation
- Create an electromagnet
- Investigate the factors that influence gravity using a simulation

Student Learning Objectives

Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact. [Clarification Statement: Examples of this phenomenon could include the interactions of magnets, electrically-charged strips of tape, and electrically-charged pith balls. Examples of investigations could include first-hand experiences or simulations.] [Assessment Boundary: Assessment is limited to electric and magnetic fields, and is limited to qualitative evidence for the existence of fields.] (MS-PS2-5)

Ask questions about data to determine the factors that affect the strength of electric and magnetic forces. [Clarification Statement: Examples of devices that use electric and magnetic forces could include electromagnets, electric motors, or generators. Examples of data could include the effect of the number of turns of wire on the strength of an electromagnet, or the effect of increasing the number or strength of magnets on the speed of an electric motor.] [Assessment Boundary: Assessment about questions that require quantitative answers is limited to proportional reasoning and algebraic thinking.] (MS-PS2-3)

Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects. [Clarification Statement: Examples of evidence for arguments could include data generated from simulations or digital tools; and charts displaying mass, strength of interaction, distance from the Sun, and orbital periods of objects within the solar system.] [Assessment Boundary: Assessment does not include Newton’s Law of Gravitation or Kepler’s Laws.] (MS-PS2-4)
### Part A: Can you apply a force on something without touching it?

<table>
<thead>
<tr>
<th>Concepts</th>
<th>Formative Assessment</th>
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</thead>
</table>
| • Fields exist between objects that exert forces on each other even though the objects are not in contact.  
• The interactions of magnets, electrically charged strips of tape, and electrically charged pith balls are examples of fields that exist between objects exerting forces on each other, even though the objects are not in contact.  
• Forces that act at a distance (electric, magnetic, and gravitational) can be explained by fields that extend through space and can be mapped by their effect on a test object (a charged object or a ball, respectively).  
• Cause-and-effect relationships may be used to predict phenomena in natural or designed systems. | Students who understand the concepts are able to:  
• Students will conduct an investigation and evaluate an experimental design to produce data that can serve as the basis for evidence that fields exist between objects exerting forces on each other even though the objects are not in contact.  
• Students will identify the cause-and-effect relationships |

### Part B: How does a Maglev train work?

<table>
<thead>
<tr>
<th>Concepts</th>
<th>Formative Assessment</th>
</tr>
</thead>
</table>
| Concepts  
• Factors affect the strength of electric and magnetic forces.  
• Devices that use electric and magnetic forces could include electromagnets, electric motors, and generators.  
• Electric and magnetic (electromagnetic) forces can be attractive or repulsive.  
• The size of an electric or magnetic (electromagnetic) force depends on the magnitudes of the charges, currents, or magnetic strengths involved and on the | Students who understand the concepts are able to:  
• Students will ask questions about data to determine the effect of the strength of electric and magnetic forces that can be investigated within the scope of the classroom, outdoor environment, and museums and other public facilities with available resources and, when appropriate, frame a hypothesis based on observations and scientific principles.  
• Students will perform investigations using |
distances between the interacting objects. • Cause-and-effect relationships may be used to predict the factors that affect the strength of electrical and magnetic forces in natural or designed systems

| Devices that use electromagnetic forces. • Students will collect and analyze data that could include the effect of the number of turns of wire on the strength of an electromagnet or the effect of increasing the number or strength of magnets on the speed of an electric motor. |

Part C: If I were able to eliminate air resistance and dropped a feather and a hammer at the same time, which would land first?

<table>
<thead>
<tr>
<th>Concepts</th>
<th>Formative Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Gravitational interactions are always attractive and depend on the masses of interacting objects. • There is a gravitational force between any two masses, but it is very small except when one or both of the objects have large mass. • Evidence supporting the claim that gravitational interactions are attractive and depend on the masses of interacting objects could include data generated from simulations or digital tools and charts displaying mass, strength of interaction, distance from the sun, and orbital periods of objects within the solar system.</td>
<td>Students who understand the concepts are able to: • Students construct and present oral and written arguments supported by empirical evidence and scientific reasoning to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects. • Students use models to represent the gravitational interactions between two masses</td>
</tr>
</tbody>
</table>

What does this look like in the classroom? Use Webb's DoK and provide specifics when appropriate.

**Activity 1 - Electric field investigation - Level 2 DOK**

**Phenomenon/Big Question - How do magnets work? Can you apply a force on something without touching it?**
The students will investigate electric fields with the following Colorado Phet simulator:
https://phet.colorado.edu/en/simulation/legacy/electric-hockey

**Engage** - Demonstrate to the students how a magnet effects iron fillings
**Explore** - Allow the students to explore the Colorado Phet simulator “Electric Field Hockey”
**Explain** - The students will need to explain with a model how electric fields works and what causes them to occur.
**Elaborate** - The students will elaborate on how electric fields are used in modern technology.
**Evaluate** - The students will present their findings, models, and further information to the rest of the class.

**Activity 2 - Create an electromagnet - Level 4 DOK**
**Phenomena/Big Questions - How does a Maglev train work?**

**Engage** - Expose the students to the Colorado Phet generator
https://phet.colorado.edu/en/simulation/legacy/generator

**Explore** - Allow the students to explore and research how generators works using digital resources.
**Explain** - The students will create a functioning generator to serve as a model.
**Elaborate** - The students will elaborate on how generators are used in our modern world.
**Evaluate** - The students will present their model and findings to the rest of the class for peer review.

**Activity 3 - How does gravity influence motion? - Level 3 DOK**
**Phenomena/Big Question - How does gravity influence motion?**

The students will work in pairs to explore how gravity influences motion in the solar system.


**Explore** - The students will explore the following Colorado Phet simulation to see how gravity influences motion.
   - Gravity and orbits
      https://phet.colorado.edu/en/simulation/legacy/gravity-and-orbits

**Explain** - The students will explore the simulator and then explain how gravity is linked to motion of the planets
**Elaborate** - The students will be directed to discover the two factors that influence gravity (mass and distance)
**Evaluate** - The students will present their final findings to the rest of the class.
Unit 8: Relationships among forms of energy

Big Idea -
How can physics explain sports?

Unit Summary

In this unit, students use the practices of analyzing and interpreting data, developing and using models, and engaging in argument from evidence to make sense of relationship between energy and forces. Students develop their understanding of important qualitative ideas about the conservation of energy. Students understand that objects that are moving have kinetic energy and that objects may also contain stored (potential) energy, depending on their relative positions. Students also understand the difference between energy and temperature, and the relationship between forces and energy. The crosscutting concepts of scale, proportion, and quantity, systems and system models, and energy and matter are called out as organizing concepts for these disciplinary core ideas. Students use the practices of analyzing and interpreting data, developing and using models, and engaging in argument from evidence. Students are also expected to use these practices to demonstrate understanding of the core ideas.

This unit is based on MS-PS3-1, MS-PS3-2, and MS-PS3-5.

End Goals

Students will behave like scientists/engineers by

- Investigating kinetic and potential energy using a simulator
- Creating a roller coaster to demonstrate how energy changes forms

Student Learning Objectives

Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object. [Clarification Statement: Emphasis is on descriptive relationships between kinetic energy and mass separately from kinetic energy and speed. Examples could include riding a bicycle at different speeds, rolling different sizes of rocks downhill, and getting hit by a wiffle ball versus a tennis ball.] (MS-PS3-1)
Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system. [Clarification Statement: Emphasis is on relative amounts of potential energy, not on calculations of potential energy. Examples of objects within systems interacting at varying distances could include: the Earth and either a roller coaster cart at varying positions on a hill or objects at varying heights on shelves, changing the direction/orientation of a magnet, and a balloon with static electrical charge being brought closer to a classmate’s hair. Examples of models could include representations, diagrams, pictures, and written descriptions of systems.] [Assessment Boundary: Assessment is limited to two objects and electric, magnetic, and gravitational interactions.] (MS-PS3-2)

Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object. [Clarification Statement: Examples of empirical evidence used in arguments could include an inventory or other representation of the energy before and after the transfer in the form of temperature changes or motion of object.] [Assessment Boundary: Assessment does not include calculations of energy.] (MS-PS3-5)

### Part A: Is it better to have an aluminum (baseball/softball) bat or a wooden bat?

<table>
<thead>
<tr>
<th>Concepts</th>
<th>Formative Assessment</th>
</tr>
</thead>
</table>
| • Kinetic energy is related to the mass of an object and to the speed of an object.  
• Kinetic energy has a relationship to mass separate from its relationship to speed.  
• Motion energy is properly called kinetic energy; it is proportional to the mass of the moving object and grows with the square of the object’s speed.  
• Proportional relationships among different types of quantities provide information about the magnitude of properties and processes. | Students who understand the concepts can: • Construct and interpret graphical displays of data to identify linear and nonlinear relationships of kinetic energy to the mass of an object and to the speed of an object. |

### Part B: What would give you a better chance of winning a bowling match, using a basketball that you can roll really fast, or a bowling ball that you can only roll slowly?

<table>
<thead>
<tr>
<th>Concepts</th>
<th>Formative Assessment</th>
</tr>
</thead>
</table>

Students who understand the concepts can: • Construct and interpret graphical displays of data to identify linear and nonlinear relationships of kinetic energy to the mass of an object and to the speed of an object.
- When the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system.
- A system of objects may contain stored (potential) energy, depending on the objects’ relative positions.
- When two objects interact, each one exerts a force on the other that can cause energy to be transferred to or from the objects.
- Models that could include representations, diagrams, pictures, and written descriptions of systems can be used to represent systems and their interactions, such as inputs, processes, and outputs, and energy and matter flows within systems.

Students who understand the concepts can:
- Develop a model to describe what happens to the amount of potential energy stored in the system when the arrangement of objects interacting at a distance changes
- Use models to represent systems and their interactions, such as inputs, processes, and outputs, and energy and matter flows within systems. Models could include representations, diagrams, pictures, and written descriptions.

Part C: Who can design the best roller coaster?

<table>
<thead>
<tr>
<th>Concepts</th>
<th>Formative Assessment</th>
</tr>
</thead>
</table>
| • When the kinetic energy of an object changes, energy is transferred to or from the object.  
• When the motion energy of an object changes, there is inevitably some other change in energy at the same time.  
• Kinetic energy may take different forms (e.g., energy in fields, thermal energy, energy of motion). | Students who understand the concepts can:  
• Construct, use, and present oral and written arguments supported by empirical evidence and scientific reasoning to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.  
• Conduct an inventory or other representation of the energy before and after the transfer in the form of temperature |

What does this look like in the classroom? Use Webb’s DoK and provide specifics when appropriate.

**Activity 1 - Energy skate park lab - Level 2 DOK**
**Phenomena/Big Question - How does energy change forms? Is it better to have an**
aluminum (baseball/softball) bat or a wooden bat? What would give you a better chance of winning a bowling match, using a basketball that you can roll really fast, or a bowling ball that you can only roll slowly?

The students will explore the skate park simulator found on Colorado Phet:

https://phet.colorado.edu/en/simulation/energy-skate-park-basics

Engage - Start the class with a discussion on skateboarding
Explore - The students will explore the Colorado Phet simulator
Explain - The students will explain how kinetic and potential energy are related. The students will explain how mass influences kinetic and potential energy. The students will explain how speed effects kinetic energy and height effects potential energy.
Elaborate - The students will create a report on energy transfer at the skate park.
Evaluate - The students will present their findings to the rest of the class.

Activity 2 - Roller Coaster Design - Level 4 DOK
Phenomena/Big Question - How does a roller coaster work? Who can design the best roller coaster?

The students will be asked to design and engineer a functional roller coaster model that demonstrates potential and kinetic energy.

Engage - Ask the students to share personal stories of roller coaster rides that they have been on.
Explore - The students will explore different roller coaster designs
Explain - The students will explain the physics involved in a roller coaster
Elaborate - The students will elaborate their roller coaster designs by including different models of varying kinetic and potential energy values
Evaluate - The students will present their final findings to the rest of the class for evaluation
The intent of the Next Generation Science Standards and the updated Mount Holly Science Curriculum is to embed students in a rigorous learning environment that challenges students to work collaboratively, think critically, be creative and to communicate, solving real world problems and questions. Students should be provided an opportunity to be innovative in planning investigations and organizing their learning through research.

5 E Instructional Model

The 5 E Instructional Model should be referenced when planning. How does each lesson/unit address the following attributes? Students should be engaged and have the opportunity to explore and explain conclusions. They should be able to elaborate on their process and findings through self evaluation.

Engage: This phase of the 5 E's starts the process. An "engage" activity should do the following:
1. Make connections between past and present learning experiences
2. Anticipate activities and focus students' thinking on the learning outcomes of current activities. Students should become mentally engaged in the concept, process, or skill to be learned.

Explore: This phase of the 5 E's provides students with a common base of experiences. They identify and develop concepts, processes, and skills. During this phase, students actively explore their environment or manipulate materials.

Explain: This phase of the 5 E's helps students explain the concepts they have been exploring. They have opportunities to verbalize their conceptual understanding or to demonstrate new skills or behaviors. This phase also provides opportunities for teachers to introduce formal terms, definitions, and explanations for concepts, processes, skills, or behaviors.

Elaborate: This phase of the 5 E's extends students' conceptual understanding and allows them to practice skills and behaviors. Through new experiences, the learners develop deeper and broader understanding of major concepts, obtain more information about areas of interest, and refine their skills.
**Evaluate:** This phase of the 5 E’s encourages learners to assess their understanding and abilities and lets teachers evaluate students’ understanding of key concepts and skill development.

**Webb’s DoK**

Webb’s Depth of Knowledge should be a strong consideration when planning lessons. Teachers should make every effort to “live in level 3” while visiting the other levels as needed (1-2) and when possible (4).
LEVEL 1 – RECALL & REPRODUCTION

Curricular elements that fall into this category involve basic tasks that require students to recall or reproduce knowledge and/or skills. The subject matter content at this particular level usually involves working with facts, terms and/or properties of objects. It may also involve use of simple procedures and/or formulas. There is little transformation or extended processing of the target knowledge required by the tasks that fall into this category. Key words that often denote this particular level include: list, identify and define. A student answering a Level 1 item either knows the answer or does not; that is, the answer does not need to be “figured out” or “solved.”

POSSIBLE PRODUCTS

<table>
<thead>
<tr>
<th>Quiz</th>
<th>List</th>
<th>Collection</th>
<th>Podcast</th>
<th>Social bookmarking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Definition</td>
<td>Workbook</td>
<td>Explanation</td>
<td>Categorizing/Tagging</td>
<td>Searching</td>
</tr>
<tr>
<td>Fact</td>
<td>Reproduction</td>
<td>Show and Tell</td>
<td>Commenting</td>
<td>Googling</td>
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<tr>
<td>Worksheet</td>
<td>Vocabulary Quiz</td>
<td>Outline</td>
<td>Bulleting</td>
<td>Highlighting</td>
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<tr>
<td>Test</td>
<td>Recitation</td>
<td>Blog</td>
<td>Blogging</td>
<td>Highlighting</td>
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<tr>
<td>Label</td>
<td>Example</td>
<td>Wiki</td>
<td>Social networking</td>
<td>Social networking</td>
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ROLES

<table>
<thead>
<tr>
<th>TEACHER</th>
<th>STUDENT</th>
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<tbody>
<tr>
<td>Directs</td>
<td>Absorbs</td>
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<tr>
<td>Shows</td>
<td>Responds</td>
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<td>Questions</td>
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<td>Demonstrates</td>
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Level 2 – Working with Skills & Concepts

Level 2 includes the engagement of some mental processing beyond recalling or reproducing a response. This level generally requires students to contrast or compare people, places, events and concepts; convert information from one form to another; classify or sort items into meaningful categories; describe or explain issues and problems, patterns, cause and effect, significance or impact, relationships, points of view or processes. A Level 2 “describe or explain” would require students to go beyond a description or explanation of recalled information to describe or explain a result or “how” or “why.” The learner should make use of information in a context different from the one in which it was learned.

Elements found in a curriculum that fall in this category involve working with or applying skills and/or concepts to tasks related to the field of study in a laboratory setting. The subject matter content at this particular level usually involves working with a set of principles, categories, heuristics, and protocols. At this level students are asked to transform/process target knowledge before responding. Example mental processes that often denote this particular level include: summarize, estimate, organize, classify, and infer.

### POSSIBLE PRODUCTS

<table>
<thead>
<tr>
<th>Photograph</th>
<th>Presentation</th>
<th>Reverse-Engineering</th>
<th>Blog Commenting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Illustration</td>
<td>Interview</td>
<td>Cracking Codes</td>
<td>Blog Reflecting</td>
</tr>
<tr>
<td>Simulation</td>
<td>Performance</td>
<td>Linking</td>
<td>Moderating</td>
</tr>
<tr>
<td>Sculpture</td>
<td>Dairy</td>
<td>Mashing</td>
<td>Testing (Alpha/Beta)</td>
</tr>
<tr>
<td>Demonstration</td>
<td>Journal</td>
<td>Relationship Mind Maps</td>
<td>Validating</td>
</tr>
</tbody>
</table>

### ROLES

<table>
<thead>
<tr>
<th>TEACHER</th>
<th>STUDENT</th>
<th>STUDENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shows</td>
<td>Facilitates</td>
<td>Solves problems</td>
</tr>
<tr>
<td>Observes</td>
<td>Evaluates</td>
<td>Calculates</td>
</tr>
<tr>
<td>Organizes</td>
<td>Questions</td>
<td>Completes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Illustrates</td>
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<tr>
<td></td>
<td></td>
<td>Demonstrates use of knowledge</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Compiles</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Constructs</td>
</tr>
</tbody>
</table>
LEVEL 3 – SHORT-TERM STRATEGIC THINKING

Items falling into this category demand a short-term use of higher order thinking processes, such as analysis and evaluation, to solve real-world problems with predictable outcomes. Stating one’s reasoning is a key marker of tasks that fall into this particular category. The expectation established for tasks at this level tends to require coordination of knowledge and skill from multiple subject-matter areas to carry out processes and reach a solution in a project-based setting. Key processes that often denote this particular level include: analyze, explain and support with evidence, generalize, and create.

POSSIBLE PRODUCTS

<table>
<thead>
<tr>
<th>Graph</th>
<th>Survey</th>
<th>Debate</th>
<th>Conclusion</th>
<th>Podcast</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spreadsheet</td>
<td>Database</td>
<td>Panel</td>
<td>Program</td>
<td>Publishing</td>
</tr>
<tr>
<td>Checklist</td>
<td>Mobile</td>
<td>Report</td>
<td>Film</td>
<td>Wiki-ing</td>
</tr>
<tr>
<td>Chart</td>
<td>Abstract</td>
<td>Evaluating</td>
<td>Animation</td>
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<tr>
<td>Outline</td>
<td>Report</td>
<td>Investigation</td>
<td>Video cast</td>
<td></td>
</tr>
</tbody>
</table>

ROLES

**TEACHER**
- Probes
- Observes
- Acts as a resource
- Organizes
- Clarifies
- Guides

**STUDENT**
- Discusses
- Evaluates
- Questions
- Dissects
- Accepts
- Guides

- Debates
- Examines
- Judges
- Assesses
- Justifies

- Uncovers
- Thinks deeply
- Questions
- Disputes
- Decides
- Argues
- Tests
- Calculates
- Compares
- Selects

Level 4 – Extended Strategic Thinking

Curricular elements assigned to this level demand extended use of higher order thinking processes such as synthesis, reflection, assessment and adjustment of plans over time. Students are engaged in conducting investigations to solve real-world problems with unpredictable outcomes. Employing and sustaining strategic thinking processes over a longer period of time to solve the problem is a key feature of curricular objectives that are assigned to this level. Key strategic thinking processes that denote this particular level include: synthesize, reflect, conduct, and manage.

POSSIBLE PRODUCTS

<table>
<thead>
<tr>
<th>Film</th>
<th>Project</th>
<th>New Game</th>
<th>Newspaper</th>
</tr>
</thead>
<tbody>
<tr>
<td>Story</td>
<td>Plan</td>
<td>Song</td>
<td>Media Product</td>
</tr>
</tbody>
</table>

ROLES

**TEACHER**
- Facilitates
- Reflects
- Evaluates

**STUDENT**
- Extends
- Analyses
- Takes risks
- Proposes

- Designs
- Takes risks
- Proposes

- Formulates
- Modifies
- Creates

- Plans
- Creates