Unit 4: Electricity and Magnetism

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Department of Curriculum and Instruction

Belleville Public Schools

Curriculum Guide

Unit 4

Electricity and Magnetism

Belleville Board of Education

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Unit Overview

In this unit, students will investigate the electromagnetic nature of matter and energy and how everyday processes are affected by these properties. Students will be able to describe and explain the electrical properties of materials and how
electric forces and fields are manipulated. Students will be able to apply Coulomb's Law to analyze the motion of charge and charged particles. Electrical energy and potential will be investigated, and the effect of voltage on moving charge will be analyzed in capacitors and circuits. Students will be able to describe, design, build, and analyze electric circuitry and will be able to explain how circuits are used in everyday life to provide electrical power. Methods of power usage and generation will be investigated, and students will discuss and research the advantages and disadvantages of various methods of generating electrical power. In addition, students will be able to describe and explain the magnetic nature of matter, and will be able to explain how magnetic fields are generated by moving charge. The electromagnetic properties of nature will also be analyzed, and students will be able to describe how electrical power can be generated by moving magnetic fields as a result of Faraday's Law and Ampere's Law. Finally, students will use their understanding of the electromagnetic properties to describe and explain why light is an electromagnetic wave using Maxwell's Field Equations.

NJSLS

CCC.2	Cause and effect: Mechanism and explanation.
CCC.4	Systems and system models.

SEP.2	Developing and Using Models
CCC.5	Energy and matter: Flows, cycles, and conservation.
SEP.3	Planning and Carrying Out Investigations
SEP.5	Using Mathematics and Computational Thinking
SEP.6	Constructing Explanations and Designing Solutions
SEP.8	Obtaining, Evaluating, and Communicating Information
SCI.HS-PS4-5	Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.
SCI.HS-PS3-2	Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative position of particles (objects).
SCI.HS-PS3-3	Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.
SCI.HS-PS3-1	Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.
SCI.HS-PS2-5	Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current.
SCI.HS-PS3-4	Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).
SCI.HS-PS3-5	Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.

Exit Skills

By the end of Unit 4 Students will:

1. Demonstrate that charged objects exert forces both attractive and repulsive.
2. Recognize that charging is the separation, not the creation, of electric charges.
3. Describe the differences between conductors and insulators.
4. Summarize the relationships between electric forces, charges, and distance.
5. Explain how to charge objects by conduction and induction.
6. Develop a model of how charged objects can attract a neutral object.
7. Apply coulomb’s law to problems in one and two dimensions.
8. Define electric field.
9. Solve problems relating to charge, electric fields, and forces.
10. Diagram electric field lines.
11. Define electric potential differences.
12. Calculate potential difference from the work required to move a charge.
13. Describe how charges are distributed on solid and hollow conductors.
14. Solve problems pertaining to capacitance.
15. Describe conditions that create current in an electric circuit.
16. Explain Ohm’s law.

17. Design closed circuits.
18. Differentiate between power and energy in an electric circuit.
19. Explain how electric energy is converted into thermal energy.
20. Explore ways to deliver electric energy to consumers near and far.
21. Define kilowatt-hour.
22. Describe series and parallel circuits.
23. Calculate currents, voltage drops, and equivalent resistances in series and parallel circuits.
24. Explain how fuses, circuit breakers, and ground-fault interrupters protect household wiring.
25. Analyze and solve problems involving combined series-parallel circuits.
26. Explain how voltmeters and ammeters are used in circuits.
27. Describe the properties of magnets and the origins of magnetism in materials.
28. Compare and contrast various magnetic fields.
29. Relate magnetic induction to the direction of the force on a current-carrying wire in a magnetic field.
30. Solve problems involving magnetic field strength and the forces on current-carrying wires, and on moving, charged particles in magnetic fields.
31. Describe the design and operation of an electric motor.
32. Explain how changing magnetic field produces an electric current.
33. Define electromotive force.
34. Solve problems involving wires moving in magnetic fields.
35. Apply Lenz's law.
36. Explain back-EMF and how it affects the operation of motors and generators.
37. Explain self-inductance and how it affects circuits.
38. Solve transformer problems involving voltage, current, and turn ratios.
39. Describe the operation of a cathode-ray tube.
40. Solve problems involving the interaction of charged particles with electric and magnetic field in cathoderay
tubes and mass spectrometers.
41. Explain how a mass spectrometer separates ions of different masses.
42. Describe how electromagnetic waves propagate through space.
43. Solve problems involving electromagnetic wave properties.
44. Describe the factors affecting an antenna's ability to receive an electromagnetic wave of a specific wavelength.
45. Solve problems involving electromagnetic wave propagation through dielectrics

Enduring Understanding

Unit Enduring Understandings:

Objects and systems have properties such as mass and charge. Systems may have internal structure.
Fields existing in space can be used to explain interactions.
The interactions of an object with other objects can be described by forces.
Changes that occur as a result of interactions are constrained by conservation laws.
Students will relate to their world in a more detailed and scientific manner.
Students will identify how their new understandings can be applied to real-world phenomena

Definition: ***Enduring Understandings***

Enduring understandings are statements summarizing important ideas and core processes that are central to a

discipline and have lasting value beyond the classroom. They synthesize what students should understand—not just know or do—as a result of studying a particular content area. Moreover, they articulate what students should "revisit" over the course of their lifetimes in relationship to the content area.

Enduring understandings:

1. Frame the big ideas that give meaning and lasting importance to such discrete curriculum elements as facts and skills
2. Can transfer to other fields as well as adult life
3. "Unpack" areas of the curriculum where students may struggle to gain understanding or demonstrate misunderstandings and misconceptions
4. Provide a conceptual foundation for studying the content area and
5. Are deliberately framed as declarative sentences that present major curriculum generalizations and recurrent ideas.

Example:

Reading/Literature

This is an Enduring Understanding

Reading is a process by which we construct meaning about the information being communicated by an author within a print or non-print medium.

This is an Essential Question

How is reading a process of constructing meaning from text?

Essential Questions

Unit Essential Questions:

What are the ways that electromagnetism affect our daily world?
How do physicists describe electromagnetic processes?Can students identify the flow of electricity from a circuit diagram?
Can students calclate electrical force using Coulomb's Law?
will students be able to identify different types of currents?
How is the electric force similar to the force of gravity? How is it different?
In what ways can static charge build up?
What is the meaning of electrical potential energy?
What is electrical potential?
In what ways is energy conserved in an electrical circuit?

Why do different materials exhibit different electrical properties, and how can these properties be utilized to build a circuit with a specific purpose?

Essential Question: A question that lies at the heart of a subject or a curriculum and one that promotes inquiry and the discovery of a subject.

•They can help students discover patterns in knowledge and solve problems.
•They support inductive teaching—guiding students to discover meaning, which increases motivation to learn.
•They are one of the most powerful tools for helping students think at more complex levels.
•They engage the personal intellect—something that traditional objectives usually fail to do.
•Have no obvious "right" answer
•Raise other important questions, often across subject-area boundaries
•Address a concept
•Raise other important questions
•Naturally and appropriately recur
•Stimulate critical, ongoing rethinking
•Are framed to provoke and sustain student interest

What makes a Questions "Essential?"
•Continues throughout all our lives
•Refers to core ideas and inquiries within a discipline
•Helps students effectively ask questions and make sense of important and complex ideas, knowledge, and know-how
•Engages a specific and diverse set of learners

Two Types of Essential Questions:
•Overarching: The overall "Big Idea"
- •More general, broader
- •Point beyond specific topics or skills
- •Promote the transfer of understanding

•Topical: Unit or lesson specific but still promotes inquiry
- •Unit or lesson specific - used to guide individual units or lessons
- •Promote inquiry
- •Resist obvious answers
- •Require explanation and justification

Examples:
•What is a true friend?
•What makes an artist amazing?
•In what sense is the body a system?
•What is the law of nature, and how is it like or unlike social laws?
•To what extent is US history a history of progress?
•In what ways do diet and exercise affect health?
•Must heroes be flawless?
•How do effective writers hook and hold their readers?
•How do cultures affect one another?

•Does practice make perfect?
•What is healthy eating? Healthy living?
•How and when do we use mathematics?
•How does something acquire value?

Learning Objectives

Students will be able to...

Demonstrate that charged objects exert forces both attractive and repulsive.
Recognize that charging is the separation, not the creation, of electric charges.
Describe the differences between conductors and insulators.
Summarize the relationships between electric forces, charges, and distance.
Explain how to charge objects by conduction and induction.
Develop a model of how charged objects can attract a neutral object.
Apply Coulomb's law to problems in one dimension.
Define electric field.
Solve problems relating to charge, electric fields, and forces.
Diagram electric field lines.
Define electric potential differences.
Calculate potential difference from the work required to move a charge.
Describe how charges are distributed on solid and hollow conductors.
Solve problems pertaining to capacitance.
Describe conditions that create current in an electric circuit.
Explain Ohm's law.
Design closed circuits.
Differentiate between power and energy in an electric circuit.
Define kilowatt-hour.
Describe series and parallel circuits.
Calculate currents, voltage drops, and equivalent resistances in series and parallel circuits.
Explain how fuses and circuit breakers protect household wiring.
Analyze and solve problems involving combined series-parallel circuits.
Explain how voltmeters and ammeters are used in circuits.
Describe the properties of magnets and the origins of magnetism in materials.
Compare and contrast various magnetic fields.
Relate magnetic induction to the direction of the force on a current-carrying wire in a magnetic field.
Solve problems involving magnetic field strength and the forces on current-carrying wires, and on moving, charged particles in magnetic fields.
Describe the design and operation of an electric motor.
Explain how changing magnetic field produces an electric current.
Define electromotive force.
Solve problems involving wires moving in magnetic fields.
Apply Lenz's law.
Explain back-EMF and how it affects the operation of motors and generators.
Explain self-inductance and how it affects circuits.
Solve transformer problems involving voltage, current, and turn ratios.
Describe how electromagnetic waves propagate through space.
Solve problems involving electromagnetic wave properties.

Describe the operation of a cathode-ray tube.
Solve problems involving the interaction of charged particles with electric and magnetic field in cathoderay tubes and mass spectrometers.
Explain how a mass spectrometer separates ions of different masses.
Describe the factors affecting an antenna's ability to receive an electromagneticwave of a specific wavelength.

Tips on Writing Good Learning Objectives

Bloom's Taxonomy

Applying Bloom's Taxonomy to Learning Objectives

Effective learning objectives need to be observable and/or measureable, and using action verbs is a way to achieve this. Verbs such as "identify", "argue," or "construct" are more measureable than vague or passive verbs such as "understand" or "be aware of". As you develop your syllabus focus on articulating clear learning objectives and then use these objectives to guide class assignments, exams and overall course assessment questions.

Sample Learning Objectives for a Lower Division Course

After completing Nutrition 101 *Humans and Food*, students will be able to:

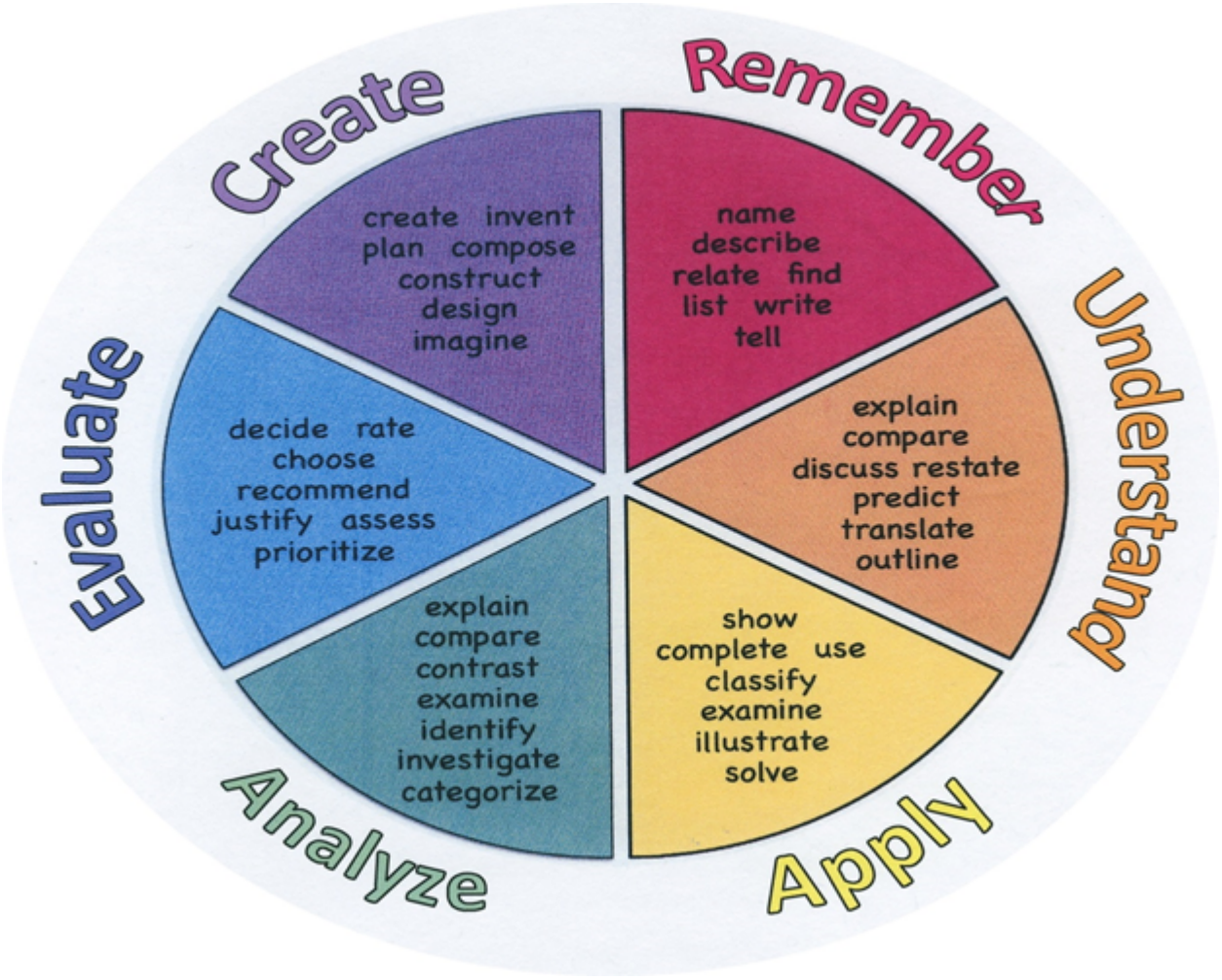
- **Identify** nutrients found in common food sources via the product's nutrition label
- Use computer dietary analysis to assess a 2-day dietary intake and **summarize** results
- **Locate** nutrition-related information on the Internet and use **evaluative** criteria to **identify** reliability of the information

Action Verbs

Below are examples of action verbs associated with each level of the Revised Bloom's Taxonomy. These are useful in writing learning objectives, assignment objectives and exam questions.

Remember	Understand	Apply	Analyze	Evaluate	Create
Choose	Classify	Choose	Categorize	Appraise	Combine
Describe	Defend	Dramatize	Classify	Judge	Compose
Define	Demonstrate	Explain	Compare	Criticize	Construct
Label	Distinguish	Generalize	Differentiate	Defend	Design
List	Explain	Judge	Distinguish	Compare	Develop
Locate	Express	Organize	Identify	Assess	Formulate
Match	Extend	Paint	Infer	Conclude	Hypothesize
Memorize	Give Examples	Prepare	Point out	Contrast	Invent
Name	Illustrate	Produce	Select	Critique	Make
Omit	Indicate	Select	Subdivide	Determine	Originate
Recite	Interrelate	Show	Survey	Grade	Organize
Select	Interpret	Sketch	Arrange	Justify	Plan
State	Infer	Solve	Breakdown	Measure	Produce
Count	Match	Use	Combine	Rank	Role Play

Draw Outline Point Quote Recall Recognize Repeat Reproduce	Paraphrase Represent Restate Rewrite Select Show Summarize Tell Translate Associate Compute Convert Discuss Estimate Extrapolate Generalize Predict	Add Calculate Change Classify Complete Compute Discover Divide Examine Graph Interpolate Manipulate Modify Operate Subtract	Detect Diagram Discriminate Illustrate Outline Point out Separate	Rate Support Test	Drive Devise Generate Integrate Prescribe Propose Reconstruct Revise Rewrite Transform



Interdisciplinary Connections

Please list all and any cross-curricular content standards that link to this Unit.

MA.S-ID.A.1	Represent data with plots on the real number line (dot plots, histograms, and box plots).
MA.K-12.2	Reason abstractly and quantitatively.
MA.A-SSE.A.1	Interpret expressions that represent a quantity in terms of its context.
MA.K-12.4	Model with mathematics.
MA.A-SSE.B.3	Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression.
MA.N-Q.A.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
MA.N-Q.A.2	Define appropriate quantities for the purpose of descriptive modeling.
MA.N-Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
MA.F-IF.C.7	Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases.
LA.RST.11-12.1	Accurately cite strong and thorough evidence from the text to support analysis of science and technical texts, attending to precise details for explanations or descriptions.
LA.RST.11-12.7	Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.
MA.A-CED.A.1	Create equations and inequalities in one variable and use them to solve problems.
MA.A-CED.A.2	Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales.
MA.A-CED.A.4	Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.
LA.WHST.11-12.2	Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.
LA.WHST.11-12.5	Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.
LA.WHST.11-12.7	Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.
LA.WHST.11-12.8	Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.
LA.WHST.11-12.9	Draw evidence from informational texts to support analysis, reflection, and research.
LA.SL.11-12.4	Present information, findings and supporting evidence clearly, concisely, and logically. The content, organization, development, and style are appropriate to task, purpose, and audience.
LA.SL.11-12.5	Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest.

Alignment to 21st Century Skills & Technology

Key SUBJECTS AND 21st CENTURY THEMES

Mastery of key subjects and 21st century themes is essential for all students in the 21stcentury.

Key subjects include:

- English, reading or language arts
- World languages
- Arts
- Mathematics
- Economics
- Science
- Geography
- History
- Government and Civics

21st Century/Interdisciplinary Themes

- Civic Literacy
- Environmental Literacy
- Financial, Economic, Business and Entrepreneurial Literacy
- Global Awareness
- Health Literacy

21st Century Skills

- Communication and Collaboration
- Creativity and Innovation
- Critical thinking and Problem Solving
- ICT (Information, Communications and Technology) Literacy
- Information Literacy
- Life and Career Skills
- Media Literacy

Technology Infusion

What technology can be used in this unit to enhance learning?



Differentiation

As a Reminder:

The basis of good differentiation in a lesson lies in differentiating by content, process, and/or product.

Resources:

- NJDOE: Instructional Supports and Scaffolds for Success in Implementing the Common Core State Standards http://www.state.nj.us/education/modelcurriculum/success/math/k2/

Special Education

- printed copy of board work/notes provided
- additional time for skill mastery
- assistive technology
- behavior management plan
- Center-Based Instruction
- check work frequently for understanding
- computer or electronic device utilizes
- extended time on tests/ quizzes
- have student repeat directions to check for understanding
- highlighted text visual presentation
- modified assignment format
- modified test content
- modified test format
- modified test length
- multi-sensory presentation
- multiple test sessions
- preferential seating
- preview of content, concepts, and vocabulary
- reduced/shortened reading assignments
- Reduced/shortened written assignments
- secure attention before giving instruction/directions
- shortened assignments
- student working with an assigned partner
- teacher initiated weekly assignment sheet
- Use open book, study guides, test prototypes

ELL

- teaching key aspects of a topic. Eliminate nonessential information

- using videos, illustrations, pictures, and drawings to explain or clarif
- allowing products (projects, timelines, demonstrations, models, drawings, dioramas, poster boards, charts, graphs, slide shows, videos, etc.) to demonstrate student's learning;
- allowing students to correct errors (looking for understanding)
- allowing the use of note cards or open-book during testing
- decreasing the amount of workpresented or required
- having peers take notes or providing a copy of the teacher's notes
- modifying tests to reflect selected objectives
- providing study guides
- reducing or omitting lengthy outside reading assignments
- reducing the number of answer choices on a multiple choice test
- tutoring by peers
- using computer word processing spell check and grammar check features
- using true/false, matching, or fill in the blank tests in lieu of essay tests

Intervention Strategies

- allowing students to correct errors (looking for understanding)
- teaching key aspects of a topic. Eliminate nonessential information
- allowing products (projects, timelines, demonstrations, models, drawings, dioramas, poster boards, charts, graphs, slide shows, videos, etc.) to demonstrate student's learning
- allowing students to select from given choices
- allowing the use of note cards or open-book during testing
- collaborating (general education teacher and specialist) to modify vocabulary, omit or modify items to reflect objectives for the student, eliminate sections of the test, and determine how the grade will be determined prior to giving the test.
- decreasing the amount of workpresented or required
- having peers take notes or providing a copy of the teacher's notes
- marking students' correct and acceptable work, not the mistakes
- modifying tests to reflect selected objectives
- providing study guides
- reducing or omitting lengthy outside reading assignments
- reducing the number of answer choices on a multiple choice test
- tutoring by peers
- using authentic assessments with real-life problem-solving
- using true/false, matching, or fill in the blank tests in lieu of essay tests
- using videos, illustrations, pictures, and drawings to explain or clarify

Evidence of Student Learning-CFU's

Please list ways educators may effectively check for understanding in this secion.

- Admit Tickets
- Anticipation Guide
- Common benchmarks
- Compare & Contrast
- Create a Multimedia Poster
- Define
- Describe
- Evaluate
- Evaluation rubrics
- Exit Tickets
- Explaining
- Fist- to-Five or Thumb-Ometer
- Illustration
- Journals
- KWL Chart
- Newspaper Headline
- Outline
- Question Stems
- Quickwrite
- Quizzes
- Red Light, Green Light
- Self- assessments
- Socratic Seminar
- Study Guide
- Teacher Observation Checklist
- Think, Pair, Share
- Think, Write, Pair, Share
- Top 10 List
- Unit tests

Primary Resources

Textbook
Internet
Science Department Video Library

Ancillary Resources

Teacher Prepared Materials

Lab Materials

Study Guide Materials

United Streaming Videos

The Physics Classroom: www.thephysicsclassroom.com

STEM Lab

Sample Lesson

One Lesson per Curriculum must bein this lesson plan template. I.e. one lesson in one unit

Unit Name:

NJSLS:

Interdisciplinary Connection:

Statement of Objective:

Anticipatory Set/Do Now:

Learning Activity:

Student Assessment/CFU's:

Materials:

21st Century Themes and Skills:

Differentiation/Modifications:

Integration of Technology: