Science Curriculum

Grade 6 Unit 3:
FOSS Electromagnetic Forces
Course Description

The students in the sixth grade Science course will develop a conceptual understanding of Science topics using hands-on instruction, interactive notebooking, observations of and interactions with natural phenomena and the use of engineering and design processes to identify problems, plan, test and revise possible solutions. In Life Science, students will explore the vast diversity of life on earth and how organisms grow and reproduce. In Physical Science they will explore how forces affect the movement of objects on Earth and across the universe, as well as how and why objects are attracted to or repelled by one another. In Earth Science, students will explore the role that water and energy play in our ocean and climate systems.

Teachers may choose from a variety of instructional approaches that are aligned with 3 dimensional learning to achieve this goal. These approaches include:

<table>
<thead>
<tr>
<th>Inquiry Kit Instruction (modified)</th>
<th>Challenge Based Instruction</th>
<th>5 E Instructional Model (BSCS)</th>
<th>Culturally Relevant Instruction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project-Based Instruction</td>
<td>Tinkering Pedagogy</td>
<td>Learning Progressions</td>
<td>Knowledge Integration</td>
</tr>
<tr>
<td>Model-based Reasoning</td>
<td>Place-based Instruction</td>
<td>Meaningful Expertise Instruction</td>
<td>Emergent Investigations (RSS)</td>
</tr>
</tbody>
</table>
Graded Six Unit 3: FOSS Electromagnetic Forces

Grade Six Pacing Chart
Please note that pacing is based upon 240 minutes per 6 day cycle.

<table>
<thead>
<tr>
<th>Unit</th>
<th>Content</th>
<th>Days</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Science Practices and Engineering Design</td>
<td>10</td>
</tr>
<tr>
<td>2</td>
<td>FOSS Gravity &amp; Kinetic Energy</td>
<td>25</td>
</tr>
<tr>
<td>3</td>
<td>FOSS Electromagnetism</td>
<td>25</td>
</tr>
<tr>
<td>4</td>
<td>FOSS Weather &amp; Water</td>
<td>60</td>
</tr>
<tr>
<td>5</td>
<td>FOSS Diversity of Life</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td>Final Assessment</td>
<td>5</td>
</tr>
</tbody>
</table>

Unit Summary

How do electromagnetic forces interact on Earth?
Students manipulate equipment to collect data about magnetic fields and electricity. They construct explanations based on observable patterns and develop models that define the cause-and-effect relationships of the forces and interactions they are measuring. The culmination of the course leads students to consider accessible energy sources and the reliance of modern lifestyles on access to this energy, as well as the consequences of such energy use. Students leave this course with an understanding of force and energy that forms a solid foundation for high school and college physics.

This unit is based on MS-PS2-2, MS-PS2-3, MS-PS2-5, MS-ETS1-1, MS-ETS1-2, MS-ETS1-3, and MS-ETS1-4.

Student Learning Objectives

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)

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)

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)
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)

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)

<table>
<thead>
<tr>
<th>Learning Objective and Standard</th>
<th>Essential Questions</th>
<th>Content Related to DCI’s</th>
<th>Sample Activities</th>
<th>Resources</th>
</tr>
</thead>
</table>
| **Investigation 1 Part 1: Push and Pull** Students gather evidence to support a claim regarding the fact that forces can be additive or cancel one another out. MS-PS2-2 | What makes things move? | • A force is a push or a pull.  
• The metric unit for force is the newton (N). | **Benchmark Assessment** *Entry-Level Survey*  
 Students start their inquiry of force using spring scales to push and pull objects, noting that some objects require more push or pull to put them into motion. They complete a series of push and pull experiments, and quantify force in terms of the amount of stretch of a steel spring. Students are introduced to the idea that forces add, producing more force or canceling one another.  
 **Embedded assessment:** Science notebook entry | Science Resources Book: “The Force Is with You” |
| **Investigation 1 Part 2: Friction** Students identify patterns in data to develop an explanation regarding the relationship between friction and motion. | How does friction affect the force needed to move an object? | • Friction is a force that acts to oppose a force acting to put a mass in motion. | Students use spring scales to measure the force needed to move loads on different surfaces. They review class results to consider patterns. Friction is developed as a force opposing motion, a force that changes depending on the two surfaces that are touching.  
 **Embedded assessment:** Performance Assessment | Science Resources Book: “The Discovery of Friction” |
### Investigation 1 Part 3: Forces in Action

**How do multiple forces affect motion?**

- Net force is the sum of the forces acting on a mass.

Students observe force exerted on one side of a rolling cart and on both sides of the cart. The idea of net force is developed to explain how force can cause motion in some instances but not in others. Students observe force being exerted on a cart that is positioned against the wall and try to explain why it is not moving. The idea that inanimate objects, like walls, can push is considered. Students use the idea of net force to analyze a number of force problems.

**Embedded assessment:** Response sheet

**Benchmark Assessment:** Investigation 1 I-Check

**Science Resources**
- Book: “Net Force”
- Video: Forces

### Investigation 2 Part 1: Properties of Magnets

**What happens when magnets interact?**

- Magnets stick to (attract) objects that contain iron.
- All magnets have two poles, a north pole on one side and a south pole on the other side. Like poles of magnets repel each other; opposite poles attract.

Students observe that the two sides (poles) of magnets are different, attracting or repelling one another, depending on orientation. While they conduct an investigation to determine if like or opposite poles attract, students learn the north/south convention for naming poles.

**Embedded assessment:** Science notebook entry

**Science Resources**
- Book: “Magnetic Force”
- Video: Magnetism

### Investigation 2 Part 2: Magnetic Fields

**How can we detect a magnetic field?**

- Magnets are surrounded by an invisible magnetic force field, which acts through space and through all nonmagnetic materials.
- Magnetic materials may become temporary magnets.

Students work with magnets and other objects to discover that magnetism acts through certain materials including air, nonmagnetic metals, and nonmetals. They also discover that bringing a magnet close to a piece of iron induces magnetism in the iron. Students learn that these effects are manifestations of the invisible magnetic field that surrounds every magnet.

**Embedded assessment:** Response sheet

**Science Resources**
- Book: “Magnetic Force”
- Video: Magnetism
### Investigation 2 Part 3: Force over Distance
**What factors affect the force of attraction between magnets?**
- **The magnitude of the magnetic force between two interacting magnetic fields decreases as the distance between them increases.**

Students use a spring scale to measure the force of attraction between magnets. They increase the distance between the magnets and re-measure the force. Students learn that the force of attraction between magnets decreases as the distance between them increases. Next, they add additional magnets to a system to learn how magnetic fields overlap. Students then use an online activity to help visualize magnetic fields and to test further predictions.

**Embedded assessment:** Performance Assessment
**Benchmark Assessment:** Investigation 2 I-Check

### Investigation 3 Part 1: Building a Circuit
**What is required to complete an electric circuit?**
- **An electric circuit is a system that includes a complete pathway through which electric current flows.**
- **A magnetic field surrounds a wire through which electric current is flowing.**

Students are introduced to electricity and energy. They discover how to make a complete circuit using a D-cell, wires, and a lightbulb. Students discuss the electricity’s pathway in the circuit and the function of each of the system’s components. They also take a close look at the anatomy of a lightbulb.

**Embedded assessment:** Response sheet

### Investigation 3 Part 2: Building an Electromagnet
**How does an electromagnet work?**
- **A magnetic field surrounds a wire through which electric current is flowing.**
- **The magnetic field produced by a current-carrying wire can induce magnetism in a**

Students discover that a steel core becomes a magnet when current flows through an insulated wire wound around the steel core.

**Embedded assessment:** Science notebook entry
### Investigation 3 Part 3: Improving the Design

Students analyze data regarding their electromagnet tests and refine their models to optimize its function.

**MS-PS2-2, MS-PS2-3, MS-PS2-5, MS-PS3-2, MS-ETS1-1, MS-ETS1-2, MS-ETS1-3, MS-ETS1-4**

**What modifications to an electromagnet will affect the strength of its magnetic field?**

- An electromagnet is made by sending electric current through an insulated wire wrapped around an iron core.
- The strength of magnetism induced in the core of an electromagnet increases with the number of winds of wire, the amount of electric current flowing in the wire, and the iron content of the core.

Students brainstorm different variables that might affect the strength of their electromagnet, and then test those variables. Working as a class, they combine their results to determine the best design for an electromagnet.

**Embedded assessment:** Performance Assessment

**Benchmark Assessment:** *Investigation 3 I-Check*

---

### Investigation 4 Part 1: Electric Motors

Students analyze the structure and function of an electric motor to develop a claim that when the motion energy of an object changes, energy is transferred to or from the object.

**MS-PS3-5**

**How does an electric motor work?**

- An electric motor is designed with a commutator that acts as a switch, turning on and off an electromagnet.
- Every energy use can be described as a sequence of energy transfers.

Students operate an electric motor in a circuit, dissect a motor, and explain how it works after analyzing its components. They describe its design and function in terms of its components and energy transfers.

**Embedded assessment:** Science notebook entry

---

*Science Resources Book:*
- “Engineering Design Process”
- “Electromagnetic Engineering”

*Online Activities:*
- “Virtual Electromagnet”
- “Motor Dissection A”
- “Motor Dissection B”
- “Kitchen Magnets”
## Investigation 4 Part 2: Electric Generators

**MS-PS3-5**

<table>
<thead>
<tr>
<th>Question</th>
<th>Plan of Activity</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>How can we generate electrical energy?</td>
<td>Electric generators transfer energy from kinetic energy to electrical energy.</td>
<td>Students observe a generator and compare its components and function to a motor. They explain the interactions in terms of energy transfer. They consider energy sources for human electricity use and use solar cells to power an electric motor. Students read about human energy sources, including resource limitations and consequences. <strong>Embedded assessment</strong>: Performance Assessment <strong>Benchmark Assessment</strong>: Investigation 3 1-Check</td>
</tr>
<tr>
<td></td>
<td>Energy cannot be created or destroyed, only transferred.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Every energy use can be described as a sequence of energy transfers.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Energy sources can be categorized as renewable or nonrenewable.</td>
<td></td>
</tr>
</tbody>
</table>

## Investigation 4 Part 3: Force and Energy

**MS-PS3-5**

<table>
<thead>
<tr>
<th>Question</th>
<th>Plan of Activity</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>What are the big ideas about electromagnetic force?</td>
<td>Energy cannot be created or destroyed, only transferred.</td>
<td>Students consider key points from the entire course to prepare for the final benchmark assessment. They revisit the Entry-Level Survey and improve their responses. <strong>Benchmark Assessment</strong>: Posttest</td>
</tr>
<tr>
<td></td>
<td>Every energy use can be described as a sequence of energy transfers.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Energy sources can be categorized as renewable or nonrenewable.</td>
<td></td>
</tr>
</tbody>
</table>

### Unit Project/Lab Performance Assessment

Engineering builds in Investigations 3 and 4 meet the Performance Assessment requirements.
What It Looks Like in the Classroom

Students will investigate magnetic and electric forces to determine the nature of the force (repulsive, attractive, or both), and factors that affect the strength of the forces. Before beginning the investigations, students will generate questions that will be used to guide their investigations. Depending on the nature of their questions, students may need to cite specific textual evidence to support the generation of a hypothesis. During the investigation, students will identify cause-and-effect relationships and use their understanding of these relationships to make predictions about what would happen if a variable in the investigation were changed. They will also determine the impact of distance on the strength of a force. Investigations may include the use of electromagnets, electric motors, or generators. During these investigations, students will collect data that they will use to answer their self-generated questions.

Investigations may take place in the classroom, outdoor environment, or museums and other public facilities with available resources and when appropriate. Students will frame a hypothesis based on observations and scientific principles about the behavior of electromagnetic forces and carry out investigations to collect data about the factors that affect the strength of electric and magnetic forces. Examples of investigations 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. Students will analyze both numerical and symbolic data and use these data to determine the factors that affect the strength of electric and magnetic fields. Students will conclude this portion of the unit by citing specific textual evidence to support the analysis of information they access while reading science and technical texts or online sources about electric and magnetic forces, attending to the precise details of explanations or descriptions.

Modifications for differentiation at all levels

(Note: Teachers identify the modifications that they will use in the unit. See NGSS Appendix D: All Standards, All Students/Case Studies for vignettes and explanations of the modifications.)

- Structure lessons around questions that are authentic, relate to students’ interests, social/family background and knowledge of their community.
- Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).
- Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from...
the community helping with a project, journal articles, and biographies).

- Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).
- Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings.
- Use project-based science learning to connect science with observable phenomena.
- Structure the learning around explaining or solving a social or community-based issue.
- Provide ELL students with multiple literacy strategies.
- Collaborate with after-school programs or clubs to extend learning opportunities.
- Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#VXmoXcfD_UA)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>acceleration</td>
<td>induced magnetism</td>
<td>automobile</td>
</tr>
<tr>
<td>compress</td>
<td>magnetic field</td>
<td>brush</td>
</tr>
<tr>
<td>force</td>
<td>magnetism</td>
<td>commutator</td>
</tr>
<tr>
<td>friction</td>
<td>particle</td>
<td>constraint</td>
</tr>
<tr>
<td>gravity</td>
<td>permanent magnet</td>
<td>criterion</td>
</tr>
<tr>
<td>interaction</td>
<td>pole</td>
<td>fossil fuel</td>
</tr>
<tr>
<td>magnet</td>
<td>repel</td>
<td>nonrenewable</td>
</tr>
<tr>
<td>net force</td>
<td>temporary magnet</td>
<td>potential energy</td>
</tr>
<tr>
<td>newton</td>
<td></td>
<td>power grid</td>
</tr>
<tr>
<td>shaft</td>
<td></td>
<td>renewable</td>
</tr>
<tr>
<td>spring scale</td>
<td></td>
<td>solar cell</td>
</tr>
<tr>
<td>weight</td>
<td></td>
<td>sustainable</td>
</tr>
<tr>
<td></td>
<td><strong>Investigation 2: The Force of Magnetism</strong></td>
<td></td>
</tr>
<tr>
<td>attract</td>
<td>battery</td>
<td></td>
</tr>
<tr>
<td>compass</td>
<td>circuit</td>
<td></td>
</tr>
<tr>
<td>gravitational field</td>
<td>climate change</td>
<td></td>
</tr>
<tr>
<td></td>
<td>closed circuit</td>
<td></td>
</tr>
<tr>
<td></td>
<td>complete circuit</td>
<td></td>
</tr>
<tr>
<td></td>
<td>component</td>
<td></td>
</tr>
<tr>
<td></td>
<td>conductor</td>
<td></td>
</tr>
<tr>
<td></td>
<td>contact point</td>
<td></td>
</tr>
<tr>
<td></td>
<td>core</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Investigation 4: Energy Transfer</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>automobile</td>
<td></td>
</tr>
<tr>
<td></td>
<td>brush</td>
<td></td>
</tr>
<tr>
<td></td>
<td>commutator</td>
<td></td>
</tr>
<tr>
<td></td>
<td>constraint</td>
<td></td>
</tr>
<tr>
<td></td>
<td>criterion</td>
<td></td>
</tr>
<tr>
<td><strong>Vocabulary</strong></td>
<td><strong>Investigation 3: Electromagnetism</strong></td>
<td></td>
</tr>
<tr>
<td>drag</td>
<td>battery</td>
<td></td>
</tr>
<tr>
<td>electric current</td>
<td>circuit</td>
<td></td>
</tr>
<tr>
<td>electric force</td>
<td>climate change</td>
<td></td>
</tr>
<tr>
<td>electromagnet</td>
<td>closed circuit</td>
<td></td>
</tr>
<tr>
<td>electromagnetic force</td>
<td>complete circuit</td>
<td></td>
</tr>
<tr>
<td>electromagnetism</td>
<td>component</td>
<td></td>
</tr>
<tr>
<td>electron</td>
<td>conductor</td>
<td></td>
</tr>
<tr>
<td>energy</td>
<td>contact point</td>
<td></td>
</tr>
<tr>
<td>engineer</td>
<td>core</td>
<td></td>
</tr>
<tr>
<td>filament</td>
<td><strong>Investigation 4: Energy Transfer</strong></td>
<td></td>
</tr>
<tr>
<td>incandescent light bulb</td>
<td>automobile</td>
<td></td>
</tr>
<tr>
<td>incomplete circuit</td>
<td>brush</td>
<td></td>
</tr>
<tr>
<td>insulator</td>
<td>commutator</td>
<td></td>
</tr>
<tr>
<td>lamp</td>
<td>constraint</td>
<td></td>
</tr>
<tr>
<td>maglev</td>
<td>criterion</td>
<td></td>
</tr>
<tr>
<td>motor</td>
<td>fossil fuel</td>
<td></td>
</tr>
<tr>
<td>open circuit</td>
<td>nonrenewable</td>
<td></td>
</tr>
<tr>
<td>semiconductor</td>
<td>potential energy</td>
<td></td>
</tr>
<tr>
<td>static</td>
<td>power grid</td>
<td></td>
</tr>
<tr>
<td></td>
<td>renewable</td>
<td></td>
</tr>
<tr>
<td></td>
<td>solar cell</td>
<td></td>
</tr>
<tr>
<td></td>
<td>sustainable</td>
<td></td>
</tr>
<tr>
<td></td>
<td>turbine</td>
<td></td>
</tr>
<tr>
<td>Educational Technology Standards</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.1.8.A.1, 8.1.8.B.1, 8.1.8.C.1, 8.1.8.D.1, 8.1.8.E.1, 8.1.8.F.1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Technology Operations and Concepts**
- Create professional documents (e.g., newsletter, personalized learning plan, business letter or flyer) using advanced features of a word processing program.
  **Example**: Create a brochure to advertise your levee design.

**Creativity and Innovation**
- Synthesize and publish information about a local or global issue or event on a collaborative, web-based service.
  **Example**: Publish a blog regarding hurricane preparedness.

**Communication and Collaboration**
- Participate in an **online learning community** with learners from other countries to understand their perspectives on a global problem or issue, and propose possible solutions.
  **Example**: Use empatico.org to collaborate with students from other countries who have experienced hurricanes.

**Digital Citizenship**
- Model appropriate online behaviors related to cyber safety, cyber bullying, cyber security, and cyber ethics.
  **Example**: Use Diigo.com to have a monitored and appropriate online conversation about an article.

**Research and Information Literacy**
- Gather and analyze findings using **data collection technology** to produce a possible solution for a content-related or real-world problem.
  **Example**: Use NOAA or AMS websites to gather data about hurricane frequency, location, etc.

**Critical Thinking, Problem Solving, Decision Making**
- Use an **electronic authoring tool** in collaboration with learners from other countries to evaluate and summarize the perspectives of other cultures about a current event or contemporary figure.
  **Example**: Utilize Voicethread to create a narrative account of a hurricane event.
<table>
<thead>
<tr>
<th>Career Ready Practices</th>
</tr>
</thead>
<tbody>
<tr>
<td>Career Ready Practices describe the career-ready skills that all educators in all content areas should seek to develop in their students. They are practices that have been linked to increase college, career, and life success. Career Ready Practices should be taught and reinforced in all career exploration and preparation programs with increasingly higher levels of complexity and expectation as a student advances through a program of study.</td>
</tr>
</tbody>
</table>

**CRP1. Act as a responsible and contributing citizen and employee**

Career-ready individuals understand the obligations and responsibilities of being a member of a community, and they demonstrate this understanding every day through their interactions with others. They are conscientious of the impacts of their decisions on others and the environment around them. They think about the near-term and long-term consequences of their actions and seek to act in ways that contribute to the betterment of their teams, families, community and workplace. They are reliable and consistent in going beyond the minimum expectation and in participating in activities that serve the greater good.

*Example:* Participate as an active an ethical member of class discussions and projects. Teacher can explore how decision making and behaviors can impact the broader community in specific science related examples, such as limiting littering, choosing to recycle, etc.

**CRP4. Communicate clearly and effectively and with reason.**

Career-ready individuals communicate thoughts, ideas, and action plans with clarity, whether using written, verbal, and/or visual methods. They communicate in the workplace with clarity and purpose to make maximum use of their own and others’ time. They are excellent writers; they master conventions, word choice, and organization, and use effective tone and presentation skills to articulate ideas. They are skilled at interacting with others; they are active listeners and speak clearly and with purpose. Career-ready individuals think about the audience for their communication and prepare accordingly to ensure the desired outcome.

*Example:* Students can develop and present well supported arguments via short presentations, during group work and gallery walks.

**CRP5. Consider the environmental, social and economic impacts of decisions.**

Career-ready individuals understand the interrelated nature of their actions and regularly make decisions that positively impact and/or mitigate negative impact on other people, organization, and the environment. They are aware of and utilize new technologies, understandings, procedures, materials, and regulations affecting the nature of their work as it relates to the impact on the social condition, the environment and the profitability of the organization.

*Example:* Participate as an active an ethical member of class discussions and projects. Teacher can explore how decision making and behaviors can impact the broader community in specific science related examples, such as limiting littering, choosing to recycle, etc.

**CRP6. Demonstrate creativity and innovation.**

Career-ready individuals regularly think of ideas that solve problems in new and different ways, and they contribute those ideas in a useful and productive
manner to improve their organization. They can consider unconventional ideas and suggestions as solutions to issues, tasks or problems, and they discern which ideas and suggestions will add greatest value. They seek new methods, practices, and ideas from a variety of sources and seek to apply those ideas to their own workplace. They take action on their ideas and understand how to bring innovation to an organization.

**Example:** Engineering tasks provide many opportunities for student to use creative and innovative approaches.

**CRP8. Utilize critical thinking to make sense of problems and persevere in solving them.**

Career-ready individuals readily recognize problems in the workplace, understand the nature of the problem, and devise effective plans to solve the problem. They are aware of problems when they occur and take action quickly to address the problem; they thoughtfully investigate the root cause of the problem prior to introducing solutions. They carefully consider the options to solve the problem. Once a solution is agreed upon, they follow through to ensure the problem is solved, whether through their own actions or the actions of others.

**Example:** Gather evidence to support a claim and identify reasoning that is being applied.

**CRP11. Use technology to enhance productivity.**

Career-ready individuals find and maximize the productive value of existing and new technology to accomplish workplace tasks and solve workplace problems. They are flexible and adaptive in acquiring new technology. They are proficient with ubiquitous technology applications. They understand the inherent risks-personal and organizational-of technology applications, and they take actions to prevent or mitigate these risks.

**Example:** Utilize Google Apps for Education suite to access and complete assignments. The teacher can use Google Classroom to identify age and subject appropriate resource materials that can be linked directly. A variety of apps or web based platforms (Tellagami, PowToons, Glogster, Padlet) can be used to generate multimedia content.

**CRP12. Work productively in teams while using cultural global competence.**

Career-ready individuals positively contribute to every team, whether formal or informal. They apply an awareness of cultural difference to avoid barriers to productive and positive interaction. They find ways to increase the engagement and contribution of all team members. They plan and facilitate effective team meetings.

**Example:** Students must be given regular opportunities to work with groups in a variety of settings for discussion, projects, etc.
**Graded Six Unit 3: FOSS Electromagnetic Forces**  
**Instructional Days: 25**

**WIDA Proficiency Levels:** At the given level of English language proficiency, English language learners will process, understand, produce or use:

<table>
<thead>
<tr>
<th>Level</th>
<th>Language Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>6- Reaching</td>
<td></td>
</tr>
</tbody>
</table>
- Specialized or technical language reflective of the content areas at grade level  
- A variety of sentence lengths of varying linguistic complexity in extended oral or written discourse as required by the specified grade level  
- Oral or written communication in English comparable to proficient English peers |
| 5- Bridging |  
- Specialized or technical language of the content areas  
- A variety of sentence lengths of varying linguistic complexity in extended oral or written discourse, including stories, essays or reports  
- Oral or written language approaching comparability to that of proficient English peers when presented with grade level material. |
| 4- Expanding |  
- Specific and some technical language of the content areas  
- A variety of sentence lengths of varying linguistic complexity in oral discourse or multiple, related sentences or paragraphs  
- Oral or written language with minimal phonological, syntactic or semantic errors that may impede the communication, but retain much of its meaning, when presented with oral or written connected discourse, with sensory, graphic or interactive support |
| 3- Developing |  
- General and some specific language of the content areas  
- Expanded sentences in oral interaction or written paragraphs  
- Oral or written language with phonological, syntactic or semantic errors that may impede the communication, but retain much of its meaning, when presented with oral or written, narrative or expository descriptions with sensory, graphic or interactive support |
| 2- Beginning |  
- General language related to the content area  
- Phrases or short sentences  
- Oral or written language with phonological, syntactic, or semantic errors that often impede of the communication when presented with one to multiple-step commands, directions, or a series of statements with sensory, graphic or interactive support |
| 1- Entering |  
- Pictorial or graphic representation of the language of the content areas  
- Words, phrases or chunks of language when presented with one-step commands directions, WH-, choice or yes/no questions, or statements with sensory, graphic or interactive support |
## Language Development Supports For English Language Learners

### To Increase Comprehension and Communication Skills

#### Environment
- Welcoming and stress-free
- Respectful of linguistic and cultural diversity
- Honors students’ background knowledge
- Sets clear and high expectations
- Includes routines and norms
- Is thinking-focused vs. answer-seeking
- Offers multiple modalities to engage in content learning and to demonstrate understanding
- Includes explicit instruction of specific language targets
- Provides participation techniques to include all learners
- Integrates learning centers and games in a meaningful way
- Provides opportunities to practice and refine receptive and productive skills in English as a new language
- Integrates meaningful and purposeful tasks/activities that:
  - Are accessible by all students through multiple entry points
  - Are relevant to students’ lives and cultural experiences
  - Demonstrate high cognitive demand
  - Offer multiple strategies for solutions
  - Allow for a language learning experience in addition to content

#### Sensory Supports*
- Real-life objects (realia) or concrete objects
- Physical models
- Manipulatives
- Pictures & photographs
- Visual representations or models such as diagrams or drawings
- Videos & films
- Newspapers or magazines
- Gestures
- Physical movements
- Music & songs

#### Graphic Supports*
- Graphs
- Charts
- Timelines
- Number lines
- Graphic organizers
- Graphing paper

#### Interactive Supports*
- In a whole group
- In a small group
- With a partner such as Turn-and-Talk
- In pairs as a group (first, two pairs work independently, then they form a group of four)
- In triads
- Cooperative learning structures such as Think-Pair-Share
- Interactive websites or software
- With a mentor or coach

#### Verbal and Textual Supports
- Labeling
- Students’ native language
- Modeling
- Repetitions
- Paraphrasing
- Summarizing
- Guiding questions
- Clarifying questions
- Probing questions
- Leveled questions such as What? When? Where? How? Why?
- Questioning prompts & cues
- Word Banks
- Sentence starters
- Sentence frames
- Discussion frames
- Talk moves, including Wait Time

---

BUILDING EQUITY IN YOUR TEACHING PRACTICE

How do the essential questions highlight the connection between the big ideas of the unit and equity in your teaching practice?

**CONTENT INTEGRATION**
Teachers use examples and content from a variety of cultures & groups.

This unit / lesson is connected to other topics explored with students.

There are multiple viewpoints reflected in the content of this unit / lesson.

The materials and resources are reflective of the diverse identities and experiences of students.

The content affirms students, as well as exposes them to experiences other than their own.

**KNOWLEDGE CONSTRUCTION**
Teachers help students understand how knowledge is created and influenced by cultural assumptions, perspectives & biases.

This unit / lesson provides context to the history of privilege and oppression.

This unit / lesson addresses power relationships.

This unit / lesson help students develop research and critical thinking skills.

This curriculum creates windows and mirrors* for students.

**PREJUDICE REDUCTION**
Teachers implement lessons and activities to assert positive images of ethnic groups & improve intergroup relations.

This unit / lesson help students question and unpack biases & stereotypes.

This unit / lesson help students examine, research and question information and sources.

The curriculum encourage discussion and understanding about the groups of people being represented.

This unit / lesson challenges dominant perspectives.

**EQUITABLE PEDAGOGY**
Teachers modify techniques and methods to facilitate the academic achievement of students from diverse backgrounds.

The instruction has been modified to meet the needs of each student.

Students feel respected and their cultural identities are valued.

Additional supports have been provided for students to become successful and independent learners.

Opportunities are provided for student to reflect on their learning and provide feedback.

**EMPOWERING SCHOOL CULTURE**
Using the other four dimensions to create a safe and healthy educational environment for all.

There are opportunities for students to connect with the community.

My classroom is welcoming and supportive for all students?

I am aware of and sensitive to the needs of my students and their families.

There are effective parent communication systems established. Parents can talk to me about issues as they arise in my classroom.

---


---

16
Students tend to think of force as a property of an object ("an object has force," or "force is within an object") rather than as a relation between objects. In addition, students tend to distinguish between active objects and objects that support or block or otherwise act passively. Students tend to call the active actions "force" but do not consider passive actions as "forces". Teaching students to integrate the concept of passive support into the broader concept of force is a challenging task even at the high-school level.

Students believe constant speed needs some cause to sustain it. In addition, students believe that the amount of motion is proportional to the amount of force; that if a body is not moving, there is no force acting on it; and that if a body is moving there is a force acting on it in the direction of the motion. Students also believe that objects resist acceleration from the state of rest because of friction -- that is, they confound inertia with friction. Students tend to hold on to these ideas even after instruction in high-school or college physics. Specially designed instruction does help students change their ideas.

Research has shown less success in changing middle-school students' ideas about force and motion. Nevertheless, some research indicates that middle-school students
can start understanding the effect of constant forces to speed up, slow down, or change the direction of motion of an object. This research also suggests it is possible to change middle-school students' belief that a force always acts in the direction of motion. Students have difficulty appreciating that all interactions involve equal forces acting in opposite directions on the separate, interacting bodies. Instead they believe that "active" objects (like hands) can exert forces whereas "passive" objects (like tables) cannot. Alternatively, students may believe that the object with more of some obvious property will exert a greater force. Teaching high-school students to seek consistent explanations for the "at rest" condition of an object can lead them to appreciate that both "active" and "passive" objects exert forces. Showing high-school students that apparently rigid or supporting objects actually deform might also lead them to appreciate that both "active" and "passive" objects exert forces (NSDL, 2015).

Prior Learning

By the end of Grade 5, students understand that:

- Objects in contact exert forces on each other.
- Electric and magnetic forces between a pair of objects do not require that the objects be in contact. The sizes of the forces in each situation depend on the properties of the objects and their distances apart and, for forces between two magnets, on their orientation relative to each other.
- The gravitational force of Earth acting on an object near Earth’s surface pulls that object toward the planet's center.

Future Learning

Physics and Chemistry

- Newton’s second law of motion (F=ma) and the conservation of momentum can be used to predict changes in the motion of macroscopic objects.
- Newton’s law of universal gravitation and Coulomb’s law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects.
- Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields.
- Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects.
- “Electrical energy” may mean energy stored in a battery or energy transmitted by electric currents.
- Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system.
- Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems.
- Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g., relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior.
- The availability of energy limits what can occur in any system.
- 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).
- When two objects interacting through a field change relative position, the energy stored in the field is changed.

<table>
<thead>
<tr>
<th>Interdisciplinary Connections</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>English Language Arts/Literacy</strong></td>
</tr>
<tr>
<td>• Cite specific textual evidence to support analysis of information about science and technical texts regarding the factors that affect the strength of electric and magnetic forces, attending to the precise details of explanations or descriptions.</td>
</tr>
<tr>
<td>• Write arguments focused on evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects.</td>
</tr>
</tbody>
</table>

| **Mathematics** |
| Reason abstractly and quantitatively while using data to determine the factors that affect the strength of electric and magnetic forces. |

<table>
<thead>
<tr>
<th>Appendix A: NGSS and Foundations for the Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>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.</strong> [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)</td>
</tr>
<tr>
<td><strong>Ask questions about data to determine the factors that affect the strength of electric and magnetic forces.</strong> [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)</td>
</tr>
<tr>
<td><strong>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.</strong> [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)</td>
</tr>
<tr>
<td><strong>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.</strong> [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**</td>
</tr>
</tbody>
</table>
Graded Six Unit 3: FOSS Electromagnetic Forces

Instructional Days: 25

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)

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

<table>
<thead>
<tr>
<th>Science and Engineering Practices</th>
<th>Disciplinary Core Ideas</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Using Mathematics and Computational Thinking</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Use mathematical representations of phenomena to describe explanations. (MS-PS2-4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Constructing Explanations and Designing Solutions</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Apply scientific ideas to solve a design problem, taking into account possible unanticipated effects. (MS-PS2-3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Planning and Carrying Out Investigations</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• 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. (MS-PS2-5)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**PS2.A: Forces and Motion**

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. (MS-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. (MS-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. (MS-PS2-4)

**ETS1.A: Defining and Delimiting Engineering Problems**

- The more precisely a design task’s criteria and

**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. (MS-PS2-4)

**Cause and Effect**

- Systems can be designed to cause a desired effect. (MS-PS2-3)
- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (MS-PS2-5)

**Connections to Engineering, Technology, and Applications of Science**

**Influence of Science, Engineering, and Technology on Society and the Natural World**

- 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
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 that are likely to limit possible solutions. (MS-ETS1-1)

**ETS1.B: Developing Possible Solutions**
- There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (MS-ETS1-2)
- A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (MS-ETS1-4)
- There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (MS-ETS1-2), (MS-ETS1-3)
- Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. (MS-ETS1-3)
- Models of all kinds are important for testing solutions. (MS-ETS1-4)

**ETS1.C: Optimizing the Design Solution**
- 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—that is, some of those characteristics may be incorporated into the new design. (MS-ETS1-3)
- The iterative process of testing the most promising solutions and modifying what is economic conditions. (MS-PS2-1)
- All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment. (MS-ETS1-1)
- The uses of technologies and 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. (MS-ETS1-1)
### Graded Six Unit 3: FOSS Electromagnetic Forces

<table>
<thead>
<tr>
<th>Instructional Days: 25</th>
</tr>
</thead>
<tbody>
<tr>
<td>proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. (MS-ETS1-4)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>English Language Arts</th>
<th>Mathematics</th>
</tr>
</thead>
<tbody>
<tr>
<td>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. (MS-PS2-5), (MS-PS2-3) WHST.11-12.7</td>
<td>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. (MS-PS2-5), (MS-PS2-4) HSN.Q.A.1</td>
</tr>
<tr>
<td>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. (MS-PS2-5) WHST.11-12.8</td>
<td>Define appropriate quantities for the purpose of descriptive modeling. (MS-PS2-5), (MS-PS2-4) HSN.Q.A.2</td>
</tr>
<tr>
<td>Draw evidence from informational texts to support analysis, reflection, and research. (MS-PS2-5) WHST.11-12.9</td>
<td>Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (MS-PS2-5), (MS-PS2-4) HSN.Q.A.3</td>
</tr>
<tr>
<td>Reason abstractly and quantitatively. (MS-PS2-4) MP.2</td>
<td>Model with mathematics. (MS-PS2-4) MP.4</td>
</tr>
<tr>
<td>Interpret expressions that represent a quantity in terms of its context. (MS-PS2-4) HSA.SSE.A.1</td>
<td>Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression. (MS-PS2-4) HSA.SSE.B.3</td>
</tr>
</tbody>
</table>

### Suggested Field Trip Sites

- Liberty Science Center
- Franklin Institute of Technology
- Thomas Edison National Historic Park