Delaware Science Coalition

Grade 9 Energy Unit Template

Preface: This unit has been created as a model for teachers in their designing or redesigning of course curricula. It is by no means intended to be inclusive; rather it is meant to be a springboard for teacher thought and creativity. The information we have included represents one possibility for developing a unit based on the Delaware content standards and the Understanding by Design framework and philosophy.

Brief Summary of Unit: This unit addresses both mechanical and radiant energy with respect to transfer and transformation. Students will use an integrated investigative approach to explore the mechanisms and effects of this transfer and transformation both conceptually and quantitatively, supporting the Law of Conservation of Energy.

This unit is to be the first unit in the ninth grade Integrated Science course. The concepts are to be reinforced in the subsequent introductory chemistry, astronomy, and earth science units.

Stage 1: Desired Results
Delaware Science Content Standards

Delaware Science Content Standards

This course focuses on the Delaware Science Content Standards and Grade- Level Expectations in Standards 1 and 3 found on the following web site: http://www.doe.k12.de.us/programs/ci/content_areas/science.shtml

Standard 1: Nature and Application of Science and Technology

Understandings and Abilities of Scientific Inquiry

1. Scientists conduct investigations for a variety of reasons including to explore new phenomena, to replicate other's results, to test how well a theory predicts, to develop new products, and to compare theories.
2. Science is distinguished from other ways of knowing by the use of empirical observations, experimental evidence, logical arguments and healthy skepticism.
3. Theories in science are well-established explanations of natural phenomena that are supported by many confirmed observations and verified hypotheses.
4. The application of theories allows people to make reasonable predictions. Theories may be amended to become more complete with the introduction of new evidence.
5. Investigating most real-world problems requires building upon previous scientific findings and cooperation among individuals with knowledge and expertise from a variety of scientific fields.
6. The results of scientific studies are considered valid when subjected to critical review where contradictions are resolved and the explanation is confirmed.

7. In communicating and defending the results of scientific inquiry, arguments must be logical and demonstrate connections between natural phenomena, investigations, and the historical body of scientific knowledge. (American Association for the Advancement of Science, 2001)
8. Knowledge and skill from sources other than science are essential to scientific inquiry. These include mathematics, reading, writing, and technology.

Science, Technology, and Society

1. The pursuit of science can generate the need for advanced technology. Advanced technology, in turn, can provide the opportunity to pursue new scientific knowledge.
2. The social, economic, and political forces of a society have a significant influence on what science and technology programs are pursued, funded, and implemented.

History and Context of Science

1. New disciplines of science emerge as older disciplines interface into an integrated study of the natural world. As the body of scientific knowledge grows, the boundaries between individual disciplines diminish.

Standard 3: Energy and its Effects

Forms and Sources of Energy

1. Electromagnetic waves carry a single form of energy called electromagnetic (radiant) energy.
2. An object has kinetic energy because of its linear motion, rotational motion, or both. The kinetic energy of an object can be determined knowing its mass and speed. The object's geometry also needs to be known to determine its rotational kinetic energy. An object can have potential energy when under the influence of gravity, elastic forces, or electric forces and its potential energy can be determined from its position.
3. Mechanical waves result from the organized vibrations of molecules in substances. Kinetic energy can be transferred very quickly over large distances by mechanical waves.
4. Thermal (heat) energy is associated with the random kinetic energy of the molecules of a substance.
5. Magnetic energy and electrical energy are different aspects of a single electromagnetic energy, which results from the motion of electrical charges.
6. Chemical energy is derived from the making and breaking of chemical bonds. *
7. Nuclear energy is a form of potential energy that is released when a portion of the mass of the nucleus is converted to energy through nuclear fusion, nuclear fission, or radioactive decay. *

Forces and the Transfer of Energy

1. Forces are mechanisms that can transfer energy from one object to another. A force acting on an object and moving it through a distance does work on that object and changes its kinetic energy, potential energy, or both. Power indicates the rate at which forces transfer energy to an object or away from it.
2. Gravity is a universal force of attraction that each mass exerts on any other mass. The strength of the force depends on the masses of the objects and the distance between them.
3. The force of gravity is generally not important unless at least one of the two masses involved is huge (a star, the Earth or another planet or a moon).
4. Electric forces between charged objects are attractive or repulsive. The electric forces between electrons and protons are attractive, determine the structure of atoms, and are involved in all chemical reactions. The electromagnetic forces acting between atoms or molecules are much stronger than the gravitational forces between the same atoms or molecules and are responsible for many common forces such as friction, tensions and supporting forces.
5. Electromagnetic forces are responsible for the physical properties of materials (e.g., the boiling point of a liquid) and the mechanical properties of materials (e.g., surface tension).
6. The nuclear forces that hold the nucleus of an atom together are much stronger than the repulsive electric forces acting between the protons that would make the nucleus fly apart, therefore, most atoms have stable nuclei.*

Energy Interacting With Materials; the Transformation and Conservation of Energy

1. Energy cannot be created nor destroyed. Energy can be transferred from one object to another and can be transformed from one form to another, but the total amount of energy never changes. Recognizing that energy is conserved, the processes of energy transformation and energy transfer can be used to understand the changes that take place in physical systems.
2. Most of the changes that occur in the universe involve the transformation of energy from one form to another. Almost all of these energy transformations lead to the production of some heat energy, whether or not heat energy is the desired output of the transformation process
3. Waves (e.g., sound and seismic waves, waves in water, and electromagnetic waves) carry energy that can have important consequences when transferred to objects or substances.
4. When waves interact with materials, the energy they transfer often leads to the formation of other forms of energy. These interactions, which depend upon the nature of the material and the wavelength of the waves, can be used to create practical devices (e.g., sonar and ultra sound imaging, solar cells, remote control units, and communication devices).
5. Through reflection and refraction, electromagnetic waves can be redirected to produce concentrated beams or images of their source.
6. When radiant energy is absorbed or emitted by individual atoms or molecules, the changes in energy involve the jump of an electron from one distinct energy level to another. These energy changes, which are characteristic of the atom or molecule, can be used to identify the material.*

The Production, Consumption and Application of Energy

1. Demand for energy by society leads to continuous exploration in order to expand supplies of fossil fuels. Nuclear energy is an alternative form of energy. Through the use of fission reactors, nuclear energy is already widely used for the generation of electrical energy. Additional technologies are being developed to increase the use of other alternate energy sources.
2. The increase in energy demand and the new technologies being developed to meet these needs and improve the efficiencies of energy systems have social and environmental consequences. Societal expectations for a sustainable environment will require new, cleaner technologies for the production and use of energy.

Big Ideas

Systems, Order, and Organization: Energy takes many forms. These forms are grouped as kinetic energy and potential energy.

Evidence, Models, and Explanation: Diagrams and equations are used to explain energy storage and transfer. Investigations supply evidence for explanations.

Constancy, Change, and Measurement: Changes are caused by the transfer of energy. These transfers can be measured. Forces are responsible for these transfers. The total amount of energy cannot change.

Form and Function: Energy stored in resources must be transferred into more useful forms before it can be helpful to us.

Unit I Energy, Forces, and Motion	**Unit II Introduction to Chemistry**	**Unit III Solar Nebula Theory**	**Unit IV Earth Systems**
• Science as Inquiry • Energy Transformation, Transfer, and Conservation	• Science as Inquiry • Familiarity and Facility with Periodicity	• Science as Inquiry • Origin and Evolution of the Solar System	• Science as Inquiry • Theory of Plate Tectonics • Interrelationships among Earth Systems

Unit Enduring Understandings

Students will understand that…

Standard 1

1. Scientific inquiry involves asking scientifically oriented questions, collecting evidence, forming explanations, connecting explanations to scientific knowledge and theory, and communicating and justifying the explanation.
2. The development of technology and advancement in science influence each other and drive each other forward.
3. Understanding past processes and contributions is essential in building scientific knowledge.

Standard 3

1. Energy takes many forms. These forms can be grouped into types of energy that are associated with the motion of mass(kinetic energy) and types of energy associated with the position of mass and energy fields(potential energy).
2. Changes take place because of the transfer of energy. Energy is transferred to matter through the action of forces. Different forces are responsible for the different forms of energy.
3. Energy readily transforms from one form to another, but these transformations are not always reversible. The details of these transformations depend upon the initial form of the energy and the properties of the materials involved. Energy may transfer into or out of a system, and it may change forms, but the total energy cannot change.
4. People utilize a variety of resources to meet the basic and specific needs of life. Some of these resources cannot be replaced. Other resources can be replenished or exist in such vast quantities they are in no danger of becoming depleted. Often the energy stored in resources must be transformed into more useful forms and transported over great distances before it can be helpful to us.

Unit Essential Question(s)

Standard 1

1. What makes a question scientific? What constitutes evidence? When do you know you have enough evidence? Why is it necessary to justify and communicate an explanation?
2. How do science and technology influence each other?
3. How have past scientific contributions influenced current scientific understanding of the world? What do we mean in science when we hay that we stand on the shoulders of giants?

Standard 3

1. Why do things have energy?
2. How can energy be transferred from one material to another?
3. What happens to a material when energy is transferred to it?
4. What happens to the energy in a system – where does this energy come from, how is it changed within the system, and where does it ultimately go? How does the flow of energy affect the materials in the system?
5. What is a "responsible" use of energy? Are there alternative forms of energy that will serve our needs, or better ways of using traditional forms of energy?

Knowledge & Skills

Students will know…

Standard 1: Nature and Application of Science and Technology

1. Scientists conduct investigations for a variety of reasons including to explore new phenomena, to replicate other's results, to test how well a theory predicts, to develop new products, and to compare theories.
2. Science is distinguished from other ways of knowing by the use of empirical observations, experimental evidence, logical arguments and healthy skepticism.
3. Theories in science are well-established explanations of natural phenomena that are supported by many confirmed observations and verified hypotheses. The application of theories allows people to make reasonable predictions. Theories may be amended to become more complete with the introduction of new evidence.
4. Investigating most real-world problems requires building upon previous scientific findings and cooperation among individuals with knowledge and expertise from a variety of scientific fields. The results of scientific studies are considered valid when subjected to critical review where contradictions are resolved and the explanation is confirmed.
5. In communicating and defending the results of scientific inquiry, arguments must be logical and demonstrate connections between natural phenomena, investigations, and the historical body of scientific knowledge.
6. Knowledge and skill from sources other than science are essential to scientific inquiry. These include mathematics, reading, writing, and technology.
7. The pursuit of science can generate the need for advanced technology. Advanced technology, in turn, can provide the opportunity to pursue new scientific knowledge.
8. The social, economic, and political forces of a society have a significant influence on what science and technology programs are pursued, funded, and implemented.
9. New disciplines of science emerge as older disciplines interface into an integrated study of the natural world. As the body of scientific knowledge grows, the boundaries between individual disciplines diminish.

Standard 3: Energy and Its Effects

1. Electromagnetic energy (radiant energy) is carried by electromagnetic waves.
2. Wavelength is used to distinguish the different groups of electromagnetic waves.
3. The kinetic energy of an object depends on the square of its speed, and that $KE = \frac{1}{2} mv^2$.
4. The gravitational potential energy of an object increases linearly with the weight of an object (mg) and with its height (h) above a pre-defined reference level. ($GPE = mgh$)
5. Energy stored in an elastic material increases nonlinearly with the extent to which the material was stretched.
6. Energy stored in an elastic material is proportional to the square of the stretch of the material, and a constant that reflects the elasticity of the material. (Elastic $PE = \frac{1}{2} kx^2$)
7. Heat energy represents the total random kinetic energy of molecules of a substance.
8. Chemical energy is stored in the chemical bonding of atoms and molecules.
9. Chemical energy is derived from the energy of the electrons that move around the nucleus of while nuclear energy is associated with the protons and neutrons in the nucleus.
10. Electromagnetic waves transfer energy from one charged particle to another.
11. The motion of molecules when a mechanical wave passes through is different from the motion associated with their random kinetic energy.
12. Mechanical waves transport energy without transporting matter.
13. Gravitational force is a universal force of attraction that acts between masses, but this force is only significant when one (or both) of the objects is massive.
14. As objects move away from the surface of a planet or moon, the gravitational pull on the object will decrease, but that near the surface the gravitational force remains nearly constant and that for Earth, the object would have to be several hundred miles above the surface before the decrease becomes detectable.
15. Mass is not the same as weight, and that weight (gravitational force acting on an object) can be calculated from the mass and gravity. ($F_G = mg$)
16. The amount of energy transferred between interacting objects can be calculated from measurable quantities.
17. Work is the process by which a force transfers energy to an object and can be calculated using measured quantities (W = energy transferred = $F \cdot D$).
18. Power is a quantity that tells how quickly energy is transferred to or away from an object.
19. The attractive forces within an atomic nucleus are different from electric forces and are responsible for the stability of the nucleus.
20. The Law of Conservation of Energy states that energy cannot be created or destroyed.
21. Selective absorption of mechanical waves is used to conduct investigations in medicine, industry, and science.
22. Selective absorption of electromagnetic waves has many medical, scientific, and industrial applications.

23. The forces of friction and air resistance transform mechanical energy into heat energy, and that the heat energy may not be transformed into any organized form of energy due to its random nature.
24. Organized forms of energy are more useful than disorganized forms.
25. Mechanical efficiency refers to the proportion of energy that remains organized. A variety of factors affect this efficiency in automobiles.

Students will be able to…

Standard 1

1. Identify and form questions that generate a specific testable hypothesis that guide the design and breadth of the scientific investigation.
2. Design and conduct valid scientific investigations to control all but the testable variable in order to test a specific hypothesis.
3. Collect accurate and precise data through the selection and use of tools and technologies appropriate to the investigations.
4. Display and organize data through the use of tables, diagrams, graphs, and other organizers that allow analysis and comparison with known information and allow for replication of results.
5. Construct logical scientific explanations and present arguments which defend proposed explanations through the use of closely examined evidence.
6. Communicate and defend the results of scientific investigations using logical arguments and connections with the known body of scientific information.
7. Use mathematics, reading, writing, and technology when conducting scientific inquiries.

Standard 3

1. Use diagrams to illustrate the differences between and similarities shared by all electromagnetic waves.
2. Conduct investigations involving moving objects to examine the effect that mass and speed have on the kinetic energy of the object.
3. Collect, graph, and interpret data relating potential energy to weight and height.
4. Collect, graph, and interpret data relating elastic potential energy to the amount the material is stretched.
5. Explain that heat energy represents the total random kinetic energy of molecules of a substance.
6. Describe the differences between nuclear energy and chemical energy.
7. Use graphics or computer animations to show how electromagnetic waves transfer energy from one charged particle to another.
8. Give examples of the applications for the transfer of energy from ion to ion.
9. Use diagrams to illustrate how the motion of molecules when a mechanical wave passes through the substance is different from the motion associated with their random kinetic energies.
10. Use diagrams or models to explain how mechanical waves can transport energy without transporting matter.

11. Use examples to illustrate that near the surface of a planet or moon, the gravitational force acting on an object remains nearly constant.
12. Explain the difference between the mass of an object and its weight.
13. Conduct investigations to determine the behavior of elastic materials. Graph and interpret data showing the relationship between the size of the force and the extent of the stretch.
14. Describe the role that forces play when energy is transferred between interacting objects and how the quantity of energy transferred can be calculated from measurable quantities.
15. Use measured quantities to make calculations of the work done by forces.
16. Conduct investigations to determine what factors influence whether a force transfers energy to an object or away from the object and how the direction of the force (relative to the motion) influences the quantity of energy transferred by the force.
17. Give examples that illustrate the differences between power, force, and energy.
18. Use models and diagrams to illustrate the structure of the atom and describe the distribution of charge and mass. Identify the forces that are responsible for the stability of the atom and which parts of the atom exert and feel these forces.*
19. Give examples of energy transfer from one object to another and examples of energy being transformed from one form to another.
20. Trace the flow of energy through a physical system Indicate the source of energy and make qualitative estimates of all the forms of the energy involved, reflecting on the consequences of the energy transfers and transformations that take place.
21. Illustrate examples of the selective absorption of mechanical waves in natural phenomena and give examples of how the selective absorption of mechanical waves is used in medicine, industry, and science.
22. Explain that what happens to electromagnetic waves that strike a substance depends on the wavelength of the waves and the physical properties of the substance.
23. Investigate the behavior of various types of electromagnetic waves when they strike different substances. Draw conclusions from this data about the physical properties of substances with respect to reflection, absorption, and refraction of the various wavelengths.
24. Give examples of how selective absorption of electromagnetic waves explains their uses.
25. Trace the flow of energy in a selective absorption process.
26. Trace the flow of energy through systems involving sliding friction and air resistance.
27. Give examples of the transformation of organized forms of energy into heat energy that can not be reversed. Explain why this reversal is not possible.
28. Reflect on why organized forms of energy are more useful than disorganized forms.
29. Discuss the factors that influence the fuel efficiency of a vehicle. Include the various types of fuel currently being used and possible alternative fuels.

Stage 2: Assessment Evidence
(Design Assessments To Guide Instruction)

Suggested Performance Task(s)

Unit summative assessment is in pilot stage and will be coming soon.

- Students develop a crash barrier that will stop a car in the shortest distance without injuring a passenger.
- Students demonstrate their understanding of how wave energy can be used by designing inventions that transfer or transform energy to perform practical tasks.
- Students create a learning map that shows their understanding of the relationships among the forms of energy and the transfer and transformation of energy.

Rubrics/Checklists for Performance Tasks

Other Evidence

- Student journals
- Exit questions
- Lab reports

Student Self-Assessment and Reflection

- Students will keep journals throughout the unit.
- Pre-learning concept checks will be used to determine potential misconceptions. Students will revisit these concepts after instruction for re-evaluation.

Stage 3: Learning Plan
(Design Learning Activities To Align with Goals and Assessments)

Key Learning Events Needed to Achieve Unit Goals

The unit is divided into 8 investigations. Each investigation is divided into activities designed to build toward a major concept.

Investigation #1: Work and Energy Principles

Students identify work as an energy transfer and distinguish between energy transfer and energy transformation. Kinetic and Gravitational Potential Energies are the focus. Students investigate the relationship between force and distance in doing work.

Investigation #2: Gravitational Potential Energy

Students investigate the relationship between an object's height and its speed as it falls. Energy diagrams are used to show how GPE and KE combine to keep the total amount of energy constant.

Investigation #3: Kinetic Energy

Students explore the relationship between an object's speed and its kinetic energy using graphs and apply their knowledge to an accident scene analysis.

Investigation #4: Elastic Energy

Students investigate the relationship between the force applied and the stretch of elastic objects and explore the relationship between the work done to stretch an elastic material and the energy then stored in that material using graphical analysis.

Investigation #5: Power and Energy Chains

Students examine the relationship between energy transfer (work) and time to develop the concept of power and use energy chains to illustrate the energy transformations and transfers that occur as common tasks are carried out.

Activity #6: Wave Mechanics

Students differentiate between transverse and longitudinal waves and between mechanical and electromagnetic waves, identify the measurable properties of the waves, and recognize the similarities among the various types of waves.

Investigation #7: Selective Absorption of Waves

Students examine various materials and frequencies of electromagnetic radiation and observe the wave behavior (reflection, refraction, absorption).

Investigation #8: Energy Applications

Students research a current energy topic and create a presentation in support or rejection of the concept, backing up their conclusions with data. They will also prepare a learning map that demonstrates their understanding of the relationships developed throughout the unit.

- What text/print/media/kit/web resources best support this unit?

Driver, Rosalind, et al, Making Sense of Secondary Science, Routlage Falmer, 2004

Stepans, Joseph, Targeting Students' Science Misconceptions, Idea Factory, Inc., FL, 1996

Iris Education and Outreach Program

- What tips to teachers of the unit can you offer about likely rough spots/student misunderstandings and performance weaknesses, and how to troubleshoot those issues?
  - *Force and energy are not equivalent.* This is addressed in the barrier experiments where students see the relationship between force and distance in energy transfer.
  - *The exponential relationship between Kinetic energy and speed.* This mathematical relationship is demonstrated for the first time in Investigation #3. Students may have a great deal of difficulty with this relationship. An exponential relationship will be addressed again in Investigation #4 with respect to elastic potential energy. Remember that the standards call for an understanding that the relationship is not linear and not for traditional problem solving.
  - *Objects do not lose all of their potential energy as soon as they begin to fall.* Energy diagrams emphasize that the total energy remains the same. As objects move faster, they increase in kinetic energy, but potential energy is reduced as they get closer to earth.
  - *Amplitude and frequency contribute to the energy carried by a wave.* Stress to students that frequency is not the sole determinant of wave energy. Explain how low frequency combined with high amplitude can carry a great deal of energy. Consider tsunamis and boom boxes.