Physics
Section 1

Physics

Lexile

Physics studies the different forms of matter, their properties, and the transformations that they undergo. From the beginnings of **physics** among the ancient Greeks, through its revival in late Renaissance Europe and its flowering in the 19th and 20th centuries, there have been continual increases in the breadth of phenomena studied by physicists and in the depth of understanding of these phenomena (see **physics**, history of). During this growth of the science, physicists have discovered general laws, such as the conservation of energy, that apply throughout space and time.

Matter and Its Transformations

Originally, the term *matter* referred to anything evident to the senses, such as solids and liquids, and possessing properties such as weight. As the scope of **physics** has expanded, however, so has the range of the concept of matter. Gases are now included, as are the near-vacuums of outer space and those attained in scientific laboratories. Individual subatomic particles are now considered to be the ultimate constituents of matter, even though some of them lack properties of mass and specific location (see fundamental particles). Today matter is broadly identified as anything that interacts with the familiar types of matter, by exchanging such qualities as energy and momentum.

The earliest transformation of matter to be studied by physicists was motion, which is treated in the branch of **physics** called mechanics. The laws of motion were codified in the 17th century by Isaac Newton, who provided a physical explanation of the motions of celestial bodies. In the 19th century, **physics** was extended to study changes in physical form that take place, as, for example, when a liquid freezes and becomes a solid. Such changes of state are studied in the branch of **physics** called thermodynamics. Other changes in the form of matter—for instance, those which occur when oxygen and hydrogen combine to form water—are usually considered to be part of chemistry rather than **physics**. This distinction is somewhat arbitrary, however, since ideas from **physics** are routinely used in chemistry.

New transformations have been discovered among subatomic particles. One type of particle can change into another, and particles can be created and destroyed. In descriptions of subatomic particles using the physical theory called quantum field theory (see quantum mechanics), such particle creations and destructions are taken as the fundamental events out of which all other transformations are built.

Microphysics and Macrophysics

Physics is divided into subdisciplines, as already noted, according to subject matter. The broadest division is between microphysics, which studies subatomic particles and their combinations in atoms and molecules, and macrophysics, which studies large collections of subatomic particles such as the solid bodies of everyday experience.

Different experimental methods are used in these two divisions. In microphysics the objects under study usually are observed indirectly, as in the use of particle detectors to observe the record of the passage of subatomic particles. Consequently, much theoretical analysis stands between the observations and their interpretation. Most individual subatomic systems can be studied only for short periods of time. It is therefore very difficult to follow a microscopic phenomenon in detail over time, even to the extent that physical laws allow this. In macrophysics, however, phenomena are usually directly observable, and less theoretical analysis is needed to determine what is happening. Furthermore, because individual systems can normally be observed over long periods of time, their evolution can be analyzed and can often be predicted.

Differences between microphysics and macrophysics also exist in the laws that apply. In microphysics the fundamental laws are those of quantum mechanics, whose descriptions are fundamentally statistical. They only allow probabilities to be predicted for individual events, such as radioactive decays. In macrophysics, fundamental laws such as Newton's laws of motion are deterministic, and, in principle, precise predictions can be made about individual events. For some macroscopic systems, however, it is necessary to use statistical methods because of difficulties in treating large numbers of objects individually.

The Methods of Physics

Physics, like other sciences, uses diverse intellectual methods. Because of the long history of **physics**, the distinctions among these methods have become pronounced.

Experimental Physics

When **physics** was revived in 16th-century Europe, Galileo and other workers in the field added an important new element. They insisted that observation and experiment are the ultimate sources of knowledge about nature. Whereas such early physicists as William Gilbert could rely on observations of natural phenomena, it soon became clear that more rapid progress could be made through experiments. These involve setting up situations that accentuate certain aspects of the phenomena under investigation. Most discoveries concerning electricity and magnetism, for example, were made through experiments.

Often the purpose of experiments is to obtain specific numerical data, such as the temperature at which a material becomes a superconductor. Sometimes the result is more qualitative and the experiment results in the recognition of novel phenomena. Physicists use a wide variety of techniques to probe specific aspects of nature. Many such methods involve instruments that themselves are outgrowths of important discoveries in **physics**, including such 20th-century inventions as particle accelerators, lasers, and nuclear magnetic resonance detectors.

Theoretical Physics

Until the late 19th century, there was no clear distinction between experimental and theoretical **physics** . Around the beginning of the 20th century, however, a sort of division of labor arose. Scientists such as Max Planck and Albert Einstein, for instance, were purely theoretical physicists. They made no serious attempts to carry out experiments but instead confined their work to seeking general principles illuminating wide areas of nature.

One aim of theoretical **physics** is to determine implications of well-known laws, such as those of quantum mechanics, for specific physical systems. On a higher level, theoretical physicists look for general laws that encompass a variety of phenomena and predict new phenomena based on such laws. Triumphs of theoretical **physics** along these lines include James Clerk

Maxwell's theory of electromagnetism, which predicted radio waves, and Paul Dirac's relativistic quantum theory, which predicted antiparticles (see antimatter). Theoretical physicists often make use of advanced mathematics in their work as a help in determining the consequences of their theories or sometimes, as with general relativity, to guide them to the proper form of the theories.

Simulations

More recently, a new technique has been introduced in some areas of **physics**: computer simulation (see computer modeling), which shares attributes of both theory and experiment. In simulations of complex experimental phenomena, computers are used to infer what should be observed when certain theories apply. The results are compared with the actual data to see whether the expectations are correct. In simulations of complex theories, a simplified version of the theory is analyzed through computer calculations. The result is used to gain insights into what the full theory implies. The increased use of simulations is blurring the standard distinction between theory and experiment in **physics**.

Basic Ideas of Physics

Discoveries in **physics** have shown that most natural phenomena can be understood in terms of a few basic concepts and laws. Some of these are apparent in everyday macroscopic phenomena, others only in the microscopic world.

Particles

The idea that the world is made up of small objects in motion goes back to ancient Greece and the atomic theories of Leucippus and Democritus. Such objects are called particles. Particles carry some fixed properties, such as charge and mass, and variable properties such as location and energy. Complex objects are combinations of one or more types of particles. Changes in the properties or behavior of complex objects are due to the motions of their component particles through space, or other changes in their variable properties. In quantum theory the fixed properties of different examples of the same particle, such as two electrons, are identical, so that they cannot be distinguished. Quantum theory also assigns novel wavelike behavior to particles.

Space and Time

The concept of space as an arena in which physical objects move is an outgrowth of the ancient idea of a void. Early physicists thought of space as passive, without its own properties. Developments in the Renaissance and thereafter led to the realization that space, as conceived in **physics**, has properties, including those of continuity, geometry, and three-dimensionality. At first these properties were taken as fixed, but Einstein's work made physicists recognize that the properties of space can vary depending on its matter content.

Time, regarded as a flow that exists independent of human perception, seems necessary to allow for physical changes. Early physicists did not attribute properties to time, but it was later realized that such familiar facts as the apparent one-dimensionality of time are statements about an actual entity. Again, in general relativity some properties of time vary with the matter content. Einstein recognized an important connection between time and space in his special theory of relativity, where the estimation of space and time intervals depends on the motion of the observer. The idea was used by Hermann Minkowski to substitute the idea of a four-dimensional space-time continuum for the separate ideas of three-dimensional space and one-dimensional time.

Laws of Motion and Evolution

Many physical laws describe how systems change with time. These laws usually are differential equations relating the rate of change of one quantity with respect to other quantities. By solving the equations, the changing quantity at a later time can be calculated in terms of its value and that of other quantities at an earlier time. These are known as initial conditions. The evolution of the system over time can be predicted if the initial conditions are known precisely. This evolution can be extremely sensitive to the initial conditions, and small uncertainty there can rapidly lead to great uncertainty in the system's evolution.

Laws of Conservation and Symmetry

It is as important to know what remains the same as to know what changes. The answer is given by laws that state what quantities remain constant in time as a system evolves. Examples are the laws of conservation of angular momentum and of electric charge. Most conserved quantities, other than energy, have only one form, but the conserved quantity may move from one to another constituent of a system. Conservation laws follow from the fact that the laws describing physical systems remain unchanged when the systems are viewed from different perspectives. Such symmetry considerations play major roles in relativity theory and quantum **physics**, where they are used to constrain laws and infer their consequences.

Fields

The work of 19th-century physicists showed that it is useful to think of electric and magnetic forces between two objects some distance apart as being generated by a two-step process. Each object influences the surrounding space, and this altered condition of space produces a force on the other object. The space in which this influence resides is said to contain an electric or magnetic field. Maxwell was able to summarize all of the theory of electromagnetism in terms of four equations describing the mutual effects of electric charges and magnetic fields. One implication of his work was that fields can become detached from the charges that produce them and travel through space (see electromagnetic radiation). In the 20th century a union of field theory with quantum mechanics led to quantum field theory, the most fundamental description of nature now available.

Statistical Averages

For systems containing many elementary objects, the mathematical problems of solving the equations of motion are prohibitive. An alternative method often employed involves calculating only the average behavior of the constituents. This approach is used in the branch of **physics** known as statistical mechanics, developed in the late 1800s by Maxwell, Ludwig Boltzmann, and Josiah Willard Gibbs. They showed that many of the results of thermodynamics, previously an independent subject, could be inferred by applying statistical reasoning to the Newtonian mechanics of gases. Statistical mechanics has also been applied to systems described by quantum theory, where the type of statistics used must recognize the indistinguishability of identical subatomic particles.

Quantization

In prequantum **physics**, physical quantities were assumed to have continuously variable magnitudes. For many quantities this is now recognized to be an illusion based on the large size of ordinary bodies compared with subatomic particles. In quantum theory, some quantities can only take on certain discrete values, often described by simple integers. This discreteness, as well as the mathematical rules enforcing it, is known as quantization. Usually a quantum description of a system can be obtained from the corresponding Newtonian description by adding suitable rules of quantization.

Current and Future Physics

Physics continues to be extended in many directions. The evolution of complex systems and the development of order are areas of current concern. The relation between the early universe and the properties of subatomic particles is another active field of study (see cosmology). Attempts to replace quantum field theory with some new description are under serious consideration, in the hope that they will allow general relativity to be merged with quantum theory (see grand unification theories). At the same time, new experimental techniques such as the scanning tunneling microscope (see electron microscope) are allowing physicists today to observe matter at the atomic level.

Gerald Feinberg

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See also: astronomy and astrophysicsbiophysicsgeophysicsnuclear **physics** physical chemistryplasma **physics** solid-state **physics**

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Name: ___________________________ Date: ___________________________

Physics Vocabulary

1. A substance that does not allow for the flow of electricity is referred to as a _________.
   a. regulator
   b. conductor
   c. insulator

2. Conductor
   a. holds many components
   b. incomplete circuit
   c. material that allows electricity to flow

3. ___________ is the release of nuclear particles and energy from unstable atomic nuclei.
   a. Superposition
   b. Indexing
   c. Radioactive decay
   d. Radiometric dating

4. The unit most commonly used to measure sound is the _________.
   a. centimeter
   b. decibel
   c. meter

5. The ____________ are regions where the magnetic force exerted by a magnet is strongest.
   a. anodes
   b. magnetic poles
   c. magnetic field lines
   d. cathodes

6. What force holds the atmosphere to Earth?
   a. centrifugal force
   b. gravity
   c. radioactive decay
   d. atmospheric pressure

7. What is force?

8. What is the difference between Distance and Displacement?

9. Motion is

   a. the push or pull of an object.
   b. a force that works against motion.
   c. a model built by an engineer.
   d. when an object changes position.

10. When a wave "bounces back", it is called _________.

   a. refraction
   b. reflection
   c. reverberation
   d. vibration

11. During _________, a light ray changes direction as it passes from one material to another.

   a. refraction
   b. reflection

12. Acceleration is the

   a. rate of change in momentum.
   b. rate of change in speed.
   c. rate of change in velocity.
   d. amount of time needed for an object to reach its destination.

13. The point in a longitudinal wave where the particles are closest together is called _________________. The point where they are farthest apart is called _________________.

14. What physical property is the ratio of the mass of a substance divided by its volume?

15. Choose 5 of the science vocabulary words on this worksheet and write a paragraph that utilizes those words in the proper context. Underline or highlight the words you use.

Energy

Lexile

Energy is the ability to do work. However, to understand **energy** we must understand what scientists mean by "work." It might seem that it is work to try to solve a problem or to stand at attention for 15 minutes. But that is not "work" to a scientist.

In science, work is motion against resistance. Lifting a box against the pull of gravity is work, as is driving a nail into a board against the friction of the wood or winding a clock against the resistance of the spring.

In doing this work (or any other kind), **energy** is used up. Both work and **energy** are measured according to the distance an object is moved and the force that must be overcome to keep the object moving. Suppose a pound of iron is lifted 1 foot. Then 1 **foot-pound** of work has been performed and 1 foot-pound of **energy** has been used up.

Work can be done in various ways. Each way represents a different kind of **energy**. For instance, you can drive a spike into the ground against the resistance of hard soil by dropping a weight on it. It is the motion of the weight that does the work. (If you placed the weight very gently on the spike, nothing would happen.) The moving weight is said to have **kinetic energy.** ("Kinetic" comes from a Greek word meaning "motion.")

Suppose you hold the weight high above the spike. As soon as you let go, it starts falling and becomes capable of doing work. While you are actually holding it, however, the ability to do work is only potential. That is, the ability can exist in the future but does not in the present. A weight held high in the air possesses **potential energy.**

In the same way, a rubber band that is stretched and held has potential **energy**. If the hold is released, the rubber band contracts. It possesses kinetic **energy** while it is contracting. Kinetic **energy** and potential **energy** can be lumped together as **mechanical energy.**

Imagine now that you have a corked glass flask with a little water at the bottom. On heating the flask, the water boils and begins to turn into steam.

The steam pressure builds up as a kind of potential **energy** and then turns into kinetic **energy** when the cork flies out with a loud pop. The cork was moved against the friction of the neck of the flask (which was holding the cork in place). This motion against a force is work. The motion was caused by the heat that formed the steam. This is known as **heat energy.**

A magnet can lift a nail against gravity. Sometimes an electric current is passed through wires wound around an ordinary iron bar. This changes the bar into an electromagnet that will lift a nail against gravity. When electricity and magnetism do work in this way, they are known as **electric energy** and **magnetic energy.**

In any chemical compound there are attractions that hold atoms in place, against their own natural tendency to move about. This is a kind of potential **energy**, like that of a stretched rubber band. (All kinds of **energy** can be stored as potential **energy**.) If anything happens to break the attraction, the result can be an explosion, like that of dynamite. Atomic attractions represent **chemical energy.**

At the center of every atom is a nucleus. The nucleus is made up of smaller bits of matter called subatomic particles. The attractions that hold the subatomic particles together are even stronger than those that hold atoms in place. When these nuclear attractions are released, the result is a far more powerful explosion than that of dynamite. Atomic bombs owe the violence of their explosions to **nuclear energy.** (Sometimes nuclear **energy** is called **atomic energy** because it is obtained from atoms. But this is not a good choice of words because other forms of **energy** can also be obtained from atoms. For example, chemical **energy** also comes from atoms. But it comes from reactions outside an atom's nucleus. "Nuclear **energy**," therefore, is a more accurate name for the source of the atomic bomb's explosion.)

Sound and light can be made to do work as **sound energy** and **light energy.** Rays of light, or light waves, are a form of radiation. Radio waves, heat, X rays, radar waves, and ultraviolet rays are other types of radiation. All these radiations, which are transmitted as waves, travel at the speed of light and represent **radiant energy.**

The radiant **energy** from the sun travels some 93,000,000 miles (150,000,000 kilometers) to the earth. Light from the sun that can be collected and converted into usable **energy** is called **solar energy.**

Measuring Energy

One kind of **energy** can always be changed into another. Electric **energy**, for example, is changed into magnetic **energy** in an electromagnet. On the other hand, magnetic **energy** is changed into electric **energy** in a generator.

When wood is burned, the atoms in wood are pulled apart and combined with oxygen in the air. The new combinations contain less chemical **energy** than the old ones did. The **energy** left over appears as flame and is felt as heat. In this way chemical **energy** is turned into heat **energy** and light **energy**. Electricity can be changed into heat **energy** and light **energy**, as in an electric light. Kinetic **energy** can turn into heat through friction, as when a fire is started by rubbing one stick against another.

All kinds of **energy** are very easily changed into heat, which is the simplest and most basic kind of **energy**. Heat is measured in units called **calories.** A calorie is the amount of heat needed to raise the temperature of 1 gram of water (about $^{1}/_{28}$ ounce) 1 degree Celsius. One thousand calories is a **kilocalorie,** or simply Calorie, with a capital "c."

Because all other forms of **energy** can be changed to heat, **energy** is often measured in terms of heat. For example, the chemical **energy** in food is measured in kilocalories. However, food **energy** is most often expressed simply as "calories," even though "kilocalories" is meant.

The Conservation of Energy

Sometimes it looks as though **energy** disappears. If the heat under a kettle of boiling water is turned off, the water will slowly cool down to room temperature. What has become of the heat **energy**? It has not disappeared—it has just spread out through the air.

A bouncing ball hits the floor and rises again. But each time it falls short of the height it reached the time before. Finally it dribbles along the ground and stops. What has happened to its kinetic **energy**? It has not disappeared. Some of the kinetic **energy** was used in pushing the air aside as the ball moved. That part of the **energy** was turned into heat. The rest of the **energy** heated up the ball and the ground it struck. Slowly all the kinetic **energy** turned into heat, and that heat spread outward through the air and ground.

In all such cases, **energy** never disappears. It changes from one form to another and always ends up as heat. But it never disappears.

Furthermore, **energy** never appears out of nowhere. A weight at the top of a pile driver has a great deal of potential **energy**. (A pile driver is a machine that drives piles—long columns used to support buildings or other structures—into the ground.) But before the weight gained that **energy**, it had to be lifted upward. **Energy** from an internal-combustion engine did the work required to lift it. The chemical **energy** of the fuel burned inside the engine was turned into the potential **energy** of the weight.

Even the sun's radiant **energy** comes from somewhere. It is produced by combinations and breakups of subatomic particles deep inside the sun. Sunlight is an example of nuclear **energy** being changed into radiant **energy**.

In fact, it is a general rule that **energy may be changed from one form to another, but it is never created and never destroyed.** This is called the **law of conservation of energy.** It is also sometimes called the **first law of thermodynamics.** (Thermodynamics is the study of **energy** in all its forms.)

Still, **energy** has a tendency to even out. Heat spreads out in all directions, causing hot things to cool down. Whenever **energy** is changed from one form to another, or whenever **energy** is turned into work, some **energy** is changed into heat. The heat spreads out evenly.

When **energy** is spread out completely evenly, it cannot be turned into work. It is still there; it has not disappeared. But it cannot be used. This spreading out evenly and loss of available **energy** is called **entropy** by scientists. Every process occurring in the world leads to **energy** spreading out more and more evenly. Thus the amount of entropy in the universe is always increasing. This basic law of nature is sometimes called the **second law of thermodynamics.**

Fortunately, it will be billions upon billions of years before all the **energy** in the universe is spread out completely evenly.

Energy and Life

Living things make use of **energy**, too. A human being uses up thousands of kilocalories of **energy** every day. Even if a person just lies quietly in bed, the heart must beat and move the blood. The chest must lift as the person breathes, and so on.

This **energy** must come from somewhere. The law of conservation of **energy** is true for living things as well as for nonliving things. **Energy** cannot be made out of nothing.

Our **energy** comes from the chemical **energy** in food. Food contains substances in which many carbon atoms are attached to hydrogen atoms. This carbon-hydrogen attachment contains considerable chemical **energy**. In the body the carbon-hydrogen attachment is broken and both kinds of atoms are attached to oxygen atoms. (In this way carbon dioxide and water are formed.)

The carbon-oxygen and hydrogen-oxygen attachments contain far less chemical **energy** than the original carbon-hydrogen did. The chemical **energy** left over is used to carry out the functions of the body. It is turned into other forms of chemical **energy** in building up our tissues. It is turned into kinetic **energy** when we move our muscles. It is turned into electrical **energy** in our nerves. It is turned into sound **energy** in our voice box.

In using **energy** we do not destroy it; we can only change it. We turn it into heat, which can radiate away as the infrared variety of radiant **energy**. To get rid of the heat even faster, we perspire. The liquid perspiration is turned into vapor by our body heat. In this way heat **energy** is turned into chemical **energy**, for water vapor contains more chemical **energy** than liquid water does. And when the vapor moves away, it carries that **energy** with it. On hot, muggy days, when the perspiration will not change into vapor, we become very uncomfortable. The reason is that we cannot get rid of the **energy** after we are through using it.

The Food Chain

All human beings eat food and make use of the chemical **energy** in it. All other animals do the same. Where does all the chemical **energy** come from and why doesn't all the food get used up? The answer is that new food is being formed as old food is used up. Green plants form the new food. Animals either eat the plants or eat other animals that have eaten plants.

Chlorophyll, the green substance in plants, can absorb sunlight. When it does so, it changes the radiant **energy** of the sun into chemical **energy**. The chemical **energy** present in sunlit chlorophyll is used to combine carbon dioxide in the air with water from the soil. Starch and other complicated compounds are formed. These are high in chemical **energy** obtained from the sunlit chlorophyll. They make up the food on which people and all other animals live. In the process of forming this food, some oxygen atoms are left over. These are given off into the air by plants. The whole process is called **photosynthesis.**

Thus, plants use sunlight to form food and oxygen from carbon dioxide and water. And animals combine food and oxygen to form carbon dioxide and water again. Plants change the radiant **energy** of the sun into chemical **energy**, and animals change the chemical **energy** into kinetic and heat **energy**.

Sources of Energy

In prehistoric times people used only the **energy** their bodies obtained from food. Then, after they had learned to use fire, they changed the chemical **energy** of wood into heat and light. This enabled them to see at night, live in cold lands, cook food, and obtain meals from ores. Without fire, there could have been no civilization.

The chemical **energy** in wood comes from the radiant **energy** of the sun because wood is formed by plant life as a result of photosynthesis. The **energy** in coal, oil, and natural gas also comes from the sun. Most scientists believe that these **fossil fuels** were formed from the remains of ancient plants and animals that fed on plants.

Ancient people learned to use the kinetic **energy** of the winds and flowing waters to drive windmills and waterwheels. Indirectly they were again using the sun's **energy**. Air rises when it is heated by the sun. As cold air moves in to take its place, we get a wind. The sun also heats ocean water, turning it into vapor, which rises into the atmosphere. The vapor condenses, falls as rain, and runs downhill in streams.

In the 1700's the chemical **energy** in fuels was put to use in steam engines to drive machines, locomotives, and ships. Steam supplied cheap **energy** on such a large scale that it began the Industrial Revolution.

Toward the end of the 1800's, internal-combustion engines were built in which liquid fuels such as gasoline were burned. These devices made automobiles and planes practical. In the 1800's, electric generators also were developed. Generators contain coils of wire. When these coils are turned at high speed by waterpower, engines, windmills, or other devices, electricity is produced. Electricity from generators is the world's major **energy** source.

In the mid-1900's, nuclear **energy** was produced by the fission (splitting) of atoms. But problems with nuclear **energy** plants have raised questions about the immediate expansion of fission as an **energy** source. Research is being done on nuclear **energy** from the fusion (union) of atomic matter. Because fusion can be fueled by elements found in common seawater, it has the potential of being an almost unlimited source of **energy**. But because fusion reactions are difficult to control, some scientists think that it will be many years before fusion becomes a useful **energy** source.

Energy from the sun can be gathered and converted to useful forms of **energy**. However, it has been difficult to produce such **energy** in large amounts and at low cost. Flowing or falling water has long been used by people as an **energy** source. Future use of water power will be limited by the often distant, hard-to-reach locations of large rivers and waterfalls. Wind power is practical only in areas that have strong and steady winds. **Energy** from the rising and falling tides, the motion of waves, and heat within the earth (geothermal **energy**) are all being looked at as possible future **energy** sources. While not an **energy** source itself, **energy** conservation is an important way of helping the earth's fossil fuel supply last as long as possible.

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See also: Electricity; **Energy** Supply; Heat; Light; Nuclear **Energy** ; Photosynthesis; Solar **Energy** ; Sound and Ultrasonics

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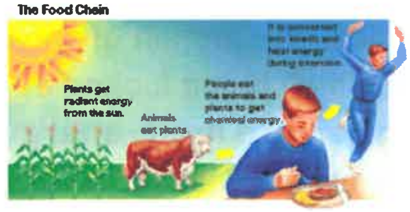
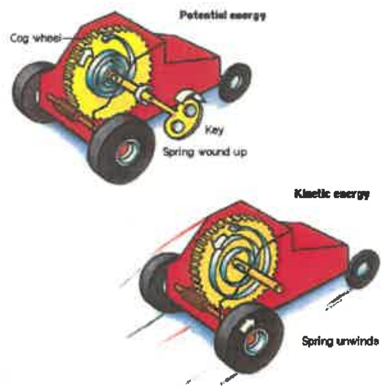
Energy Changes

The Food Chain





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Work and Energy

1. Which of the following is NOT an example of kinetic energy being converted to potential energy?
    a. a basketball player jumping for a rebound
    b. releasing a compressed spring
    c. squeezing a rubber ball
    d. pulling a sled up a hill

2. Which one is doing the most work?
    a. pulling a box 10 m with a force of 100 N
    b. pushing a box 100 m with a force of 200N
    c. pulling a sled 1000 m with a force of 10N
    d. pushing a car with a force of 100000 N and it doesn't move

3. A 100-kg rock is 100 m above the ground, what is the potential energy of the rock?
    a. 100000 J
    b. 86000 J
    c. 45382 J
    d. 98000 J

4. An example of potential energy is
    a. a basketball sitting on a rack.
    b. a bird flying.
    c. Grandma rocking in her chair.
    d. none of the above.

5. A car or truck moving down the highway has _________ energy by virtue of its motion.
    a. kinetic
    b. potential
    c. thermodynamic
    d. chemical

6. Ethan carried a 200 Newton bag 3 meters up a ladder in 30 seconds. How much power did he use?
    a. 2000 Watts
    b. 18000 Watts
    c. 20 Watts
    d. 0 Watts

7. Which situation is an example of increasing potential energy?
    a. a bicyclist stopping at a stop sign
    b. a cat jumping from a tree
    c. emptying a bucket of water
    d. pulling a wagon uphill

8. An arrow in a bow has 70 J of potential energy. Assuming no loss of energy due to heat, how much kinetic energy will it have after it has been shot?
   a. 140 J
   b. 70 J
   c. 50 J
   d. 35 J

9. Imagine an object held at some height above the ground. It is released and falls toward the ground. Ignoring air resistance or friction, which of the following must be true?
   a. Before it falls, all of its energy must be potential energy.
   b. At the end of its fall, all of its energy must be converted to kinetic energy.
   c. During its fall, the combination of its kinetic and potential energy must equal the amount of potential energy with which it started.
   d. All of the above are true?

10. An object with the mass of .1 kg was dropped from a cliff 200 m high. Immediately before hitting the ground, it was clocked to travel with the speed of 40 m/s. Calculate how much energy was dissipated by the air drag.

Name: ____________________________ Date: ____________________________

Types of Energy

1. Energy is
   a. only found in batteries.
   b. never used for fun.
   c. the ability to move or change matter.
   d. none of the above.

2. Any energy that is stored is called _________ energy.
   a. kinetic
   b. cooking
   c. potential
   d. thermal
   e. sound
   f. electrochemical

3. Energy stored in the bonds between atoms is called
   a. kinetic energy.
   b. mechanical energy.
   c. chemical energy.
   d. thermal energy.

4. Friction causes kinetic energy to be converted into
   a. potential energy.
   b. thermal energy.
   c. mechanical energy.
   d. electrical energy.

5. What do solar panels convert radiant energy into?
   a. Electrical energy
   b. Thermal energy
   c. Nuclear energy
   d. Kinetic energy

6. The energy possessed by matter due to its motion is __________.
   a. potential energy
   b. kinetic energy
   c. static energy
   d. none of the above

7. Which form of energy does a plant store when light is transformed during photosynthesis?
   a. chemical energy
   b. thermal energy
   c. mechanical energy
   d. electrical energy

8. A car or truck moving down the highway has _________ energy by virtue of its motion.
   a. kinetic
   b. potential
   c. thermodynamic
   d. chemical

9. A football player running for a touchdown exemplifies __________.
   a. mechanical energy
   b. thermal energy
   c. chemical energy
   d. radiant energy

10. A generator converts mechanical energy to _________ energy.
   a. heat
   b. electrical
   c. radiant
   d. chemical

11. A student placed one hundred dominoes upright in a row. He knocked over the first domino and the rest all fell over; one after another. What made the domino at the end of the row move?

a. chemical energy
b. heat energy
c. mechanical energy
d. electric energy

12. An example of the transformation of energy is

a. energy changing from potential to kinetic.
b. energy changing from radiant to electrical.
c. energy changing from chemical to thermal.
d. all of the above.