Integrated Science Unit 3: Energy on Earth
Copied on: 08/04/26

Content Area: **Science**
Course(s): **Integrated Science**
Time Period: **MP3**
Length: **45 days**
Status: **Published**

NJSLS - Science

HS-PS1-4	Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.
HS-PS3-1	Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.
HS-PS3-4	Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).
HS-ESS2-1	Develop a model to illustrate how Earth's internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features.
HS-ESS2-2	Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems.
HS-ESS2-3	Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection.
HS-ESS2-4	Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.

Science and Engineering Practices

Developing and Using Models

- Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-ESS2-1), (HS-ESS2-3), (HS-PS1-4)
- Use a model to provide mechanistic accounts of phenomena. (HS-ESS2-4)

Analyzing and Interpreting Data

- Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. (HS-ESS2-2)

Planning and Carrying Out Investigations

- Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-PS3-4)

Using Mathematics and Computational Thinking

- Create a computational model or simulation of a phenomenon, designed device, process, or system. (HS-PS3-1)

Developing and Using Models

- Modeling in 9–12 builds on K–8 and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.

- Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-PS1-4)

Scientific Knowledge is Based on Empirical Evidence

- Science knowledge is based on empirical evidence. (HS-ESS2-3)

- Science disciplines share common rules of evidence used to evaluate explanations about natural systems. (HS-ESS2-3)

- Science includes the process of coordinating patterns of evidence with current theory. (HS-ESS2-3)

- Science arguments are strengthened by multiple lines of evidence supporting a single explanation. (HS-ESS2-4)

Disciplinary Core Ideas

ESS2.A: Earth Materials and Systems

- Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. (HS-ESS2-1), (HS-ESS2-2)

- Evidence from deep probes and seismic waves, reconstructions of historical changes in Earth's surface and its magnetic field, and an understanding of physical and chemical processes lead to a model of Earth with a hot but solid inner core, a liquid outer core, a solid mantle and crust. Motions of the mantle and its plates occur primarily through thermal convection, which involves the cycling of matter due to the outward flow of energy from Earth's interior and gravitational movement of denser materials toward the interior. (HS-ESS2-3)

- The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun's energy output or Earth's orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles. (HS-ESS2-4)

ESS2.B: Plate Tectonics and Large Scale System Interactions

- The radioactive decay of unstable isotopes continually generates new energy within Earth's crust and mantle, providing the primary source of the heat that drives mantle convection. Plate tectonics can be

viewed as the surface expression of mantle convection. (HS-ESS2-3)

- Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geologic history. Plate movements are responsible for most continental and ocean-floor features and for the distribution of most rocks and minerals within Earth's crust. (ESS2.B Grade 8 GBE) (HS-ESS2-1)

ESS2.D: Weather and Climate

- The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's reradiation into space. (HS-ESS2-2), (HS-ESS2-4)

- Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate. (HS-ESS2-4)

PS3.A: Definitions of Energy

- Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms. (HS-PS3-1)

PS3.B: Conservation of Energy and Energy Transfer

- Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system. (HS-PS3-1)

- Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. (HS- PS3-1), (HS-PS3-4)

- Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g. relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior. (HS-PS3-1)

- The availability of energy limits what can occur in any system. (HS-PS3-1)

- Uncontrolled systems always evolve toward more stable states—that is, toward more uniform energy distribution (e.g., water flows downhill, objects hotter than their surrounding environment cool down). (HS-PS3-4)

PS3.D: Energy in Chemical Processes

- Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment. (HS-PS3-4)

PS1.A: Structure and Properties of Matter

- A stable molecule has less energy than the same set of atoms separated; one must provide at least this energy in order to take the molecule apart. (HS-PS1-4)

PS1.B: Chemical Reactions

- Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy. (HS-PS1-4)

Crosscutting Concepts

Cause and Effect

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-ESS2-4)

Energy and Matter

- Energy drives the cycling of matter within and between systems. (HS-ESS2-3)
- Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. (HS-PS1-4)

Stability and Change

- Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. (HS-ESS2-1)
- Feedback (negative or positive) can stabilize or destabilize a system. (HS-ESS2-2)

Interdependence of Science, Engineering, and Technology

- Science and engineering complement each other in the cycle known as research and development (R&D). Many R&D projects may involve scientists, engineers, and others with wide ranges of expertise. (HS-ESS2-3)

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

- New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology. (HS-ESS2-2)

Systems and System Models

- When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. (HS- PS3-4)
- Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models. (HS-PS3-1)

Scientific Knowledge Assumes an Order and Consistency in Natural Systems

- Science assumes the universe is a vast single system in which basic laws are consistent. (HS-PS3-1)

Rationale and Transfer Goals

Now, more than ever before, the study of how energy, particularly thermal energy, flows as a system is one of the most important topics due to the growing concerns of climate change in today's world. In this unit, students will begin working with the basics of thermodynamics and the flow of thermal energy. These concepts will be applied to the everyday life of students including in cooking and refrigeration. Students will model heat transfer using Newton's Law of Cooling which will allow them to observe and interact with objects gaining heat from or losing heat to the enironment. Computing models (i.e. temperature vs. time graphs) help students relate broader phenomomena to hands-on measurements of temperature over time that they make. Students will identify how thermal energy flows from one source to another, how to stop or encourage this flow of energy, and applications of this in terms of today's society and climate change.

Enduring Understandings

- Thermodynamics, the study of the movement of thermal energy, can explain everything from sea floor spreading to changes in the weather.
- Changes in the earth's surface have both environmental and thermal effects on Earth's climate.
- The rock cycle is partly fueled by the thermal convection inside the earth.
- Conductors and insulators influence the rate of flow of thermal energy.
- Heat transfer is the flow of energy from one area with a higher concentration of thermal energy to an area of a lower concentration.
- This happens naturally and results in objects approaching the temperature of the ambient environment.

Essential Questions

- Why does the earth have a magnetic field? (phenomenon)
- How do whole continents move?(phenomenon)
- How can the graphite in my pencil be the same material as a diamond?(phenomenon)
- How is heat transfer important in daily life as well as on a global scale?
- What is our influence on climate change?(phenomenon)

- How can I make my house more energy efficient during the winter?(phenomenon)
- What can influence how quickly heat tranfers between an object and the environment, and how does that impact temperature of both?

Content - What will students know?

- Thermodynamics is the study of how thermal energy moves and can be applied to better understand geologic phenomena on the earth.
- Convection currents can explain the movement of both air and sea currents.
- Climate change has a direct effect on the earth and we, and future generations, must prepare for the effects of it.
- Interpreting energy and phase diagrams for a substance gaining or losing heat with phase changes (i.e. melting, boiling, freezing, evaoporating) and temperature changing.
- Newton's Law of Cooling, how graphing temperature and time can model things in daily life.
- How to quantify energy transfers for different materials and conditions using specific heat and mass.
- Conserving energy in everyday life provides both a financial and environmental benefit for everyone.

Skills - What will students be able to do?

- Explain the movement of the earth's internal processes using thermal dynamics.
- Identify reasons for changes in weather, as well as movement found in the oceans of the world.
- Create presentations concerning the effects of climate change and human influences on it.
- Build a spreadsheet model of Newton's Law of Cooling to produce temperature vs. time curves for objects
- Measure temperature and time experimentally and compare that real data to the predictions of a model
- Curve fitting: Adjust rate constant terms or other parameters of a model to fit experimental data

Activities - How will we teach the content and skills?

- Students will devise an argument for how to explain the occurrence of sea floor spreading, using evidence they collect,as well as these notes.

- Students will look into how thermal currents cause sea floor spreading in this activity.
- Students will host a debate on climate change and human involvement after reading this article.
- Students will measure temperature over time in a heat transfer lab
- Students will construct a model that uses Newton's Law of Cooling and use it to model heat transfer as temperature vs. time graphs.

Evidence/Assessments - How will we know what students have learned?

- **Assessments can be reviewed for each course in this folder.**
- Students will propose explanations for certain events found in nature that impact us as a society, such as storms and droughts.
- Students will be asked to create a presentation on certain areas of climate change and the changes it has made on society.
- Students will produce a computational model on a spreadsheet and use it to simulate the temperature vs. time of objects in a colder or warmer environment.
- Students will complete a heat transfer lab by fitting experimental data to a curve by modeling the objects mass and specific heat and then varying the rate constant.
- Integrated Science Unit 3 Benchmark

Spiraling for Mastery

Content or Skill for this Unit	Spiral Focus from Previous Unit	Instructional Activity
• Movement in the earth's internal process, driven by thermal convection currents cause the magnetic field of the earth • Energy efficiency and acts to conserve energy in our daily lives will need to be put into practice to ensure the survival of our species. • Climate change is driven by the Greenhouse effect	• Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current. • Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.	• Students will construct an electromagnet and compare its magnetic field to a bar magnet and that of the earth. • Students will measure temperature and time of a cooling fluid and fit it to a temperature vs. time curve that they mathematically model. • Students will explain what

	• Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.	the Greenhouse Effect is and how energy from the sun interacts with our atmosphere as the process continues.

Key Resources

Savaas Physical Science

Shared Google Drive of Notes and Vocabulary

Phet Simulations

Google Classroom

Spreadsheet Lab Manual module 305 (or 306) Newton's Law of Cooling and heat transfer lab (mod 305-L2)

21st Century Life and Careers

9.2.12.CAP.3	Investigate how continuing education contributes to one's career and personal growth.
9.2.12.CAP.4	Evaluate different careers and develop various plans (e.g., costs of public, private, training schools) and timetables for achieving them, including educational/training requirements, costs, loans, and debt repayment.
9.2.12.CAP.5	Assess and modify a personal plan to support current interests and post-secondary plans.

Career Readiness, Life Literacies, & Key Skills

9.4.12.CT.3	Enlist input from a variety of stakeholders (e.g., community members, experts in the field) to design a service learning activity that addresses a local or global issue (e.g., environmental justice).
9.4.12.CT.4	Participate in online strategy and planning sessions for course-based, school-based, or other project and determine the strategies that contribute to effective outcomes.
9.4.12.IML.2	Evaluate digital sources for timeliness, accuracy, perspective, credibility of the source, and relevance of information, in media, data, or other resources (e.g., NJSLSA.W8, Social Studies Practice: Gathering and Evaluating Sources.
9.4.12.IML.3	Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions (e.g., S-ID.B.6a., 8.1.12.DA.5, 7.1.IH.IPRET.8).
9.4.12.IML.4	Assess and critique the appropriateness and impact of existing data visualizations for an

	intended audience (e.g., S-ID.B.6b, HS-LS2-4).
9.4.12.TL.2	Generate data using formula-based calculations in a spreadsheet and draw conclusions about the data.
9.4.12.TL.4	Collaborate in online learning communities or social networks or virtual worlds to analyze and propose a resolution to a real-world problem (e.g., 7.1.AL.IPERS.6).

Interdisciplinary Connections/Companion Standards

Science Standard	Math Connection	ELA Connection	Science
Patterns in rates of change and other numerical relationships can provide information about natural and human-designed systems.	Recognize and represent proportional relationships between quantities.	Close Reading of Text: Read closely to determine what the text says explicitly and make logical inferences.	MS-PS1-
Graphs, charts, and images can be used to identify patterns in data.	Describe qualitatively the functional relationship between two quantities by analyzing a graph.	Diverse Media and Formats: Synthesize content presented in diverse media and formats, including visually and quantitatively, as well as in words.	MS-
Planning and Carrying out Investigations: Scientists and engineers plan and carry out investigations in the field or laboratory, working collaboratively as well as individually.	Make sense of problems and persevere in solving them.	Participate Effectively: Prepare for and participate effectively in a range of conversations and collaborations with diverse partners.	S