2024 Unit 3: How does energy shape and affect stars and planets?

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

NJSLS - Science

SCI.HS-ESS1-2	Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe.
SCI.HS-ESS1-3	Communicate scientific ideas about the way stars, over their life cycle, produce elements.
SCI.HS-ESS1-1	Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun's core to release energy that eventually reaches Earth in the form of radiation.
SCI.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.
SCI.HS-ESS1-4	Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.
SCI.HS-ESS2-3	Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection.
SCI.HS-PS2-4	Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.
SCI.HS-PS3-4	Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).
SCI.HS-PS3-5	Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.
SCI.HS-PS3-2	Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative position of particles (objects).
SCI.HS-PS1-8	Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay.

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-ESS1-1, HS-ESS2-1, HS-ESS2-3, HS-PS1-8, HS-PS3-2, HS-PS3-5)

Constructing Explanations and Designing Solutions

- Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue

to do so in the future. (HS-ESS1-2)

Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena

- A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment and the science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence. (HS-ESS1-2)
- Theories and laws provide explanations in science. (HS-PS2-4)
- Laws are statements or descriptions of the relationships among observable phenomena. (HS-PS2-4)

Obtaining, Evaluating, and Communicating Information

- Communicate scientific ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). (HS-ESS1-3)

Using Mathematical and Computational Thinking

- Use mathematical or computational representations of phenomena to describe explanations. (HS-ESS1-4, HS-PS2-4)

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)

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)

Disciplinary Core Ideas

ESS1.A: The Universe and Its Stars

- The star called the sun is changing and will burn out over a lifespan of approximately 10 billion years. (HS-ESS1-1)
- The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth. (HS-ESS1-2, HS-ESS1-3)
- The Big Bang theory is supported by observations of distant galaxies receding from our own, of the measured composition of stars and non-stellar gases, and of the maps of spectra of the primordial radiation (cosmic microwave background) that still fills the universe. (HS-ESS1-2)
- Other than the hydrogen and helium formed at the time of the Big Bang, nuclear fusion within stars produces all atomic nuclei lighter than and including iron, and the process releases electromagnetic

energy. Heavier elements are produced when certain massive stars achieve a supernova stage and explode. (HS-ESS1-2, HS-ESS1-3)

PS3.D: Energy in Chemical Processes and Everyday Life

- Nuclear Fusion processes in the center of the sun release the energy that ultimately reaches Earth as radiation. (HS-ESS1-1)
- 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)

PS4.B: Electromagnetic Radiation

- Atoms of each element emit and absorb characteristic frequencies of light. These characteristics allow identification of the presence of an element, even in microscopic quantities. (HS-ESS1-2)

ESS1.B: Earth and the Solar System

- Kepler's laws describe common features of the motions of orbiting objects, including their elliptical paths around the sun. Orbits may change due to the gravitational effects from, or collisions with, other objects in the solar system. (HS-ESS1-4)

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)
- 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)

ESS2.B: Plate Tectonics and Large-Scale System Interactions

- 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. (HS-ESS2-1)
- 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)

PS4.A: Wave Properties

- Geologists use seismic waves and their reflection at interfaces between layers to probe structures deep in the planet. (HS-ESS2-3)

PS1.C: Nuclear Processes

- Nuclear processes, including fusion, fission, and radioactive decays of unstable nuclei, involve release or absorption of energy. The total number of neutrons plus protons does not change in any nuclear process. (HS-PS1-8)

PS2.B: Types of Interactions

- Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects. (HS-PS2-4)
- Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields. (HS-PS2-4)

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-PS3-2)
- At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. (HS-PS3-2)
- These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as a combination of energy associated with the motion of particles and energy associated with the configuration (relative position of the particles). In some cases the relative position energy can be thought of as stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space. (HS-PS3-2)

PS3.B: Conservation of Energy and Energy Transfer

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

- When two objects interacting through a field change relative position, the energy stored in the field is changed. (HS-PS3-5)

Crosscutting Concepts

Scale, Proportion, and Quantity

- The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. (HS-ESS1-1)
- Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth). (HS-ESS1-4)

Energy and Matter

- Energy cannot be created or destroyed–only moved between one place and another place, between objects and/or fields, or between systems. (HS-ESS1-2, HS-PS3-2)

- In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. (HS-ESS1-3, HS-PS1-8)
- Energy drives the cycling of matter within and between systems. (HS-ESS2-3)

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-ESS1-2, HS-ESS1-4, HS-ESS2-3)

Scientific Knowledge Assumes an Order and Consistency in Natural Systems

- Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and they will continue to do so in the future. (HS-ESS1-2)
- Science assumes the universe is a vast single system in which basic laws are consistent. (HS-ESS1-2)

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)

Patterns

- Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS2-4)

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)

Cause and Effect

- Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. (HS-PS3-5)

Rationale and Transfer Goals

The purpose of this unit is to have students gain an understanding of how gravity shapes the motion and formation of the heavens. Students will review the concept of kinematics and forces before applying them to natural, observed phenomena on earth and in space. Students will also investigate how forces and energy affect earth processes such as weather. By studying gravity and Kepler's Laws, students should be able to answer the question of how energy shapes and affects the stars and planets.

Enduring Understandings

- Energy can be transferred via conduction, convection, or radiation.
- Macroscopic and microscopic systems experience energy changes in very similar ways.
- The geosphere experiences changes due to a flow of energy to and from the Earth.
- Gravitation is the result of the attraction between all mass/matter.
- All charged objects have electric fields.
- As distance increases, the strength of a field will exponentially decrease.
- Kepler's Laws of Motion can be used to accurately describe the moon of planets and other stellar bodies.

Essential Questions

- How long does it take to make a mountain?
- Why are people on Earth stuck here while astronauts appear to be weightless?
- How does the weight (force of gravity) of an astronaut of a specific mass change at specific distances from Earth as the shuttle moves away from the Earth?
- How can an object exert a force on another object without touching it?

Content - What will students know?

- If two objects are in thermal contact, they will exchange heat until they reach thermal equilibrium.
- Earth processes occur over many millennia and are variable due to changes within the Earth.
- When a gas or liquid is heated, it will undergo convection.
- The strength of a force decreases as you move further away from the source of a field.
- Changes in the relative position of objects in a field can affect the energy of the field.
- Evidence for the Big Bang is seen by the moon of galaxies observed by a red-shift.
- The further away an object is from what it is revolving around, the longer its period will be.

Skills - What will students be able to do?

- Solve for the amount of heat that was transferred based on the changes in temperature of two objects in thermal equilibrium.
- Use equations of kinetic and potential energy to solve for the rate at which content will move.
- Observe the flow of heat within a gas and observe that hot gas will rise as cold air will sink.
- Use climate change as an example of what happens when the energy input to the Earth's atmosphere changes over time due to human interactions.

- Correctly use the given mathematical formulas to predict the gravitational force between objects or predict the electrostatic force between charged objects.
- Develop a model in which they identify and describe the relevant components to illustrate the forces and changes in energy involved when two objects interact.
- Use evidence of the expansion of the universe to show that galaxies in general are moving away from one another.
- Use Kepler's Second Law to explain why Halley's comet comes every 76 years

Activities - How will we teach the content and skills?

- Use a PhET simulation to show the effect of adding or removing heat from a liquid or gas. {link]
- Use simulations of continental drift and determine the rate at which continents move in order to determine the energy needed to move them. [link]
- Review the effect of density on floating and sinking and explain what is observed in videos of convection. [link]
- Read scholarly resources and use the knowledge of work and energy as well as convection to explain why the Earth's average temperature is increasing and why that leads to a bigger chain reaction down the line. [link]
- Calculate the strength of the gravitaonal force based on parameters given such as in this PhET simulaon [link].
- Using this PhET simulaon [link], understand what is meant by the term voltage and how it describes a change in energy based on the location to the source of a field.
- Use data recorded by NASA to understand the evidence presented for the Big Bang and relate it to an explosion and how the momentum will all remain conserved [link].
- Determine how far away Halley's comet travels if it appears every 76 years and figure out how far away it must be now [link].

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

- Students will be able to answer the unit question, how does energy affect and shape the stars and planets?
- Students will be able to determine the amount of heat that has been transferred based on the change in temperature of a mass.
- Students will be able to explain the difference between conduction, convection, and radiation
- Students will be able to use work and energy to explain climate change.
- Explain how scientists were able to use evidence presented to us today as a way to predict what happened 13 billion years ago.
- Solve for the distance of any planet in the solar system knowing their orbital period.
- Students will be able to use Newton's Law of Gravitation equation and Coulomb's Law equation to solve for unknown variables within the equations.
- Students will be able to explain what happens to the energy of an object as it moves closer to or further from the source of a field correctly.

- Physics Quarter 3 Benchmark on LinkIT website.

Spiraling for Mastery

Content or Skill for this Unit	Spiral Focus from Previous Unit	Instructional Activity
• Create models of the interior of the Earth that describe the cycling of matter by thermal convection. The continents do not move over the ocean floor; rather, the entire plate moves over the mantle. • The continents do not move over the ocean floor; rather, the entire plate moves over the mantle. • The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them. • Construct and present arguments using evidence to support the claim that gravitational interactions are arriving and depend on the masses of interacting objects. • Develop and use a model of the Earth-sun-moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons. • Develop and use a model to describe the role of gravity in the moons within galaxies and the solar system.	• The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter. • Gravitational forces are always arrive. There is a gravitational force between any two masses, but it is very small except when one or both of the objects have large masses—e.g., Earth and the sun. • The term “heat” as used in everyday language refers both to thermal energy (the moon of atoms or molecules within a substance) and the transfer of that thermal energy from one object to another. In science, heat is used only for this second meaning; it refers to the energy transferred due to the temperature difference between two objects. • All Earth processes are the result of energy flowing and cycling within and among the planet’s systems. • This energy is derived from the sun and Earth’s hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth’s materials and living	• Review the layers of the Earth and our ability to “see” underneath the Earth’s crust • Review heat and how the transfer of heat changes the temperature of a substance. • Review the hierarchy of the solar system and why planets revolve around the sun. • A review of the gravitational force and its purpose within the solar system. • Review conservation laws and how a closed or open makes a difference.

	organisms. • Maps of ancient land and water patterns, based on invasions of rocks and fossils, make clear how Earth's plates have moved great distances, collided, and spread apart. • Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects. • Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact. • Develop and use a model of the Earth-sun-moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons. • Develop models to describe the atomic composition of simple molecules and extended structures. Gravitational forces are always active. There is a gravitational force between any two masses, but it is very small except when one or both of the objects have large masses—e.g., Earth and the sun. • Patterns of the apparent moon of the sun, the moon, and stars in the sky can be observed, described, predicted, and explained with models. • The solar system appears to have formed from a disk of dust and gas, drawn	

	together by gravity.	

Key Resources

OpenSTAX College Physics [Link]

WebAssign Homework [Link]

PhET Simulations [Link]

Physics [Link]

Physlet [Link]

NASA Website [Link]

The Physics Classroom [Link]

Career Readiness, Life Literacies, & Key Skills

WRK.9.1.2.CAP.2	Explain why employers are willing to pay individuals to work.
WRK.9.1.2.CAP.3	Define entrepreneurship and social entrepreneurship.
WRK.9.1.2.CAP.4	List the potential rewards and risks to starting a business.
TECH.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).
TECH.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.
TECH.9.4.12.GCA.1	Collaborate with individuals to analyze a variety of potential solutions to climate change effects and determine why some solutions (e.g., political. economic, cultural) may work better than others (e.g., SL.11-12.1., HS-ETS1-1, HS-ETS1-2, HS-ETS1-4, 6.3.12.GeoGI.1, 7.1.IH.IPERS.6, 7.1.IL.IPERS.7, 8.2.12.ETW.3).
TECH.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.
TECH.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).
TECH.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).
TECH.9.4.12.IML.5	Evaluate, synthesize, and apply information on climate change from various sources appropriately (e.g., 2.1.12.CHSS.6, S.IC.B.4, S.IC.B.6, 8.1.12.DA.1, 6.1.12.GeoHE.14.a, 7.1.AL.PRSNT.2).

TECH.9.4.12.IML.6	Use various types of media to produce and store information on climate change for different purposes and audiences with sensitivity to cultural, gender, and age diversity (e.g., NJSLSA.SL5).

Interdisciplinary Connections/Companion Standards

MA.N-Q.A.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
MA.N-Q.A.2	Define appropriate quantities for the purpose of descriptive modeling.
MA.N-Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
LA.RST.11-12.1	Accurately cite strong and thorough evidence from the text to support analysis of science and technical texts, attending to precise details for explanations or descriptions.
LA.RST.11-12.2	Determine the central ideas, themes, or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.
LA.WHST.11-12.7	Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.
LA.WHST.11-12.8	Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.
LA.WHST.11-12.9	Draw evidence from informational texts to support analysis, reflection, and research.