Electricity through Chemistry and Mathematics

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GRADE LEVEL: **9th grade, 1st semester**

ESTIMATED TIME: **Twelve weeks, considering the particular design for this unit (3 sessions a week, each session being 2×40 minutes)**

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STAGE 1 - DESIRED RESULTS

We will study electricity in this unit. Electricity is an important area in the study of Physics (another branch of science). It can be described as the flow of electrons that travel at the speed of light. It is the source of heat, light and power for household appliances and industrial machinery. The worldwide demand for electricity has been increasing every year for many decades. In the United States alone, the demand for electricity has increased by 60% since 1970. Although most of us take it for granted, life is not the same without electricity. It behooves us all to help preserve what we have and conserve our natural resources.

Through the study of electricity students will demonstrate an understanding of the atomic structure of matter and its properties in relation to the periodic table. They will also show an understanding of how energy is transformed into other forms such as heat and light and motion energy. They will understand how current flows and how it is measured. They will apply this knowledge to monitor their own electrical usage at home and also try to convince their community that they can save energy and money by understanding how and why to conserve. The goals of this unit are highlighted using the Vermont Framework of standards and learning opportunities for science and mathematics and in grades 9-12.

CHEMISTRY:

- **7.12bbb--- students will understand the atomic structure of matter in relationship to the periodic table.**
- **7.12eee ---students will be able to provide examples of transformation of energy from one form to another and**
- **7.12fff---students will understand that alternating magnetic fields generate electric fields and vice versa (e.g. generators).**

MATHEMATICS

- **Standard 7.6: Arithmetic, Number, and Operation Concepts**

  MHS: 1 Accurately solves problems involving conceptual understanding and magnitude of real numbers, or simple vectors.

  MHS: 7 Estimates and evaluates the reasonableness of numerical computations and solutions, including those carried out with technology.
- **Standard 7.8: Functions and Algebra Concepts**

MHS: 19 Solves and models problems by formulating, extending, or generalizing linear and common nonlinear functions/relations).

Makes connections among representations of functions/relations using equations, tables, graphs, symbolic notation and text

MHS: 20 Demonstrates conceptual understanding of linear relationships and linear and nonlinear functions (including f(x) = ax2, f(x) = ax3, absolute value function, exponential growth) through analysis of intercepts, domain, range and constant and variable rates of change in mathematical and contextual situations.

MHS: 21 Demonstrates conceptual understanding of algebraic expressions by evaluating, simplifying, or writing algebraic expressions; and writes equivalent forms of algebraic expressions or formulas (d = rt—> r = d/t or solves a multivariable equation or formula for one variable in terms of the others).

MHS: 22 Demonstrates conceptual understanding of equality by solving linear equations, systems of two linear equations, or problems using tables, graphs, algebraic manipulation, or technology.

- **Standard 7.9: Data, Statistics, and Probability Concepts**

MHS: 23 Interprets a given representation(s) (box-and-whisker or scatter plots, histograms, frequency charts) to make observations, to answer questions or justify conclusions, to make predictions, or to solve problems.

- **Standard 7.10: Mathematical Problem Solving and Reasoning—Applications**

MHS: 30 Demonstrate understanding of mathematical problem solving[2] and communication by:[4]

• Approach and Reasoning—The strategies and skills used to solve the problem, and the reasoning that supports the approach;

• Execution—The answer and the mathematical work that supports it;

• Observations and Extensions—Demonstration of observation, connections, application, extensions, and generalizations;

• Mathematical Communication—The use of mathematical vocabulary and representation to communicate the solution; and

• Presentation—Effective communication of how the problem was solved, and of the reasoning used.

[2] Problem-solving situations are mathematical problems that reflect the levels of mathematics in the Grade Level Expectations.
[4] See Vermont High School Level Mathematics Portfolio Scoring Guide for additional information.

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With the above standards as the basis, the understandings, essential questions, knowledge and skills for this unit are highlighted below.

<u>Understandings:</u>

Students should understand:

- **Why only some elements conduct electricity and not others.**
- **How electric current flows.**
- **How current, voltage, resistance and power can be measured.**

- **How electricity can become useful to us.**
- **How the cost of electricity can be calculated.**
- **How electricity can be conserved.**

They will do so using:

- **atomic structure and the periodic table to understand:**
  - **why some elements conduct electricity and not others**
  - **how electric current flows**
  - **the role of CFLs energy efficiency and conservation**

- **principles of Physics and dimensional analysis to understand:**
  - **how current, voltage, resistance and power are measured**
  - **what the mathematical relationship among these variables are**
  - **how a knowledge of some two variables can be used to calculate another one**
  - **how electrical energy is consumed**
  - **how the cost of electricity is calculated**
  - **how electrical energy can be conserved**

- **knowledge of current electricity and energy transformation to understand:**
  - **how electrical energy can become useful to us in daily life**

- **Use the knowledge of the "best fit" curve to understand:**
  - **our energy consumption**
  - **cost of usage and how different variables can change it (e.g. average outside temperature, type of light bulbs used)**
  - **and ways to conserve resources**

Essential questions:

- **We can neither see nor touch electricity, so how do we know it exists? Where can we see effects of electricity? How would we describe them? What causes them?**
- **What do you know about electricity? And how could you describe/define it in your own words?**
- **How do you think a toaster works?**
- **If all atoms contain electrons, why is it that they don't all conduct electric current to the same extent? Are there factors that facilitate or hinder the flow of electrons? What makes a good conductor/insulator?**
- **What is needed for electric current to flow? How can the flow of electrons in a circuit be controlled? How are current, voltage and resistance related?**
- **In lieu of the above questions, how has your view of a toaster changed?**
- **We all use electricity, but do we know how to read our electric meters and our monthly electric (utility) bills?**
- **How can we be efficient in our usage and promote conservation? The demand for electricity increases every year. In the United States alone, we use 60%**

more electricity than we did in 1970.[1] It behooves us all to conserve our natural resources.

Knowledge - Students will know:

- **There is a universality of electricity in nature (even heart is an electric pump).**
- **Why some substances conduct electricity, while others do not.**
- **How current flows through a circuit.**
- **Definitions of unit specific vocabulary terms.**
- **Units of measurement for current, voltage and resistance, power and electrical energy.**
- **Electrical energy becomes useful when it is converted to other forms of energy such as heat, light and motion energy.**
- **Units in which electrical usage is measured and how the cost of usage is calculated.**
- **How to read electric meters and understand utility bills.**
- **How to use software to plot, analyze and interpret graphs.**
- **This unit is talking about a real world issue of energy resources.**
- **There is a lot happening before we turn on a switch or light a bulb; the electric current does not just flow into the light bulb from nowhere – there are various and complex methods of gathering electrical energy (i.e. transformation of chemical to electrical energy) and transferring it through a network of circuits into households (electrical main). After closing the switch, electrical energy stored within a chemical structure is freed to push the electrons inside a circuit at home, creating a domino like effect that immediately supports a device with electrical energy. And finally, the device transfers the electrical energy either to radiant energy (e.g. a light bulb) or mechanical energy (e.g. electric motor).**
- **How to conserve a natural resource.**

Skills - Students will be able to:

- **from a mathematical point of view:**
  -multiply,
  -divide,
  -use fractions and composite numbers,
  -use cancelation rule, identify and solve basic exponential functions (with the base number 10) while naming metric multipliers,
  -solve linear equations with one variable and two unknown variables,
  -plot and read graphs and interpret bills
- **Predict which substances are conductors/insulators.**
- **Design series and parallel circuits and learn how to stop and start the flow of current.**

[1]http://www.centerpointenergy.com/staticfiles/CNP/Common/SiteAssets/doc/EEI%20Electricity_101.pdf (page #51)

- **Make informed decisions before buying batteries and bulbs for home or special projects.**
- **Be aware of electrical usage and find ways to save energy and money.**
- **Make conscious changes in habits or lifestyle to conserve energy and resources.**
- **Know how to live without electricity for short periods of time.**
- **Monitor and track their electrical energy usage over a period of time using software.**

<u>Essential Vocabulary:</u>

- **electricity, electric current,**
- **atomic structure, flowing charge, energy conversion,**
- **batteries, generators,**
- **voltage, resistance, power,**
- **insulator, conductor,**
- **parallel circuits, series circuits,**
- **decalescent light bulbs, fluorescent light bulbs,**
- **energy usage costs**

We are also aware of a couple of misconceptions about electricity. The first misconception is that most people think that electricity flows like water. In fact, the electrons are arranged like a row of marbles. If one end is flicked really hard, the marble at the far end shoots off. So each electron simply knocks into the next one along the line in a domino fashion passing the current through the circuit. The second misconception is more of a more practical consideration. Most people believe that when an appliance is turned off, it does not use electricity. However, even when a microwave or stove is turned off, the clocks on it is still on. These electronic displays on stoves, microwaves and VCRs are called 'phantom lights' and turn off only when the appliance is unplugged! Changing this misconception will need a change in habits.

In terms of engagement this unit is a winner because "the light bulb literally turns on" during some activities as well as some assessments (e.g. designing circuits and switches, testing a material for conductivity, using computer software to plot graphs of consumption over a period of time like a month or year etc.). We must remember to remind the students about "peak electricity", when they are analyzing their electric bills. According to a power company, the cost of electricity, in some states varies depending on when, where and what it is used for.

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STAGE 2 – ASSESSMENT EVIDENCE

If we want students to learn the basics of electricity so they can be aware of their own consumption and conservation, what would serve as evidence of that learning? Note that we want them to have both contextual reading skills from chemistry and mathematical skills of computation. Our aim is to work through explanation of basic concepts (see ***Knowledge*** and ***Skills*** in the previous section).

Students will be able to read their electric meters and utility bills. They will be able to monitor electrical usage over a period of time and calculate its cost. By understanding how to use software (EXCEL for example) they will be able to plot, analyze and interpret graphs of their family's usage (**Project**). Using all the above skills they will be able to do a comparative study of energy-cost savings using standard light bulbs versus candescent fluorescent light bulbs (CFLs), and existing habits and lifestyle versus conservation oriented habits and lifestyle. They will use this information in a persuasive essay to convince their families and communities to make changes in the favor of conscientious consumption and conscious conservation. This experience will help them use not only content knowledge across several domains but also literate activity to promote conservation for a healthier planet (**Task**). In addition, they will take several quizzes, tests and answer true or false statements on atomic structure, periodic table, current and static electricity, elements of a circuit, definitions of vocabulary terms, units of voltage, current and resistance, conductors and insulators, electrical usage and cost calculations as well as numerical problems applying Ohm's law and demonstrate an awareness of the importance of conservation through changes in habits and lifestyle.

Project:

Students will analyze a hypothetical family's electric bill and propose ways to lower usage by changing their habits and lifestyles (e.g. using draft guards, unplugging appliances, sealing windows, keeping refrigerator doors open for as little time as possible, etc) thereby improving conservation. Students should also try to calculate approximate savings in energy and cost from changing decalescent to fluorescent light bulbs. We can then design assessments to test their awareness of usage and conservation.

Task:

Students will study the impact of various energy saving measures such as using CFLs versus incandescent light bulbs, changes in habits and lifestyle etc, on the consumption and cost of electrical energy. They will use this information in a persuasive essay to convince families and neighborhoods in their community to make appropriate changes, with the goal of conservation. In addition, since CFLs contain mercury, which is a neurotoxin, they will design a pamphlet with safety and disposal instructions. This will include information about what should be done in case the bulb breaks and there is a danger that the mercury might spill to the floor as well as how to dispose an unbroken but spent bulb safely.

Key criteria – questions to be considered throughout the unit in order to build appropriate assessment/evidence forms:

- Have the students shown any progress and development of their ideas?
- Are the students doing their tasks responsibly and actively participating in class?
- Can the students distinguish basic concepts taught one at a time?
- Are students able to see a detailed structure of an atom/periodic table in their mind? Can they relate atomic structure and the periodic table to the ability of atoms to conduct electrons?
- Do they realize that electricity can manifest as heat, light, motion or chemical energy?
- Have their misconceptions been overcome?
- How are students doing on parallel versions of the same content across different assessment formats such as project versus an electricity and energy data sheet or task versus understanding the structure of a CFL?
- To broaden the assessment evidence, hands-on applications like the culminating task will require interpretation and self-assessment and self-reflection and the product will be evaluated on the basis of creativity, purpose and dynamics of group work. Do students clearly understand these assessment criteria?
- Students will be asked to show their work regularly, reason out their answers and asked to show connections to the big ideas or larger principles. Can they do so? And if not, is it because of the inappropriately big course load or of their disproportionately small effort?
- In their calculations, are students using their understanding of mathematical relationships, computing from memory, or guessing based on trial-and-error? Also, are they able to use their estimation skills to validate appropriateness of their results?
- If students make calculations intuitively without trial-error approach, i.e. trying to calculate either through division or multiplication and guessing more likely answer (thence, some numerical examples should include numbers too big or too small – to uncommon – to be observed in the natural world), what specific teaching style helped them to understand the concepts? Could a teacher modify that process for other students too? How?
- Are the students able to solve more complex tasks such as exponential functions and functions with two unknown variables?
- Can students transfer the knowledge to real-world application of energy conservation?
- Do students have fun, enjoy the class and are they engaged?
- Do they understand that some appliances use more energy than others and that it costs money to use energy?

These key criteria including those for project and task will be used to constantly reflect on teaching, improve lesson planning, student learning and assessment.

<u>Assessment of project and task for the unit:</u>

Criteria for Project:

- Gathering appropriate information (current, voltage and resistance) with units (15 points).
- Knowledge of Ohm's law (5 points).
- Computation of energy consumed, with appropriate units (10 points)
- Computation of costs of energy usage, with appropriate units (10 points)
- Understanding what type of graph to choose (line, pie or bar graph) and why (5 points)
- Choice of dependent and independent variable, scale and units(5 points)
- Actual plotting of the graph itself (10 points)

Criteria for task:

- Draw and explain the structure of a CFL (10 points)
- Short answer: What is its role of Argon, mercury vapor and phosphor powder in saving energy and how? (10 points)
- Short answer: Role of habit/lifestyles in conservation (10 points)
- Short answer: how would you dispose a spent or broken CFL?(10 points)

There will be partial credit for showing some understanding, their work in computation and use of estimation skills, even though the answer may not be correct.

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STAGE 3 – LEARNING PLAN

In accordance with what we learned about backward design we will need to think of what essential knowledge and skills our students will need if they are going to demonstrate through performance, the skills we are seeking. They will need to know the structure of an atom and understand how the periodic table is organized. They will understand the relationship between the periodic table and the properties of various elements, in particular electrical conductivity and resistance. To understand resistance, they will test various materials. They will know how to design a circuit, use a switch and understand the role of a battery as the power source. They will identify conductors and insulators from a collection of materials. As a culminating project in the lesson on circuits, they will participate in an electrical design challenge and use everything they have learned about electricity (battery, switch, circuits, conductors etc.) to create an electrical device that uses a battery with some practical application as in lighting up a habitat, a burglar alarm or a battery tester. To ensure optimal creativity and access to varying ability levels, they will participate in groups of three or four for this task. The assessment criteria for the culminating task are mentioned in the lesson plan.

To understand consumption and ways of conservation they will learn about electrical usage at home and school, particularly using electric meters. In order to understand the function of meters, they will learn specific units to measure electricity and their relationships to each other. Students will also understand how to use Excel spreadsheets to plot, analyze and interpret graphs. They will learn how to calculate the cost of energy. They will use this information to read and interpret their electric bills and plot their family's consumption of electricity over the course of a period of time like a week, month or year. For conservation, they can think of the kinds of light bulbs they are presently using, their habits around the house or their lifestyle (for example leaving lights on in the basement when no one is around, or leaving the computer on even when not in use etc.). After making some or all of these changes, they will again monitor their electrical usage and plot the new energy usage over a period of time. By comparing the two graphs they will understand how conservation of energy can be achieved by making simple changes. As an extension, we would have the students do a home electrical safety inspection.

For learning experiences, we will use resources such as an IMAX theatre or an innovation museum with an exhibit on electricity. We will use physics and chemistry textbooks selectively for content and scaffold textbook reading using content oriented reading instruction (CORI) strategies. In addition to textbooks, some of the recommended readings will include:

- "*Electricity*" by Steven Parker, Science Museum (ISBN: 0751361321/ ISBN-13: 9780751361322) – for better visual information about electricity, i.e. colored photographs of real-life objects
- "*Conductors and Insulators*" by Angela Royston (ISBN: 9781432914431 (143291443X)) – for comprehensive understanding of conductors, insulators and electrical circuits
- and "*Electricity (Eyewitness Books Series)*" by Steve Parker and Laura Buller (ISBN: 0756613884, ISBN-13: 9780756613884) – for supportive information about electricity from physical, biological and chemical point of view, i.e. how electricity works nerves and muscles, what causes lightning, how electricity can transmit voices and images across an ocean, what makes a silicon chip work,

discovering the amazing speed of charged atoms, what happens when you tune in the radio, etc.

Students will also access the work of authors like Bill McKibben's "*End of nature*" or Al Gore's "*Tipping point*" to enhance their awareness of the need and importance of conservation. Students will research and access websites for interactive online activities which clarify concepts in creative ways. For example, to understand simple circuits students can visit "http://www.bgfl.org/bgfl/custom/resources_ftp/client_ftp/ks2/science/ electricity_book1/index.htm". We will use other real world resources like guest speakers in the classroom and have them talk about efficiency (including use of (CFLs) and tips on conservation). These field experts can also address topics like, "*Alternate sources of energy*", "*The national electric grid and its importance in maintaining national security*" if time permits. Students can also study pamphlets such as "*How to read your meter*" and learn to record daily meter readings at home and calculate monthly electrical usage. Additional pamphlets such as "*How to understand your utility (includes gas and electricity) bill*" and "*Energy costs of major home appliances*" will be assigned as homework for parents and students. Our teaching methods will be inclusive of all learners and include a blend of direct instruction, hands-on and interactive online activities, cooperative group learning and individual activities, as well as resources such as websites, related current science articles, and related reading from biographies of famous scientists.

We are team teaching this unit on electricity. Very early in the planning process we realized that we would be using chemistry and mathematics to teach electricity (a unit in physics). We also agreed on what each of our contributions to the unit would be, and how we would dovetail our content domains to ensure a seamless transfer of knowledge and understanding. This might be trickier than we think, but for now we know that the mathematical and chemical concepts have to be taught sequentially but not necessarily in a regular CMCMCM …(C=chemistry and M= mathematics) pattern. Instead, Vijaya will teach the first few lessons and then Erik will teach a few others, followed by Vijaya´s and then Erik´s lessons again. The order of our lessons will roughly follow the sequence depicted in the unit calendar on the next page. The lesson plans will include the use of technology as well as literature to emphasize multiple forms of representation, access to diverse learning styles and to encourage literate activities of communication in the process of studying this unit.

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Learning Experiences Plan:

(WHERETO elements, HW = homework)

Day A and Day B will be used to introduce the unit. Day C will be used for modelling how to read an electric bill. Day D will be used at the end of the unit for teacher reflection on the unit as a whole.

Each day represents a lesson that is taught during one or more specific classroom meetings. For the specific time estimation, i.e. how many classroom meetings each Day is going to be consisting of, please follow the ***Unit Calendar***, right after this table of WHERETO.

Day A	Day B	Day 1
Hook students with a discussion about the effects of electricity on their lives. **H** Introduce the essential questions and discuss culminating unit performance tasks. **W** Monitor their family's Electrical usage and make changes in habits or lifestyle for conserving electricity. Use comparative savings in energy and cost to write a persuasive essay to convince your community to conserve electricity. **E-2** Have someone from the power company show students how electric meters are read. **R**	Introduce key vocabulary terms as needed by the various learning activities and performance tasks. **E** Students read and discuss relevant selections from the textbook. **E** Support reading with CORI strategies. **O** Students keep track of their daily electrical usage by reading their meters for later review. **E**	**Present concept attainment lesson on atomic structure. E** Introduce the model of the atom and have students model various elements. **E-2** Give a quiz on which atoms have loosely bound electrons and why this is important. **E, E-2** Perform a skit or build a model of the atom. **E, T, O**
Day 2 **Present concept attainment lesson on periodic table. E** Play Jeopardy with vocabulary terms. **T, O** Play "Who wants to be a chemist?" with three lifelines. **H, T, O**	**Day 3a** **Static Electricity and lab** Explain that electrons are what make electricity flow. **E** Name and define two kinds of electricity. **E** Demonstration #1: breaking up a friendship between two balloons. **E** Observe and discuss results. **E-2** Demonstration #2: Bringing the balloons back together. **E** Observe and discuss results. **E-2** Group activity #1: Like charges repel. Observe and discuss results. **E-2, O**	**Day 3b** **Current electricity and Lab** Demonstration #1: electron train Group activity #1: making nature's batteries **E, T** Discuss EMF and batteries **E** Conductors and Insulators, Resistance. **E** Lead discussion on possible dangers of electricity. **E**
Day 4 **Fundamental units & dimensional analysis of electricity E** Write a homework paragraph describing conceptual understanding of the fundamental units. HW	**Day 5** **Electrical conductivity, resistance, conductors and insulators. E-2** Online activities to test for conductors and insulators. **E-2**	**Day 6** **Transformation of Energy** Making a battery. **W, E, E-2**

Then the teacher is able to evaluate students' way of thinking. **T** Work through various activity sheets that will first seek for the conceptual understanding (without numbers). Then they will work through some numerical examples as well. **W, H, E** Complete a final exam. **R, E-2**		
Day 7 **Heat light and motion** Identify power sources for various appliances **H, E** Online activities bout how current flows, and exploring what resistance is. **H, E** Observe and question how energy has been transformed into other forms as in a light bulb, toaster and a fan. **H, E** Skit about what happened when the lights went out. **E-2, T, O**	**Day 8** **Electrical power** Write a homework paragraph describing conceptual understanding of the electrical power. HW Then the teacher is able to evaluate students' way of thinking. **T** Work through an activity sheet that clearly explains the physical definition of electrical power as product of voltage and current. **W, E**	**Day 9** **Ohm's law** Write a homework paragraph describing conceptual understanding of the relationship among all four electrical units. HW Then the teacher is able to evaluate students' way of thinking. **T** Work through various activity sheets that clearly illustrate the mathematical relationships of the basic two formulas V=IR, P=VI (where V is voltage, I current, R resistance and P power) introduced individually during Days 4 and 8, respectively. **W, H, E** Complete online activities. **E, O** Complete a final exam. **R, E-2**
Day 10 **Guest Speaker E** Electricity and Energy data sheet as homework **T** Each student completes the electricity energy data sheet and records relevant information for each appliance and calculates the energy consumed per appliance/week/month/year. HW Students plot graphs of various appliances versus their energy consumption. **E, T** The whole class plots a graph of	**Day 11** **Making connections and simple circuits** What is a circuit? What are the elements of a circuit? Represent a circuit using symbols. Build a switch. Build a simple circuit. Build a parallel circuit. Design a circuit to test for conductors and insulators	**Day 12** **Batteries and EMF** Complete online activities showing internal structure of batteries and their significance on EMF **W, E, O** Solve examples on the board clearly explaining why batteries have certain internal resistance. **O** Work through various activity sheets that mathematically prove an impact of such internal resistance on the total power usage in a circuit. **E-2, R, T**

total energy consumed by each appliance per class/week/ month. **E** **Ohm's law, power and electrical usage** Define Ohm's law and the terms volt, ampere and watts. Solve example problems on the board. Guest Speaker, "How to read your appliances". Teacher models, how to read an electric bill. Give Electricity and energy sheet for homework. Show how to calculate watt hours/week/month/year.	Making a switch, **E-2** Designing circuits, **E-2** Testing for resistance, **E-2** Electrical design challenge, **T, O**	
Day 13 **Mathematics behind Series & Parallel circuits, Reciprocals** Calculate the total resistance of "Human Circuit" created on the end of a session. Months of their birthdays would represent the numerical values to be calculated with. Students would not only gain a different, three-dimensional view on circuits, they will also learn something about themselves as a community. **H, E, T** Work through various activity sheets that will first seek for the conceptual understanding (without numbers). Then they will work through some numerical examples as well that add on complexity by considering series and parallel circuits at the same time. **W, H, E** Complete a final exam. **R, E-2**	**Day C** Review and discuss a pamphlet about "How to read your electric bill". **R** Everyone must read these to understand what they are trying to save and why it's important. **R** Working in groups students analyze a hypothetical family's electricity bill and make recommendations for usage and conservation. Teacher observes and coaches students as they work. **E-2** Have groups share their analysis and discuss as a class. Teacher collects analyses for misunderstandings needing instructional attention. **E, E-2**	**Day 14** **Cost-energy Savings Analysis of CFLs versus Incandescent Light Bulbs by Reading Electric Bills** Read electrical bills, gather the data and enter them into an Excel worksheet. **W, O** This class is a constant group work, therefore contribute to the class brainstorming during various stages of the class is required. **H, E-2, T** Complete an excel worksheet by plotting graphs and exploring direct and indirect changes of power usage. **E, R**
Day 15 **Structure of CFLs** Teacher models how to read and interpret information on boxes of CFLs and incandescent light	**Day 16** **Guest Speaker** "Tips on conservation". Discuss energy guzzlers and ways of making changes in habits and	**Day 17** **Conservation** Draw back on what was presented and applied about graphs during the Day #14 (group work), what

bulbs. Students practice Doing the same. **E** Students work independently to calculate the savings in energy and cost of using CFLs versus light bulbs. OR Students can also study comparative savings in energy and cost of changing habits and lifestyle. **E-2, T** Draw and explain the structure of a CFL (10 points) **E** Short answer: What is its role of Argon, mercury vapor and phosphor powder in saving energy and how? (10 points) **E** Short answer: Role of habit/lifestyles in conservation (10 points) **E** Short answer: how would you dispose a spent or broken CFL? (10 points) **E**	lifestyle. **E** As homework, students will write a letter to an elected official about the need and importance of conservation by suggesting three ways in which each of them would do it. **E** Students respond to a written prompt after analyzing their graphs. They discuss their observations about which items are energy guzzlers and whether it is more economical to use certain appliances at certain times of day. They will explain what changes they will make to lower energy usage. These will be collected and graded by the teacher. **E-2**	was found out about conservation during the Day #15, and what was concluded after the discussion during the Day #16. **O, R** Analyze the energy-cost savings in electrical usage by using either CFLs or making changes in habits and lifestyle, individually applied to students' own environment (house, apartment). **H, E, E-2** Plotting graphs of possible power-usage savings will be later used in the final work during the Day #18. **W**
Day 18 **Conclusion of the Unit:** Students review their daily use of electricity and self-assess their usage. Have they noticed any changes? Do they see savings in energy and costs? **E-2** Students develop a "personal energy action plan" for conscientious consumption. These are presented at upcoming student involved parent conferences. **E-2, T** Conclude unit with self-evaluation and personal energy saving habits and a persuasive essay. Have each student develop an action plan with a goal of Energy conservation. **E-2, T**	**Day D** The last lesson of the Unit. Students discuss what learnt and how their views about electricity changed. They also evaluate the flow of the course, share their positive and negative impressions, give suggestions and express their opinions about the course as a whole. This can be later used by teachers to further improve the course and make it more engaging, enjoyable and student tailored. **R, E-2**	

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Unit Calendar:

Lesson #1 (classroom meetings #1-2), Vijaya
Title: Atomic Structure
Description: Students will understand how the structure of the atom of an element will affect its charge carrying ability.
Goals: What is an atom made of? What are subatomic particles? How do atomic number and atomic mass relate to the number of electrons, protons and neutrons? How are electrons, protons and neutrons distributed within the atom of an element?
Estimated time: 2 meetings
Assessment activities: Build a model of an atom or perform a subatomic skit.

Lesson #2 (classroom meetings #3-4), Vijaya
Title: The Periodic Table
Description: Students will understand the arrangement of elements in the periodic table and how their position affects their properties.
Goals: Students will learn about the periodic law, analyze the difference between groups and periods, predict atomic mass of an element from the atomic number, explain vocabulary terms like atomic size, electro-negativity, ionization energy and ionic size, analyze periodic trends in the properties of elements in the periodic table.
Estimated Time: 2 meetings
Assessment activities: Jeopardy with vocabulary terms and "Who wants to be a chemist" using three lifelines.

Lesson #3 (classroom meetings #5-6), Vijaya
Title: Static and Current Electricity
Description: Types of electricity and their uses.
Goals: Students will understand that current flows by the movement of electrons in a domino like fashion and that like charges repel and unlike charges attract.
Estimated Time: 2 class meetings
Assessment activities: Activity sheets and Labs: electron train and experiments with balloons.

Lesson #4 (classroom meetings #7-9), Erik
Title: Fundamental units & dimensional analysis of electricity
Description: Electrical Voltage (potential difference), Current and Resistance.
Goals: Students will understand the physical definitions of electrical voltage, current and resistance. They will also work on their mathematical relationships, exploring various mathematical concepts such as composite numbers, exponential numbers of the tenth power (metric multipliers and their prefixes) or two linear equations with two variables.
Estimated Time: 3 class meetings
Assessment activities: Activity sheets, short homework paragraphs seeking for understanding, final exam.

Lesson #5 (classroom meetings #10-11), Vijaya **Title: Electrical Conductivity, Resistance, conductors and Insulators** **Description: Current carrying substances and their properties.** **Goals: Students will what makes atoms conduct electricity and why. They will test for conductors and insulators as well as resistance. In the process, they will also learn a set of vocabulary terms.** **Estimated Time: 2 class meetings.** **Assessment activities: Online and hands-on activities to test for conductors, insulators and resistance.**
Lesson #6 (classroom meetings #12-13), Vijaya **Title: Transformation of energy** **Description: Electricity can be used by transforming it into various forms.** **Goals: Students will understand that, electricity can be produced from chemical reactions and used as the driving force in a battery.** **Estimated Time: 2 class meetings.** **Assessment activities: Making a battery**
Lesson #7 (classroom meetings #14-15), Vijaya **Title: Heat, Light and Motion** **Description: Electricity and its applications** **Goals: How does resistance affect the flow of current? How can electricity be used? What happens if we don't have it?** **Estimated Time: 2 class meetings.** **Assessment activities: Online activities, activity sheets, skit, safety around electricity.**
Lesson #8 (classroom meeting #16),* Erik** ***Title: Electrical power ***Description: Electrical Power as the fourth dimension besides Voltage, Current and Resistance*** ***Goals: Students will understand the physical definition of electrical power and also how it is related to voltage and current (power as the product of the voltage and the current drop "P=VI"). No further exploration is done yet since the complete analysis takes place during the Ohm's law lesson. Also, students will continue working on the SI prefixes and metric multipliers during this lesson.*** ***Estimated Time: 1 class meetings.*** ***Assessment activities: Activity sheet, short homework paragraph seeking for understanding.***
Lesson #9 (classroom meetings #17-19),* Erik** ***Title: Ohm's law ***Description: All four variables of Electrical Voltage, Current, Resistance and Power (V, I, R, P respectively) being integrated into one mathematical relationship, i.e. an***

equation using three variables
Goals: ***Students will learn how to modify two independent formulas they have previously discovered (i.e. V=IR, P=VI) into universal mathematical relationships (such as $P=I^2R$), using non-linear equations of squares. They will be also introduced to proper use of calculators.***
Estimated Time: ***3 class meetings.***
Assessment activities: ***Online activities, activity sheets, short homework paragraphs seeking for understanding, final exam.***

Lesson #10 (classroom meeting #20), Vijaya and Erik
Title: **Guest speaker**
Description: **"How to read your electric meters."**
Goals: **Students will learn to read electric meters and use the information on their appliances to estimate the energy consumed by them.**
Estimated Time: 1 class meeting
Assessment activities: **As homework, students will complete an electricity and energy data sheet and be ready with the information needed to plot a graph in class at the next meeting.**

Lesson #11 (classroom meetings #21-22), Vijaya
Title: **Making connections and simple circuits**
Description: **Elements of a circuit, types of circuits, design and representation of circuits.**
Goals: **What is a circuit? What are the elements of a circuit? Represent a circuit using symbols. Build a switch. Design a circuit to test for conductors and insulators. Build a simple circuit. Represent and build series and parallel circuits.**
Estimated Time: **2 class meetings.**
Assessment activities: **Lab: Circuit design and building switches, representation of various types of circuits using electronic symbols for battery, circuit and resistors, designing series and parallel circuits, culminating task.**

Lesson #12 (classroom meetings #23-24), **Erik**
Title: ***Batteries and EMF***
Description: ***Batteries and Electromotive Force (EMF)***
Goals: ***What exactly are they? And what do they do in the circuit? Do they have any physical significance on the circuit, i.e. changing its properties over the time? Then what exactly is internal resistance?***
Estimated Time: ***2 class meetings.***
Assessment activities: ***Online activities, activity sheets***

Lesson #13 (classroom meetings #25-28), **Erik**
Title: ***Mathematics behind Series & Parallel circuits, Reciprocals***
Description: ***Calculating total resistance in Series & Parallel circuits***
Goals: ***Students will learn how to generalize their understanding of the physical world into a few useful mathematical formulas using the idea of reciprocals. They will also***

intensively work on reading diagrams and calculating examples using calculators.
Estimated Time: 4 class meetings.
Assessment activities: Activity sheets, homework example of a complex circuit ("human circuit") to figure out its resistance, final exam.

Lesson #14 (classroom meeting #29), **Erik**
Title: Cost-energy Savings Analysis of CFLs versus Incandescent Light Bulbs by Reading Electric Bills
Description: Reading Electric Bills, analyzing the data by plotting graphs, introducing other variables to the same graph and drawing out conclusions
Goals: Students will first learn how to read electrical bills and how to record the data in graphs using Excel. Then they will work with more variables on the same graph (e.g. average temperature, estimate number of CFLs), seeing direct and indirect changes of power usage and so exploring comparative cost-energy savings analysis of CFLs versus incandescent light bulbs. After this class, students will further explore CFLs and other possible measures to conserve energy.
Estimated Time: 1 class meeting.
Assessment activities: Excel worksheet, plotting and analysis of graphs, contribution to the class brainstorming as this class is a group work.

Lesson #15 (classroom meeting #30), Vijaya
Title: Structure and composition of CFLs versus incandescent light bulbs and their role in conserving energy.
Description: Students will be exposed to various measures of conservation. We will also discuss costs of usage that will be further developed during the next lesson.
Goals: Students will learn that there are several ways to conserve energy at home as well as in the community.
Estimated Time: 1 class meeting.
Assessment activities: listening and asking questions.

Lesson #16 (classroom meeting #31), Vijaya and Erik
Title: Guest speaker
Description: Tips on conservation
Goals: Students will be exposed to various measures of conserving energy and resources and their part in it.
Estimated Time: 1 class meeting.
Assessment activities: As homework, students will write a letter to an elected official about the need and importance of conservation by suggesting three ways in which each of them would do it.

Lesson #17 (classroom meetings #32-33), **Erik**
Title: Conservation
Description: CFLs and other measures of conservation
Goals: This class is a direct continuation of previous classes. Students will analyze the energy-cost savings in electrical usage by using either CFLs or making changes in

habits and lifestyle, individually applied to their own environment (house, apartment). They will draw back on what they learned about graphs as a group in the lesson #14, what they found out about conservation in the lesson #15, and what they have concluded after the discussion in the lesson #16.
Estimated Time: 2 class meetings.
Assessment activities: Electricity and energy data sheet, plotting and analysis of graphs.

Lesson #18 (classroom meetings #34-35), Erik and Vijaya
Title: Conclusion of the unit.
Description: students draft their personal energy action plan and the persuasive essay.
Goals: Students will apply everything they have learned about electricity to draft a personal energy action plan and write a persuasive essay to convince their community to adopt one of the various measures for conserving energy. ***Their work from the lesson #17 should be included as the graphs add on a general relevance of the paper by recalling specific data examples.***
Estimated time: 2 class meetings.
Assessment activities: Personal energy action plan and persuasive essay.

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As is evident from the unit calendar, Erik's portion will include a mathematical interpretation of how charge flows through a circuit, definition and units of measurement of current, voltage, resistance and power, Ohm's law, conductors, insulators, dimensional analysis and conversion factors for energy and cost analysis, reading electric meters and monthly electric bills, measurement and cost calculations of electrical usage, using Excel software for plotting graphs of usage and tracking usage over time, computing comparative cost savings in energy usage with CFLs versus regular light bulbs. Vijaya´s portion will include lessons on atomic structure, the periodic table, static and current electricity, transformation of energy, heat, light and motion, transformation of energy, making connections and simple circuits, ohm's law, electrical power and usage, structure and composition of CFLs and incandescent light bulbs and their role in conservation and energy consumption. We have a total of 18 lessons and 35 class meetings planned for the unit. Some of them will include both of us in the classroom together as in the concluding unit and guest speaker sessions. It is understood that if we need extra time for covering any of the lessons we might consult with each other and adjust the time between the two of us.

In order to teach for understanding, we both agreed that our teaching style will be overlapping but integrative over the course of the unit. We will not be shy about introducing new terms such as 'a conductor' metaphorically at first, only to come back to a scientific explanation later. We will try and use CORI strategies for supporting students in the reading of scientific texts where necessary. Our first lessons will be attempts to check for prior knowledge because that would be the first time the lesson meets the students. The unit will be a work in progress as we receive feedback from the students through learning logs and warm up activities. Our teaching methods will be inclusive of all the diverse learners in a classroom providing challenge and extensions for advanced learners and extra support for budding learners. To that extent we will engage students in a combination of direct instruction, individual and cooperative learning activities as well as hands-on activities in the spirit of "tell me I forget, show me I remember and involve me I understand".

The unit has been designed with the tenets of Paulo Freire's sociopolitical theory (reflected in the final communication task of writing a persuasive essay to convince their community about the need and importance of conservation through the knowledge and skills garnered in this unit) and Vygotsky's sociocultural theory (as reflected in stage 3 by students participating in learning experiences through group work, guest speakers, parents, field experts and trips to museums) in mind. The unit also reminds us that the resources we take for granted might not always be available and that we must all do our part not only to preserve what is available but also to conserve energy in our schools, homes and communities! The design of the unit takes into consideration culturally responsive practices (as in using the appeal of toys as a hook to inviting them into the lesson on circuits) and attributes such as creativity, innovative ways of thinking, curiosity, flexibility, a spirit of enthusiasm and the ability to inspire change, attributes generally associated with adolescents. It provides students with opportunities to solve problems and evaluate results, plot and graph and analyze information and engage in critical thinking processes. By the end of the unit, students will have learned content literacy across multiple domains and will be able to integrate and apply the enduring understandings through multiple forms of representation such as writing, symbols, formulas, equations, circuits and graphs, to other disciplines and ultimately for the benefit of society. For example, the persuasive essay will tap into the students' ability as writers and critical thinkers, in addition to their content-domain literacy. To underscore the authenticity of the task, and enhance motivation and student empowerment, these essays will be published and sent to local officials and policy makers.

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