Shelby County Schools Science Vision

Shelby County Schools' vision of science education is to ensure that from early childhood to the end of the 12th grade, all students have heightened curiosity and an increased wonder of science; possess sufficient knowledge of science and engineering to engage in discussions; are able to learn and apply scientific and technological information in their everyday lives; and have the skills such as critical thinking, problem solving, and communication to enter careers of their choice, while having access to connections to science, engineering, and technology.

To achieve this, Shelby County Schools has employed The Tennessee Academic Standards for Science to craft meaningful curricula that is innovative and provide a myriad of learning opportunities that extend beyond mastery of basic scientific principles.

Introduction

In 2014, the Shelby County Schools Board of Education adopted a set of ambitious, yet attainable goals for school and student performance. The District is committed to these goals, as further described in our strategic plan, Destination 2025. In order to achieve these ambitious goals, we must collectively work to provide our students with high quality standards aligned instruction. The Tennessee Academic Standards for Science provide a common set of expectations for what students will know and be able to do at the end of each grade, can be located in the Tennessee Science Standards Reference. Tennessee Academic Standards for Science are rooted in the knowledge and skills that students need to succeed in post-secondary study or careers. While the academic standards establish desired learning outcomes, the curriculum provides instructional planning designed to help students reach these outcomes. The curriculum maps contain components to ensure that instruction focuses students toward college and career readiness. Educators will use this guide and the standards as a roadmap for curriculum and instruction. The sequence of learning is strategically positioned so that necessary foundational skills are spiraled in order to facilitate student mastery of the standards.

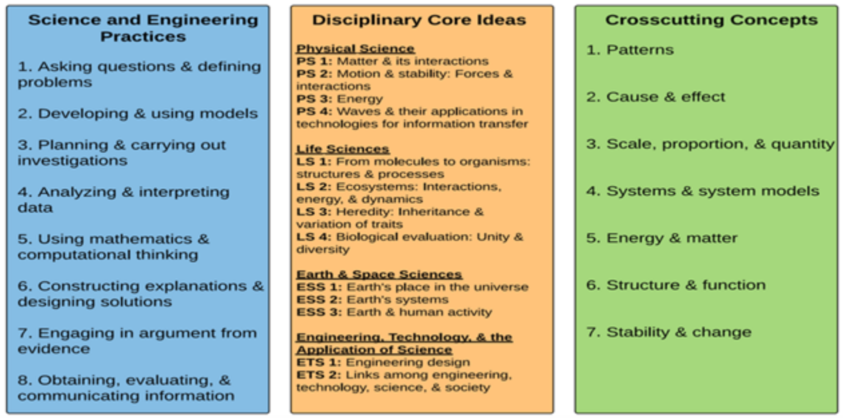
Our collective goal is to ensure our students graduate ready for college and career. Being College and Career Ready entails, many aspects of teaching and learning. We want our students to apply their scientific learning in the classroom and beyond. These valuable experiences include students being facilitators of their own learning through problem solving and thinking critically. The Science and Engineering Practices are valuable tools used by students to engage in understanding how scientific knowledge develops. These practices rest on important "processes and proficiencies" with longstanding importance in science education. The science maps contain components to ensure that instruction focuses students toward understanding how science and engineering can contribute to meeting many of the major challenges that confront society today. The maps are centered around five basic components: the Tennessee Academic Standards for Science, Science and Engineering Practices, Disciplinary Core Ideas, Crosscutting Concepts, and Phenomena.

The Tennessee Academic Standards for Science were developed using the National Research Council's 2012 publication, A Framework for K-12 Science Education as their foundation. The framework presents a new model for science instruction that is a stark contrast to what has come to be the norm in science classrooms. Thinking about science had become memorizing concepts and solving mathematical formulae. Practicing science had become prescribed lab situations with predetermined outcomes. The framework proposes a three-dimensional approach to science education that capitalizes on a child's natural curiosity. The Science Framework for K-12 Science Education provides the blueprint for developing the effective science practices. The *Framework* expresses a vision in science education that requires students to operate at the nexus of three dimensions of learning: Science and Engineering Practices, Crosscutting Concepts, and Disciplinary Core Ideas. The *Framework* identified a small number of disciplinary core ideas that all students should learn with increasing depth and sophistication, from Kindergarten through grade twelve. Key to the vision expressed in the *Framework* is for students to learn these disciplinary core ideas in the context of science and engineering practices. The importance of combining Science and Engineering Practices, Crosscutting Concepts and Disciplinary Core Ideas is stated in the *Framework* as follows:

Standards and performance expectations that are aligned to the framework must take into account that students cannot fully understand scientific and engineering ideas without engaging in the practices of inquiry and the discourses by which such ideas are developed and refined. At the same time, they cannot learn or show competence in practices except in the context of specific content. (NRC Framework, 2012, p. 218)

To develop the skills and dispositions to use scientific and engineering practices needed to further their learning and to solve problems, students need to experience instruction in which they use multiple practices in developing a particular core idea and apply each practice in the context of multiple core ideas. We use the term "practices" instead of a term such as "skills" to emphasize that engaging in scientific investigation requires not only skill but also knowledge that is specific to each practice. Students in grades K-12 should engage in all eight practices over each grade band**.** Crosscutting concepts have application across all domains of science. As such, they are a way of linking the different domains of science. Crosscutting concepts have value because they provide students with connections and intellectual tools that are related across the differing areas of disciplinary content and can enrich their application of practices and their understanding of core ideas. There are seven crosscutting concepts that bridge disciplinary boundaries, uniting core ideas throughout the fields of science and engineering. Their purpose is to help students deepen their understanding of the disciplinary core ideas and develop a coherent and scientifically based view of the world.

The map is meant to support effective planning and instruction to rigorous standards. It is *not* meant to replace teacher planning, prescribe pacing or instructional practice. In fact, our goal is not to merely "cover the curriculum," but rather to "uncover" it by developing students' deep understanding of the content and mastery of the standards. Teachers who are knowledgeable about and intentionally align the learning target (standards and objectives), topic, text(s), task, and needs (and assessment) of the learners are best-positioned to make decisions about how to support student learning toward such mastery. Teachers are therefore expected--with the support of their colleagues, coaches, leaders, and other support providers--to exercise their professional judgment aligned to our shared vision of effective instruction, the Teacher Effectiveness Measure (TEM) and related best practices. However, while the framework allows for flexibility and encourages each teacher/teacher team to make it their own, our expectations for student learning are non-negotiable. We must ensure all of our children have access to rigor—high-quality teaching and learning to grade level specific standards, including purposeful support of literacy and language learning across the content areas.



Learning Progression

At the end of the elementary science experience, students can observe and measure phenomena using appropriate tools. They are able to organize objects and ideas into broad concepts first by single properties and later by multiple properties. They can create and interpret graphs and models that explain phenomena. Students can keep notebooks to record sequential observations and identify simple patterns. They are able to design and conduct investigations, analyze results, and communicate the results to others. Students will carry their curiosity, interest and enjoyment of the scientific world view, scientific inquiry, and the scientific enterprise into middle school.

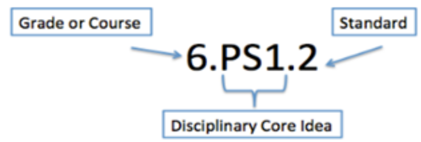
At the end of the middle school science experience, students can discover relationships by making observations and by the systematic gathering of data. They can identify relevant evidence and valid arguments. Their focus has shifted from the general to the specific and from the simple to the complex. They use scientific information to make wise decision related to conservation of the natural world. They recognize that there are both negative and positive implications to new technologies.

As an SCS graduate, former students should be literate in science, understand key science ideas, aware that science and technology are interdependent human enterprises with strengths and limitations, familiar with the natural world and recognizes both its diversity and unity, and able to apply scientific knowledge and ways of thinking for individual and social purposes.

Structure of the Standards

- Grade Level/Course Overview: An overview that describes that specific content and themes for each grade level or high school course.
- Disciplinary Core Idea: Scientific and foundational ideas that permeate all grades and connect common themes that bridge scientific disciplines.

• Standard: Statements of what students can do to demonstrate knowledge of the conceptual understanding. Each performance indicator includes a specific science and engineering practice paired with the content knowledge and skills that students should demonstrate to meet the grade level or high school course standards.



Purpose of Science Curriculum Maps

This map is a guide to help teachers and their support providers (e.g., coaches, leaders) on their path to effective, college and career ready (CCR) aligned instruction and our

pursuit of Destination 2025. It is a resource for organizing instruction around the Tennessee Academic Standards for Science, which defines what to teach and what students need to learn at each grade level. The map is designed to reinforce the grade/course-specific standards and content (scope) and provides *suggested* sequencing, pacing, time frames, and aligned resources. Our hope is that by curating and organizing a variety of standards-aligned resources, teachers will be able to spend less time wondering what to teach and searching for quality materials (though they may both select from and/or supplement those included here) and have more time to plan, teach, assess, and reflect with colleagues to continuously improve practice and best meet the needs of their students.

The map is meant to support effective planning and instruction to rigorous standards. It is *not* meant to replace teacher planning, prescribe pacing or instructional practice. In fact, our goal is not to merely “cover the curriculum,” but rather to “uncover” it by developing students’ deep understanding of the content and mastery of the standards. Teachers who are knowledgeable about and intentionally align the learning target (standards and objectives), topic, text(s), task, and needs (and assessment) of the learners are best-positioned to make decisions about how to support student learning toward such mastery. Teachers are therefore expected--with the support of their colleagues, coaches, leaders, and other support providers--to exercise their professional judgment aligned to our shared vision of effective instruction, the Teacher Effectiveness Measure (TEM) and related best practices. However, while the framework allows for flexibility and encourages each teacher/teacher team to make it their own, our expectations for student learning are non-negotiable. We must ensure all of our children have access to rigor—high-quality teaching and learning to grade level specific standards, including purposeful support of literacy and language learning across the content areas.

Physics Quarter 3 Curriculum Map Curriculum Map Feedback Survey											
Quarter 1			Quarter 2			**Quarter 3**			Quarter 4		
Unit 1 One Dimensional Kinematics	Unit 2 Two Dimensional Kinematic	Unit 3 Forces	Unit 4 Work and Energy	Unit 5 Momentum	Unit 6 Circular Motion and Gravitation	**Unit 7 Heat Energy and Thermo.**	Unit 8 Electric Forces, Fields and Energy	Unit 9 Capacitors, Resistors and Circuits	Unit 10 Waves and Sound	Unit 11 Light and Light Behaviors	Unit 12 Nuclear Physics
3 weeks	2 weeks	4 weeks	3 weeks	3 weeks	3 weeks	**2 weeks**	4 weeks	3 weeks	3 weeks	4 weeks	2 weeks

UNIT 7: Heat Energy and Thermo Energy [2 weeks]			
Overarching Question(s)			
What is meant by conservation of energy? How is energy transferred between objects or systems?			
Unit, Lesson	**Lesson Length**	**Essential Question(s)**	**Vocabulary**
Unit 7 Heat Energy and Thermo.	**0.5 Weeks**	• What is heat? • What is temperature? • What is the relationship among temperature, heat, and internal energy?	Heat, Temperature, Internal energy, Thermal equilibrium, Conduction, Convection, Radiation

Standards and Related Background Information	Instructional Focus	Instructional Resources
DCI(s) PS3: Energy **Standard(s)** PHYS.PS3.2 Investigate conduction, convection, and radiation as a mechanism for the transfer of thermal energy **Explanation** Thermal energy is the energy of a system due to the motion of the particles in that system. One object can transfer its thermal energy to another object through the processes of heating or radiating. Convection and conduction are processes which	**Learning Outcomes** • Relate temperature to the kinetic energy of atoms and molecules. • Describe the changes in the temperatures of two objects reaching thermal equilibrium. • Identify the various temperature scales and convert from one scale to another. • Explain heat as the energy transferred between substances that are at different temperatures.	**Curricular Materials** **Engage** Interactive Demonstration: Temperature Conversions Animated Physics: Heat Quick Lab: Sensing Temperature, TE pg. 300 Demonstration: Temperature and Internal Energy, TE pg. 301 Demonstration: Conduction, TE pg. 310 Demonstration: Internal Energy, TE pg. 311 **Explore** Discovery Lab: Temperature and Internal Energy Quick Lab: Sensing Temperature STEM Lab: Thermal Expansion

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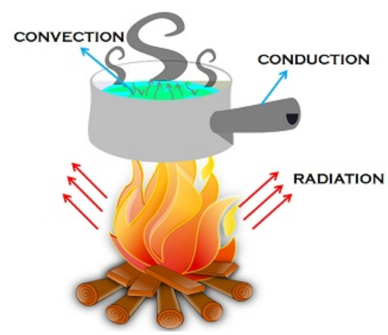
require a physical medium to transfer the thermal energy. In the case of conduction, two objects are in direct contact, while convection transfers thermal energy through a liquid or gaseous medium. Radiation is a unique form of energy transfer which can transfer without a medium. One packet of this energy is called a photon. The energy of the photon determines the effect that it will have when it interacts with matter. Low energy photons such a microwaves add to the motion of matter and result in an increase of the thermal energy. Photons carry energy from the sun to Earth. **<u>Misconceptions</u>** • Heat is a substance. Heat is not energy. Many students think of "cold" and "heat" as substances that flow from one object to another. Point out that in all cases, *energy* is transferred from one object to another. Heat and cold do not flow between objects, but the energy transferred does change the temperature of the objects involved because the distribution of internal energy changes. Also, be sure students understand that heat is not *in* a body; it is the amount of energy that is transferred between two bodies. • Temperature is a property of a particular material or object. Some students do not recognize the universal tendency toward temperature equalization. Because metal sometimes feels colder than wood, students tend to believe that different materials in the same surroundings have	• Relate heat and temperature change on the macroscopic level to particle motion on the microscopic level. • Apply the principle of energy conservation to calculate changes in potential, kinetic, and internal energy. **<u>Suggested Phenomenon</u>** **Conduction, Convection and Radiation** Heat energy is transferred by multiple mechanisms. 	Virtual Lab: Joule Heating **<u>Explain</u>** Section 9.1 Sample Problem Set I: Sample Problem A: Temperature Conversion Section 9.1 Sample Problem Set II: Sample Problem A: Temperature Version Classroom Practice: Temperature Conversions, TE pg.305 Interactive Reader: Section 9.1: Temperature and Thermal Equilibrium **<u>Elaborate</u>** Problem Solving: Deconstructing Problems, TE pg. 305 Classroom Practice: Conservation of Energy, TE pg. 312 **<u>Evaluate</u>** Interactive: Heat Concept Map Section 9.1 Quiz Section 9.2 Quiz Ch 9 Section Study Guides Section 9.1 Formative Assessment, TE pg. 306 Section 9.2 Formative Assessment, TE pg. 313 Interactive Reader: Chapter 9 Review **<u>Textbook</u>** *HMH TN Physics:* Chapter 9 • Section 9.1 Temperature and Thermal Equilibrium; pgs. 300-306 • Section 9.2 Defining Heat; pgs. 307-313 **Additional Resources** HMD Science Explore Ch. 9: Heat Graphing Calculator Ch 9 SAT Bellringer Activity

different temperatures. Ask them to describe the direction of energy transfer between a variety of objects made of different materials and the air surrounding them. Ask them when this transfer of energy would stop. • The temperature of an object depends on its size. • Heat and cold are different. Some students may confuse their perceptions of hot and cold with the temperature of an object; these students think that objects that feel hot have high temperatures and objects that feel cold have low temperatures. **Suggested Science and Engineering Practice** **Constructing explanations and designing solutions:** *Students form explanations that incorporate sources (including models, peer reviewed publications, their own investigations), invoke scientific theories, and can evaluate the degree to which data and evidence support a given conclusion.* **Suggested Cross Cutting Concepts** **Cause and Effect:** *Students use cause and effect models at one scale to make predictions about the behavior of systems at different scales.*		Student Science Standards Guide: PS3.2 Conduction, Convection, and Radiation pgs. 37-38

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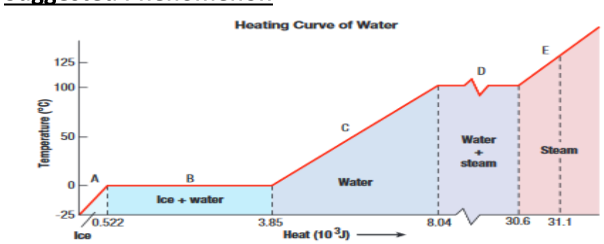
3 weeks	2 weeks	4 weeks	3 weeks	3 weeks	3 weeks	**2 weeks**	4 weeks	3 weeks	3 weeks	4 weeks	2 weeks

UNIT 7: Heat Energy and Thermo Energy [2 weeks]

Overarching Question(s)

What is meant by conservation of energy?
How is energy transferred between objects or systems?

Unit, Lesson	Lesson Length	Essential Question(s)	Vocabulary
Unit 7 Heat Energy and Thermo.	**0.5 Weeks**	• What is temperature? • How the temperature of a substance change? • What is heat capacity? • How can we use heat capacity to describe the energy required to change the temperature of a substance?	Heat, Temperature, Internal energy, Specific heat, Heat capacity, Heat curve, Calorimetry, Phase change, Latent Heat

Standards and Related Background Information	Instructional Focus	Instructional Resources
DCI(s) PS3: Energy **Standard(s)** PHYS.PS3.5 Construct an argument based on qualitative and quantitative evidence that relates the change in temperature of a substance to its mass and heat energy added or removed from a system. **Explanation** Two different materials will undergo different degrees of temperature change even with the same	**Learning Outcomes** • Perform calculations with specific heat capacity. • Interpret the various sections of a heating curve. **Suggested Phenomenon** 	**Curricular Materials** **Engage** Interactive Demonstration: [Calorimetry](#) Animated Physics: [Specific Heat and Latent Heat](#) **Explore** Lab: [Conservation of Mechanical Energy](#) Virtual Lab: [Specific Heat of a Metal](#) Skills Practice Lab: [Specific Heat Capacity](#) **Explain**

amount of energy added to each. Heat capacity is a ratio (the slope of a temperature vs. heat added) that describes the change in temperature of a sample dependent on the amount of heating. Empirical determination of the heat capacity of a substance requires that both phase and mass of the substance are constants. Students can utilize proportional reasoning in the design of a second portion of this experiment to determine the effect of mass on temperature change. **Misconceptions** • Students may be confused by the assertion that direct measurement of heat is difficult. This is another opportunity to point out that temperature and heat are not the same. • Cold is transferred from one object to another. Energy will transfer from the hotter object to the cooler object. Therefore, the equilibrium temperature will always be lower than the initial temperature of the hotter object. Also students should make sure that their answers for calorimetry problems reflect the law of conservation of energy. • Objects that keep things warm (sweaters, mittens, blankets) are sources of heat. • Some substances (flour, sugar, air) cannot heat up. • Objects that readily become warm (conductors of heat) do not readily become cold. • Students know from lessons in chemistry that heating and cooling can cause changes	**Heating Curve of Water** The idealized graph shows the temperature change of 10.0 g of ice as it is heated from -25°C in the ice phase to steam above -125°C at atmospheric pressure. (Note that the horizontal scale of the graph is not uniform.)	Classroom Practice: Calorimetry; TE/SE pg. 317-318 Problem Solving: Deconstructing Problems & Take it Further; TE pgs. 318-319 Section 9.3 Sample Problem Set I: Sample Problem C: Calorimetry Section 9.3 Sample Problem Set II: Sample Problem C: Calorimetry Section 9.3 Sample Problem Set I: Sample Problem D: Heat of Phase Change Section 9.3 Sample Problem Set II: Sample Problem D: Heat of Phase Change **Elaborate** Interactive Reader: Section 9.3: Changes in Temperature and Phases Why It Matters: Earth-Coupled Heat Pumps; TE/SE pg. 318 **Evaluate** Interactive: Heat Concept Map Section 9.3 Quiz Ch 9 Section Study Guides Section 9.3 Formative Assessment, TE/SE pg. 321 **Textbook** *HMH TN Physics:* Chapter 9 • Section 9.3 Changes in Temperature and Phase; pgs. 315-321 **Additional Resources** HMD Science Explore Ch. 9: Heat **Graphing Calculator:**

in the chemical properties of materials. To ensure they distinguish these phenomena from the physical process of phase change, ask if a substance chemically changes in the course of melting or boiling. **Suggested Science and Engineering Practice** **Analyzing and interpreting data:** *Students should derive proportionalities and equalities for dependent variables which include multiple independent variables, considering uncertainty, and limitations of collected data.* **Suggested Cross Cutting Concepts** **Systems and System Models:** *Students design or define systems in order to evaluate a specific phenomenon or problem.*		TI-83/84 Graphing Calculator Activity Guide Sheet: Heat Capacity Ch 9 SAT Bellringer Activity Student Science Standards Guide: PS3.5 Temperature Changes pgs. 43-44

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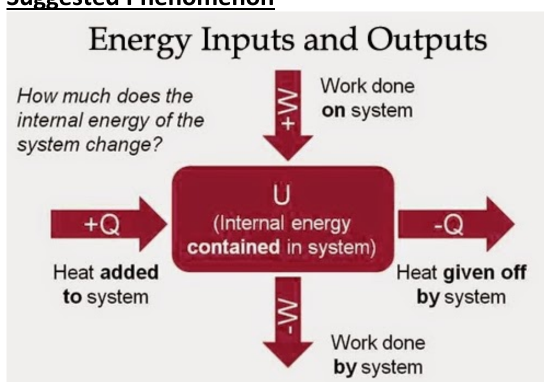
UNIT 7: Heat Energy and Thermo Energy [2 weeks]											
Overarching Question(s)											
What is meant by conservation of energy? How is energy transferred between objects or systems?											

Unit, Lesson	**Lesson Length**	**Essential Question**	**Vocabulary**

Unit 7 Heat Energy and Thermo.	**1 Week**	• What is thermodynamics? • What impact do the Laws of Thermodynamics have on machines? • How is the temperature of a substance related to the thermal energy of its atoms? • What is the underlining principle behind the movement of heat by conduction, convection and radiation?	System, environment, isovolumetric process, isothermal process, adiabatic, cyclic process, entropy

Standards and Related Background Information	Instructional Focus	Instructional Resources
DCI(s) PHYS.PS3: Energy **Standard(s)** PHYS.PS3.7 Investigate and evaluate the laws of thermodynamics and use them to describe internal energy, heat, and work. **Explanation** Internal energy of a system can be changed by either work or heat. For example: If a system is defined as Earth's gravitational field, then lifting a lump of clay upwards increases the energy/instability of this system as the field stores gravitational potential energy. It can be said that the person who lifted the clay higher and higher did work on the system. If the person is removed, the clay will fall. As the clay falls and strikes the ground, the internal energy of the gravitational field decreases by heating the surroundings (the clay and surface it falls onto). Systems move towards conditions of stability where their energy is at a minimum. According to the law of conservation of energy, the decrease in the energy of the system must mean that energy is transferred to the surroundings. Some of this energy can be	**Learning Outcomes** • Given a schematic of a refrigeration process, identify the four parts of the process. • Describe all forms of heat exchange. • Distinguish between isovolumetric, isothermal, and adiabatic thermodynamic processes. • Demonstrate a conceptual understanding of the First and Second Laws of Thermodynamics and their implications in natural phenomena. **Suggested Phenomenon** 	**Curricular Materials** **Engage** Interactive Demonstration: The First Law of Thermodynamics Animated Physics: First Law of Thermodynamics Demonstration: Dispersion; TE pg. 350 **Explore** Lab: Entropy and Probability Quick Lab: Entropy and Probability; TE/SE pg. 355 **Explain** Interactive Reader: The First Law of Thermodynamics Interactive Reader: The Second Law of Thermodynamics Classroom Practice: The First Law of Thermodynamics; TE/SE pgs. 343-344 Classroom Practice: Heat-Energy Efficiency; TE/SE pgs. 352-353 **Elaborate** Interactive Reader: Ch. 10 Review Section 10.2 Sample Problem Set I: Sample Problem B: The First Law of Thermodynamics

utilized in designed systems to do productive work (e.g., lift something, turn something). In all cases, a portion of this energy will heat the surroundings by releasing photons of varying wavelengths. When a system loses energy and moves towards stability, the entropy of the universe increases. **Misconceptions** • Students tend to believe that $W_{out} = W_{in}$ because volume increases and then decreases by the same amount as the piston returns to its original position. Remind students that $W = P\Delta V$ applies only when pressure is constant. • Students may be used to considering systems in isolation and may have trouble recognizing that most systems they think about are really part of larger systems. **Suggested Science and Engineering Practice** **Developing and using models** *Students can create models for interactions of two separate systems.* **Suggested Cross Cutting Concepts** **Stability and Change** *Students provide examples and explanations for sudden and gradual changes.*		Section 10.2 Sample Problem Set II: Sample Problem B: The First Law of Thermodynamics Section 10.3 Sample Problem Set I: Sample Problem C: Heat-Engine Efficiency Section 10.3 Sample Problem Set II: Sample Problem C: Heat-Engine Efficiency Why It Matters: Gasoline Engines; TE/SE pgs. 346-347 Why It Matters: Refrigerators; TE/SE pgs. 348-349 Why It Matters: Deep Sea Air Conditioning; TE/SE pg. 356 **Evaluate** Interactive Concept Map: Thermodynamics Section 10.2 Quiz Section 10.3 Quiz Ch. 10 Section Study Guide Section 10.2 Formative Assessment, TE/SE pg. 347 Section 10.3 Formative Assessment, TE/SE pg. 355 Conceptual Challenge; TE/SE pg. 351 **Textbook** *HMH TN Physics*: Ch. 10 Thermodynamics • Section 2: The First Law of Thermodynamics; pgs. 340-347 • Section 3: The Second Law of Thermodynamics; pgs. 350-355 **Additional Resources** HMD Science Explore Ch. 10 Thermodynamics Graphing Calculator: Chapter 10 Graphing Calculator Activity: Carnot Efficiency

		Chapter 10 SAT © Bellringer Activity

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3 weeks	2 weeks	4 weeks	3 weeks	3 weeks	3 weeks	2 weeks	**4 weeks**	3 weeks	3 weeks	4 weeks	2 weeks

UNIT 8: Electric Forces, Fields, and Energy [4 weeks]			
Overarching Question(s)			
Why are some physical systems more stable than others?			
Unit, Lesson	**Lesson Length**	**Essential Question**	**Vocabulary**
Unit 8 Electric Forces, Fields and Energy	**2 Weeks**	• Which combinations of charges attract? Which repel? • What are charges doing when there is Conduction? • What are charges doing when there is Induction? • What is grounding? • How is Coulomb's law like Newton's law of Universal Gravitation? • How is Coulomb's law different from the law of Universal Gravitation?	**There is no vocabulary highlighted for this standard.*

Standards and Related Background Information	**Instructional Focus**	**Instructional Resources**
DCI(s) PS2: Motion and Stability: Forces and Interactions **Standard(s)**	**Learning Outcomes** • Calculate electric force using Coulomb's law.	**Curricular Materials** **Engage** Demonstration: Electric Force TE pg. 556 Animated Physics: Section 16.2: Coulomb's Law

PHYS.PS2.10 Describe and mathematically determine the electrostatic interaction between electrically charged particles using Coulomb's law. Compare and contrast Coulomb's law and gravitational force, notably with respect to distance.

Explanation

Comparisons should note that both of these forces decrease proportional to the square of the distance and both are field interactions. Due to the nature of electric charge, it is possible that coulombic forces can be either attractive or repulsive depending on the charges, while gravitational forces are attractive. Descriptions of electrostatic fields should also include field line diagrams representing both strength and direction of the field in space.

Misconceptions

- Gravitational force is stronger than electrical force. The effects of the gravitational force are more apparent than the effects of the electric force in our typical experiences. These observations may cause some students to think that the gravitational force is stronger than the electric force. Remind students that the electric force between a proton and an electron is much larger than the gravitational force between the two particles.

Suggested Science and Engineering Practice

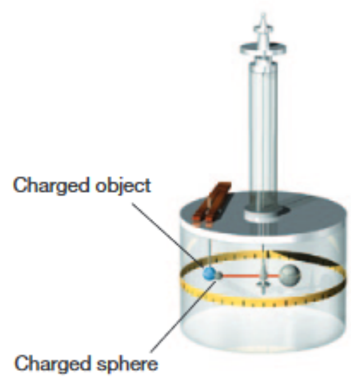
Use Mathematics and Computational Thinking

Students differentiate between the appropriateness of quantitative and qualitative data. Students create

- Compare electric force with gravitational force.
- Apply the superposition principle to find the resultant force on a charge and to find the position at which the net force on a charge is zero.

Suggested Phenomenon

Coulomb's Apparatus Coulomb's torsion balance was used to establish the inverse-square law for the electric force between two charges.



Explore

Open Inquiry Lab: Electric Force

PhETb Lab: Section 7.2 PhET Simulation: Gravity Force Lab

Explain

Differentiated Instruction: ;TE pg. 556

Conceptual Challenge; TE/SE pg. 558

Problem Solving: Take It Further; TE pg. 557

Problem Solving: Take It Further; TE pg. 559

Problem Solving: Deconstructing Problems; TE pg. 561

Interactive Reader: Electric Force

Interactive Concept Map: Electric Force

Elaborate

Classroom Practice: Coulomb's Law; TE pg. 557

Classroom Practice: The Superposition Principle; TE pg. 559-561

Classroom Practice: Equilibrium; TE pg. 561-562

Ch. 16 Section Study Guide

Section 16.2 Sample Problem Set I: Sample Problem A: Coulomb's Law

Section 16.2 Sample Problem Set II: Sample Problem A: Coulomb's Law

Evaluate

Section 2 Formative Assessment; TE/SE pg. 563

Section 16.2 Quiz

Conceptual Challenge; TE/SE pg. 558

Textbook

HMH TN Physics: Ch. 16 Electric Forces and Fields

- Section 2: Electric Force; pgs. 556-563

computational or mathematical models for interactions in the natural world, utilizing unit equivalencies. **Suggested Cross Cutting Concepts** **Cause and Effect** *Students use cause and effect models at one scale to make predictions about the behavior of systems at different scales*		**Additional Resources** **Web Resource**: HMD Science Explore: Ch. 16 Electric Forces and Fields **Graphing Calculator:** TI-83/84 Graphing Calculator Activity Guide Sheet: Coulomb's Law Student Science Standards Guide: PS2.10 Coulomb's Law pgs. 25-26

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UNIT 8: Electric Forces, Fields, and Energy [4 weeks]			
Overarching Question(s)			
How are forces related to energy?			
Unit, Lesson	**Lesson Length**	**Essential Question**	**Vocabulary**
Unit 8 Electric Forces, Fields and Energy	**2 Weeks**	• How can one explain and predict the interactions between objects and within a system of objects? • What are the relationships between electric currents and magnetic fields? • How can I exert a force on an object when I can't touch it? • How far away can my finger be from someone if I want to zap them with static electricity?	Electrical conductor, electrical insulator, induction, electric field, magnetic field.
Standards and Related Background Information		**Instructional Focus**	**Instructional Resources**

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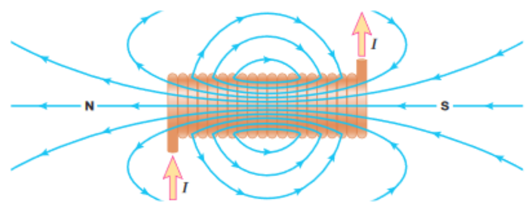
DCI(s)	Learning Outcomes	Curricular Materials
PS3: Energy **Standard** PHYS.PS3.9 Describe, compare, and diagrammatically represent both electric and magnetic fields. Qualitatively predict the motion of a charged particle in each type of field but avoid situations where the two types of fields are combined in the same region of space. Restrict magnetic fields to those that are parallel or perpendicular to the path of a charged particle. **Explanation** Students have explored the concept of non-contact forces in investigations of gravity, the effects of forces on the motion of an object and have discussed the capacity of fields to store energy. This standard unites these principles by considering the impact of an object changing position within a field. As a charge moves through a field, the changes in position (depending on the direction of motion) can result in a change to the potential energy stored by the field. A decrease in the potential energy stored in the field, coupled with the law of conservation of energy, implies that work has been done by the field. If the work being done is applied to a moving charge, the applied force will result in a change to the trajectory of the moving charge. Students should be able to qualitatively describe the force applied to the charge using right hand rules. Such discussions may also be used to relate to the function of electrical generation or electric motors through induction. A demonstration of the electromotive force and the effect of the orientation can be	• Calculate electric force using Coulomb's law. • Compare electric force with gravitational force. • Apply the superposition principle to find the resultant force on a charge and to find the position at which the net force on a charge is zero. **Suggested Phenomenon** 	**Engage** Demonstration: Magnetic Poles; TE pg. 666 Demonstration: Magnetic Domains; TE pg. 667 Demonstration: Magnetic Fields; TE pg. 668 Demonstration: Current-Carrying Wire; TE pg. 672 **Explore** Quick Lab: Magnetic Field of a File Cabinet; TE/Se pg. 669 Discovery Lab: Magnetism Quick Lab: Electromagnetism; TE/SE pg. 673 Skills Practice Lab: Magnetic Field of a Conducting Wire Open Inquiry Lab: Magnetism From Electricity **Explain** Interactive Reader: Magnets and Magnetic Fields Problem Solving: Reality Check; TE pg. 669 Interactive Reader: Magnetism from Electricity **Elaborate** Interactive Concept Map: Magnetic Fields Why It Matters: Magnetic Resonance Imaging; TE/SE pg. 671 **Evaluate** Section 19.1 Formative Assessment; TE/SE pg. 670 Section 19.2 Formative Assessment; TE/SE pg. 674 Section 19.1 Quiz Section 19.2 Quiz

observed using an electrical extension cord, unplugged with a galvanometer connecting the two ground prongs. If the cord is twirled through Earth's magnetic field, deflection will be observed. **Suggested Science and Engineering Practice** **Constructing explanations and designing solutions** *Students form explanations that incorporate sources (including models, peer reviewed publications, their own investigations), invoke scientific theories, and can evaluate the degree to which data and evidence support a given conclusion.* **Suggested Cross Cutting Concepts** **Cause and Effect** *Students use cause and effect models at one scale to make predictions about the behavior of systems at different scales*		Ch. 19 Section Study Guide Interactive Reader: Chapter 19 Review **Textbook** *HMH TN Physics*: Ch. 19 Magnetism • Section 1: Magnets and Magnetic Field; pgs. 666-670 • Section 2: Magnetism from Electricity **Additional Resources** **Web Resource**: HMD Science Explore Ch. 19 Magnetism **Graphing Calculator:** TI-83/84 Graphing Calculator Activity Guide Sheet: Solenoids Student Science Standards Guide: PS3.9 Electric and Magnetic Fields pgs. 51-52

Physics Quarter 3 Curriculum Map
Quarter 3 Curriculum Map Feedback

Quarter 1			Quarter 2			Quarter 3			Quarter 4		
Unit 1 One Dimensional Kinematics	Unit 2 Two Dimensional Kinematic	Unit 3 Forces	Unit 4 Work and Energy	Unit 5 Momentum	Unit 6 Circular Motion and Gravitation	Unit 7 Heat Energy and Thermo.	Unit 8 Electric Forces, Fields and Energy	**Unit 9 Capacitors, Resistors and Circuits**	Unit 10 Waves and Sound	Unit 11 Light and Light Behaviors	Unit 12 Nuclear Physics
3 weeks	2 weeks	4 weeks	3 weeks	3 weeks	3 weeks	2 weeks	4 weeks	**3 weeks**	3 weeks	4 weeks	2 weeks

UNIT 9: Capacitors, Resistors and Circuits [3 Weeks]			
Overarching Question(s)			
How is energy transferred between objects or systems?			
Unit, Lesson	**Lesson Length**	**Essential Question**	**Vocabulary**

<table>
<tr>
<td>Unit 9
Capacitors, Resistors and Circuits</td>
<td>1 Week</td>
<td>Calculate the equivalent capacitance of a series or parallel combination.
Describe how stored charge is divided between capacitors connected in parallel.
Calculate the voltage or stored charge, under steady-state conditions, for a capacitor connected to a circuit consisting of a battery and resistors.</td>
<td>Electrical potential energy. electric potential, potential difference, capacitance, electric current, drift velocity, resistance.</td>
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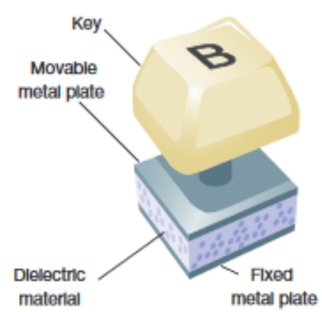
<tr>
<th colspan="2">Standards and Related Background Information</th>
<th>Instructional Focus</th>
<th>Instructional Resources</th>
</tr>
<tr>
<td colspan="2"><u>DCI(s)</u>
PS3: Energy

<u>Standard(s)</u>
PHYS.PS3.10 Develop a model (sketch, CAD drawing, etc.) of a resistor circuit or capacitor circuit and use it to illustrate the behavior of electrons, electrical charge, and energy transfer.

PHYS.PS3.13 Predict the energy stored by a capacitor and how charge flows among capacitors connected in series or parallel.

<u>Explanation</u>
Parallel plate capacitors provide a means to store an electric potential difference across the two plates. Charges can flow onto or off the two plates when the poles are connected to a battery, until the potential difference across the plates is equal to the potential difference of the connected battery. When disconnected from the source, the potential difference remains in place across the capacitor. If the two ends are connected the two plates will return to their equipotential state. The flow of charge in capacitors should be explained by considering the</td>
<td><u>Learning Outcomes</u>
Relate capacitance to the storage of electrical potential energy in the form of separated charges.
Calculate the capacitance of various devices
Calculate the energy stored in a capacitor.
<u>Suggested Phenomenon</u>

Capacitors in Keyboards
A parallel-plate capacitor is often used in keyboards.

</td>
<td><u>Curricular Materials</u>
<u>Engage</u>
Demonstration: Capacitor Discharge; TE pg. 591
Demonstration: Functions of a Capacitor; TE pg. 593
Interactive Demonstration: Capacitance

<u>Explore</u>
Capacitators Lab
Virtual Lab: RC Circuits

<u>Explain</u>
Problem Solving; TE pg. 594
Interactive Reader: Section 17.2 Capacitance
Interactive Concept Map: Electricity

<u>Elaborate</u>
Conceptual Challenge: TE pg. 592
Section 17.2 Sample Problem Set I: Sample Problem B: Capacitance
Section 17.2 Sample Problem Set II: Sample Problem B: Capacitance

<u>Evaluate</u></td>
</tr>
</table>

point where charge ceases to flow due to the entire circuit having equal potential differences and justifying why current has stopped. A charged capacitor creates an electric field with the capacity to do work **Misconceptions** • Charges moving in a circuit are always positive. • Charge carriers move at the speed of light. • Resistance is a variable that can change, like force or acceleration. **Suggested Science and Engineering Practice** **Developing and using models** *Students can create models for the interactions of two separate systems. Students can test the predictive abilities of their models in a real world setting and make comparisons of two models of the same process or system.* **Suggested Cross Cutting Concepts** **Stability and Change** *Students provide examples and explanations for sudden and gradual changes.*		Section 17.2 Formative Assessment; TE/SE pg. 595 Section 17.2 Quiz Ch. 17 Section Study Guide **Textbook** *HMH TN Physics*: Ch. 17: Electrical Energy and Current • Section 2: Capacitance **Additional Resources** **Web Resource**: HMH Ch. 17 Electrical Energy & Current Student Science Standards Guide: PS3.10 Circuits pgs. 53-54 & PS3.13 Capacitors and Circuits pgs. 59-60

Physics Quarter 3 Curriculum Map **Quarter 3 Curriculum Map Feedback**											
Quarter 1			Quarter 2			**Quarter 3**			Quarter 4		
Unit 1 One Dimensional Kinematics	Unit 2 Two Dimensional Kinematic	Unit 3 Forces	Unit 4 Work and Energy	Unit 5 Momentum	Unit 6 Circular Motion and Gravitation	Unit 7 Heat Energy	Unit 8 Electric Forces,	**Unit 9 Capacitors, Resistors and Circuits**	Unit 10 Waves and Sound	Unit 11 Light and Light Behaviors	Unit 12 Nuclear Physics

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						and Thermo.	Fields and Energy				
3 weeks	2 weeks	4 weeks	3 weeks	3 weeks	3 weeks	2 weeks	4 weeks	**3 weeks**	3 weeks	4 weeks	2 weeks

UNIT 9: Capacitors, Resistors and Circuits [3 Weeks]			
Overarching Question(s)			
Unit, Lesson	**Lesson Length**	**Essential Question**	**Vocabulary**
Unit 9 Capacitors, Resistors and Circuits	**1 Week**	• How are electric current, resistance and voltage related?	Electrical potential energy. electric potential, potential difference, capacitance, electric current, drift velocity, resistance.
Standards and Related Background Information		**Instructional Focus**	**Instructional Resources**
DCI(s) PS3: Energy **Standard(s)** PHYS.PS3.11 Investigate Ohm's law (I=V/R) by conducting an experiment to determine the relationships between current and voltage, current and resistance, and voltage and resistance. **Explanation** Models can include the use of simulations. The focus of the models should be on the flow of charge and the utilization of energy within the circuit. It is important that students recognize that heat dissipated by resistors represents energy lost from the system that did not do effective work. (Extreme care should be taken if capacitors are used in the class.) Ohm's law relates the current through a device or portion of a circuit to the voltage drop observed across that device. The voltage drop across a device		**Learning Outcomes** • Describe the basic properties of electric current, and solve problems relating current, charge, and time. • Distinguish between the drift speed of a charge carrier and the average speed of the charge carrier between collisions. • Calculate resistance, current, and potential difference by using the definition of resistance. • Distinguish between ohmic and non-ohmic materials and learn what factors affect resistance. • Interpret and construct circuit diagrams **Suggested Phenomenon**	**Curricular Materials** **Engage** Demonstration: Drift Speed; TE pg. 599 Demonstration: Non-Ohmic Resistance; TE pg. 601 Demonstration: Factors That Affect Resistance; TE pg. 601 Interactive Demonstration: Current Interactive Demonstration: Resistance Animated Physics: Ohm's Law **Explore** Quick Lab: A Lemon Battery; TE/SE pg. 598 Virtual Lab: Ohm's Law Virtual Lab: RC Circuits Skills Practice Lab: Ohm's Law Skills Practice Lab: Current and Resistance **Explain** Classroom Practice: Current; TE/SE pgs. 597 Classroom Practice: Resistance; TE/SE pg. 602-603

will increase in a linear fashion as the current through that device is increased. The resistance of the device is given by the ratio of voltage drop to current across the device. In an ohmic device, this ratio will be constant. Simple, single-loop circuits may be analyzed by considering each resistor as part of the total (equivalent) resistance of the circuit. (It may be beneficial to describe non-ohmic devices, but such devices are beyond the scope of this standard.)

Misconceptions

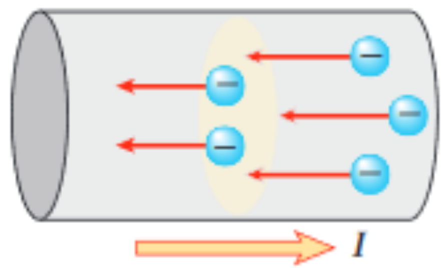
- Some student may thing that charges moving in a circuit are always positive. Stress that charge curriers can be positive, negative, or a combination of the two.
- Some student may have the misconception that charge carriers move at the speed of light. When discussing the concepts of drift velocity, address the misconception directly with students.
- Some students may develop the idea that resistance is a variable that can change, like force or acceleration. Emphasize that the resistance of an object is more like mass (assuming temperature remains constant).
- Once a resistor is built, it usually has a fixed resistance. The resistance of a circuit can be changed by adding or changing resistors just as adding mass to an object changes its total mass

Suggested Science and Engineering Practice

Planning and Carrying Out Controlled Investigations

Students plan and perform investigations to aid in the development of a predictive model for interacting

Current The current in this wire is defined as the rate at which electric charges pass through a cross-sectional area of the wire.



Interactive Reader: Current and Resistance
Section 17.3 Sample Problem Set I: Sample Problem C: Current
Section 17.3 Sample Problem Set II: Sample Problem C: Current
Section 17.3 Sample Problem Set I: Sample Problem D: Resistance
Section 17.3 Sample Problem Set II: Sample Problem D: Resistance

Elaborate
Problem Solving: Take It Further; TE pg. 597
Why It Matters: Superconductors; TE/SE pg. 605

Evaluate
Conceptual Challenge; TE/SE pg. 599
Section 3 Formative Assessment; TE/SE pg. 604
Interactive Reader: Ch. 17 Review
Section 17.3 Quiz

Textbook
HMH TN Physics: Ch. 17 Electrical Energy and Current

- Section 17.3 Current and Resistance; pgs. 596-604

Additional Resources
Web Resource:
HDM Science Explore: Ch. 17 Electrical Energy and Current
Graphing Calculator: Resistance and Current Activity; Students Activity Sheet
Ch. 17 Section Study Guide

variables, consider the quantity of data with respect to experimental uncertainty, and select methods for collection and analysis of data. **Suggested Cross Cutting Concepts** **Stability and Change** *Students provide examples and explanations for sudden and gradual changes.*		

Physics Quarter 3 Curriculum Map
Quarter 3 Curriculum Map Feedback

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UNIT 9: Capacitors, Resistors and Circuits [3 Weeks]

Overarching Question(s)

Unit, Lesson	Lesson Length	Essential Question	Vocabulary
Unit 9 Capacitors, Resistors and Circuits	**1 Week**	• How do I construct series and parallel circuits? • What are some devices and procedures for maintaining electrical safety?	Electrical potential energy. electric potential, potential difference, capacitance, electric current, drift velocity, resistance.

Standards and Related Background Information	Instructional Focus	Instructional Resources
DCI(s) PS3: Energy **Standard(s)**	**Learning Outcomes** • Calculate the equivalent resistance for a circuit of resistors in series and find the current in and potential difference across each resistor in the circuit.	**Curricular Materials** **Activities from this unit can be used for this standard.* Lab-Resistors in Series and in Parallel

PHYS.PS3.12 Apply the law of conservation of energy and charge to assess the validity of Kirchhoff's loop and junction rules when algebraically solving problems involving multi-loop circuits.

Explanation

Analysis of circuits using Ohm's Law is efficient for small, simple circuits. In more complex circuits, it is beneficial to evaluate the flow of charge and potential drops using Kirchhoff's Rules. These rules present an excellent opportunity to consider conservation laws. The junction rule reflects a conservation of charge, while the loop rule addresses conservation of energy for a unit of charge. This may be presented by considering the capacity of each charge to either do work or produce heat. In a complete loop, all of that capacity will have been eliminated.

Misconceptions

- current is used up in the resistor.
- In the closed-circuit current comes back to the battery but has decreased in magnitude.

Suggested Science and Engineering Practice

Using Mathematics and Computational Thinking

Students can apply and test computational models for the function of a device.

Suggested Cross Cutting Concepts

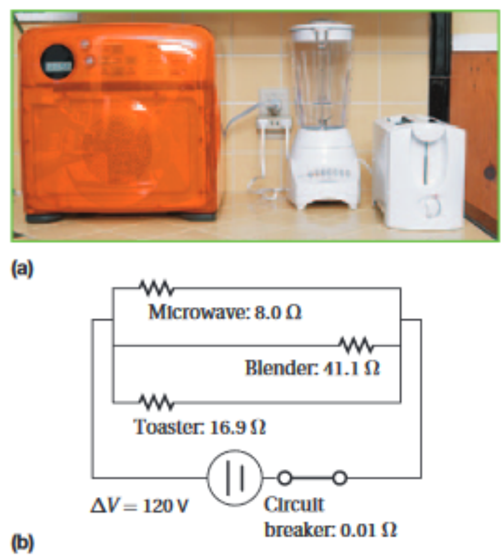
Energy and Matter

Students demonstrate and explain conservation of mass and energy in systems including systems with inputs and outputs.

- Calculate the equivalent resistance for a circuit of resistors in parallel. Find the current in and the potential difference across each resistor in the circuit.
- Calculate the equivalent resistance for a complex circuit involving both series and parallel portions.
- Calculate the current in and potential difference across individual elements within a complex circuit.

Suggested Phenomenon

A Household Circuit **(a)** When all of these devices are plugged into the same household circuit, **(b)** the result is a parallel combination of resistors in series with a circuit breaker.



Lab-Series and Parallel Circuits

Virtual Lab-Series and Parallel Circuit:

Textbook

HMH TN Physics:

Ch. 17 Electrical Energy & Current

- Section 17.2 pgs. 590-595

Ch. 18 Circuit and Circuit Elements

- Section 18.1 pgs. 630-635
- Section 18.2 pgs. 637-646

Additional Resources

Web Resource:

HMH Ch. 18 Circuit and Circuit Elements

Science Standards Guide: PS3.12: Kirchhoff Loop and Junction Rules; pgs. 57-58

Curriculum and Instruction- Science			
RESOURCE TOOLKIT			
Quarter 3 Physics			
Textbook Resources *HMH TN Physics* HMH Online	**DCIs and Standards** **DCI(s)** PS3: Energy PS2: Motion and Stability **Standard(s)** PHYS.PS3.2 PHYS.PS3.5 PHYS.PS3.7 PHYS.PS2.10 PHYS.PS3.9 PHYS.PS3.13 PHYS.PS3.11 PHYS.PS3.10 PHYS.PS3.12	**Videos** Khan Academy Illuminations (NCTM) Discovery Education The Futures Channel The Teaching Channel Teachertube.com Acceleration Lab: Bungee Jump Accelerations	**Additional Resources** **ACT & SAT** TN ACT Information & Resources ACT College & Career Readiness Mathematics Standards SAT Connections SAT Practice from Khan Academy