

Physics

by Emma Kisner

Work, Power & Machines



Have you ever wondered what work looks like? Can an object ever work on its own? How is power started? What is a simple machine? How do simple machine works in a compound machine? Come along and discover more about work, power and machines.

Work



Section Content

1. Define work.
2. What effort is required to create work?
3. A force does work.
4. A force does no work.
5. Equation for work.
6. SI unit for work.
7. How you calculate work.
8. Examples of work.



Work is accomplished when a force acts upon an object in the **direction** the object is moving toward. Example of this include dragging a chair across the room, or rolling a bowling ball down the lane.

Work requires two things to be considered work. First, it needs **motion**. Without motion there is no force. No force, no motion. Second, work depends on the direction the object is

moving. If the force and the direction of the object do not act in the same relative direction, then, there is no work performed on this object.

There are three different outcomes with work. 1). Force and motion in same direction. 2). No work as a result of force but no motion. 3). A lifting force does not move in the direction of motion.

Types of Work

These three images all represent different types of work.



Image “A”, does do work because the force and motion move in the same direction.



Image “B” shows force but no motion since the force is going in two different directions.

Image “C” does no force is progressing that the motion.



work at all because the in a different direction

If any part of a force direction then no on the object.

not act in the same work is accomplished

Work



Calculating Work

To calculate work, we first need to know several things. One the equation to solve for work, two the unit of work, and three how to use the formula when calculating.

The equation for work is $\text{work} = \text{force} \times \text{distance}$. The work accomplished, is calculated by multiplying the consistent force acting in the direction of the motion of the object by the **distance** that the object advances.

If you do not know the amount of force used, but you have the mass and acceleration of the object you can figure out exactly

how much force. The equation for this is: *mass times acceleration equals the force* used in the object.

Or: force (f) = mass (m) x acceleration (a). Once you know the force you can continue with your equation to discover the unit of work.

The unit of work is found by multiplying force (measured in newtons) by distance (measured in meters). The result is measured in newton-meters, also known as **joules**.

Problem one:

Scientific Calculator



Use this calculator and equation 1 to solve for force. Then use equation 2 to solve for work.

Review 1.1

Question 1 of 5

True or False: Work does not require motion.

☐ A. True

☒ B. False



Check Answer

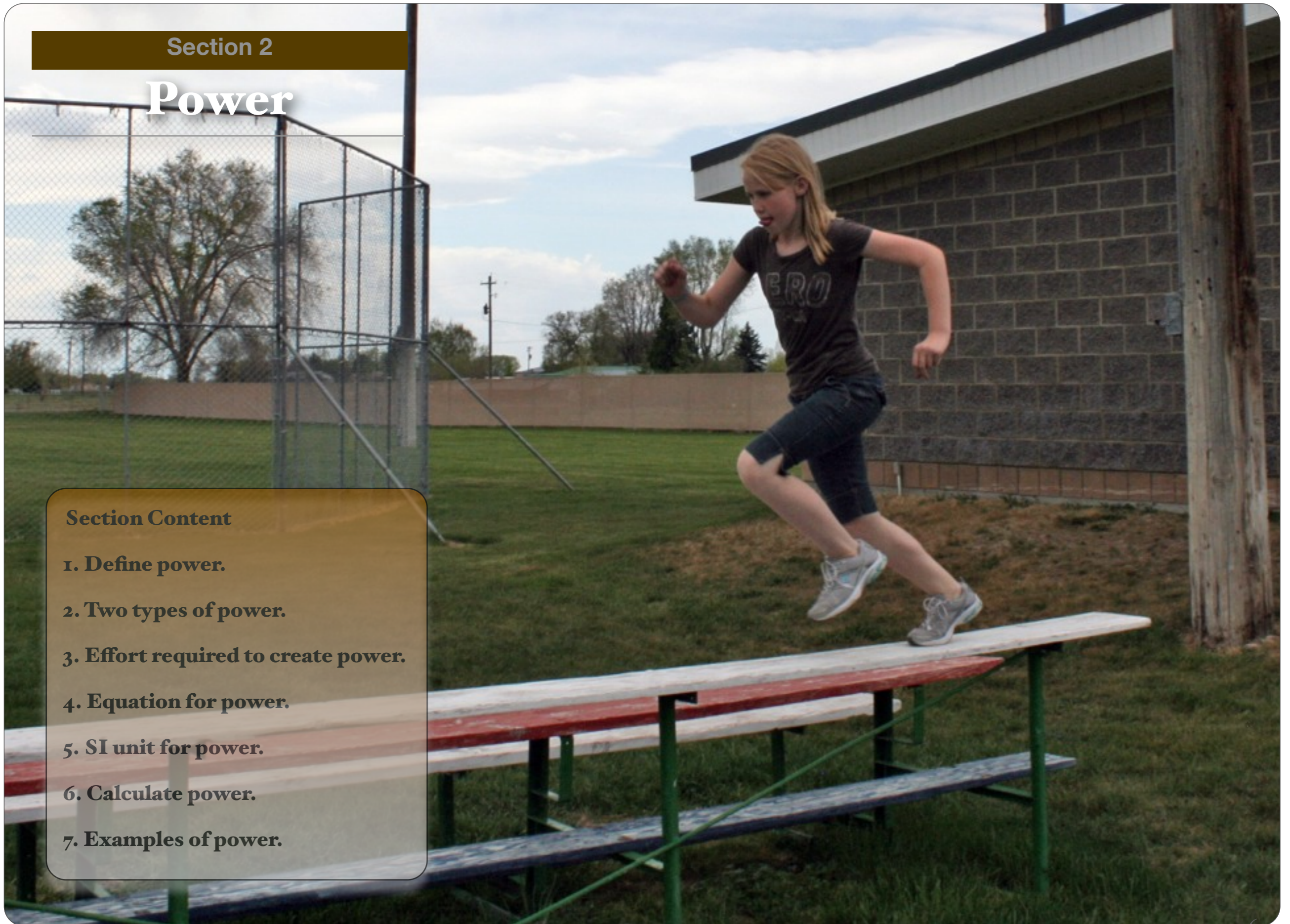


Section 2

Power

Section Content

1. Define power.
2. Two types of power.
3. Effort required to create power.
4. Equation for power.
5. SI unit for power.
6. Calculate power.
7. Examples of power.



Doing more work at a faster pace requires more power. If you increase the power, you can increase the amount of work that is done, that is power.

Power can be faster and is some ways much more efficient. Let's say you have someone shoveling snow from a walkway, and their neighbor has a snowblower. The shovel would need to do more work to shovel all the snow. But the snowblower has more power, so the person using it produces less work to move the snow.

The quantity work has to do with a force causing a displacement. Work has nothing to do with the amount of time that this force acts to cause the displacement. Sometimes, the work is done very quickly and other times the work is done rather slowly.



Lawn mowers are another example of an object with power that requires a user to perform less work.

Work and Power



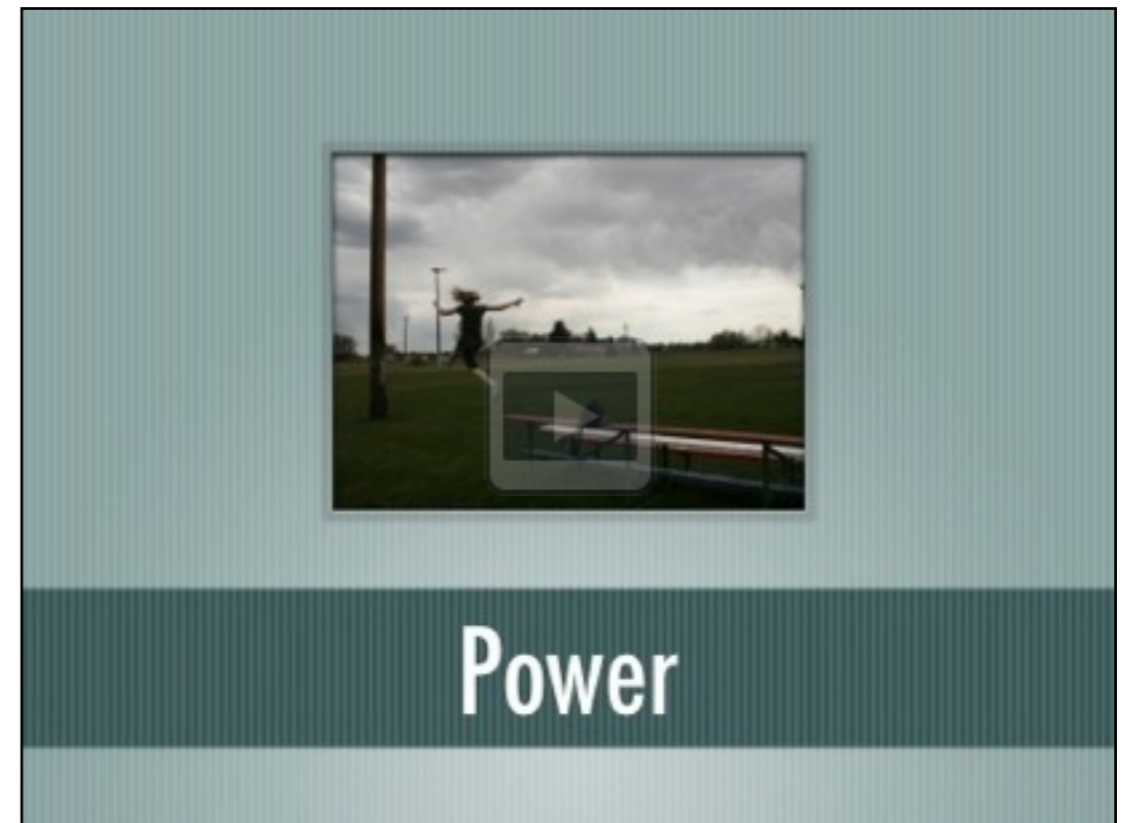
This is a word search for work and power using the vocabulary words in this section

Because most machines are designed and built to do work on objects. All machines are typically described by a power rating. The power rating indicates the rate at which that machine can do work upon other objects. Thus, the power of a machine is the work/time ratio for that particular machine.

A person is also a machine that has a power rating. Some people are more powerful than others.



Power



Another way of explaining it is that some people are capable of doing the same amount of work in less time or more work in the same amount of time. A common physics lab involves quickly climbing a flight of stairs and using mass, height and time information to determine an individual's personal power.



Calculating Power

To calculate power first you need an equation. And the equation is *power equals work divided by time*. Or power (p) = work (w) / time (t).

The unit of power is called horsepower. Horsepower doesn't necessarily involve a horse, but it does involve watts.

Horsepower is a unit of work established by James Watt. He wanted to measure the amount of energy required to raise coal out of a coal mine and he used "horsepower" as the unit of measure.

Watt used this particular term because he estimated that this captured the amount of work an strong horse could perform.

Watt's name is used for another unit of energy — the watt, which is a unit of measure for electricity. Interestingly, horsepower can be converted into watts: 1 horsepower is equivalent to 746 watts.

Horsepower has survived to this day as a way of expressing the power harnessed by automobiles and other engine-driven machines such as tractors and garden equipment. Modern cars typically have 125 to 200 horsepower, but some high-performance cars have upwards of 400 horsepower.

Power



Video

Power

Question 1 of 5

What is power?

- ☐ A. Power
- ☐ B. Work
- ☒ C. Making work easier
- ☐ D. Machines



Check Answer

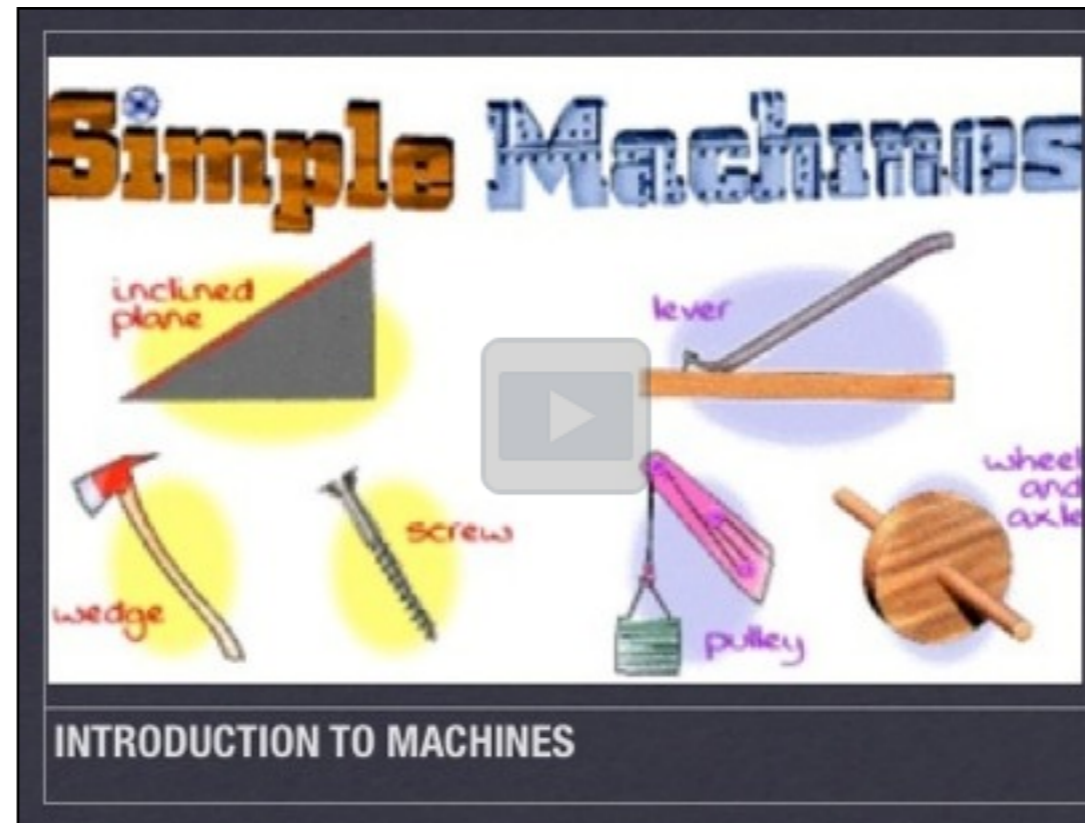


Machines



Section Content

1. Define a simple machine.
2. Different types of machines.
3. How each type works.
4. Examples of simple machines.
5. Define a compound machine.
6. Examples of compound machines.



Simple Machines

Simple machines are tools that make work easier. They have few or no moving parts. These machines use energy to work. Simple machines convert a smaller amount of force exerted over a larger distance to a greater amount of force exerted over a shorter distance, or vice

versa. The concept of simple machine was introduced by the Greek philosopher Archimedes around the 3rd century. There are six types of simple machines. The six types of simple machines are Pulley, Screws, Wedge, Inclined plane, Wheel and axle, Lever. Among these the wheel and axle simple machine is widely used.

Lever

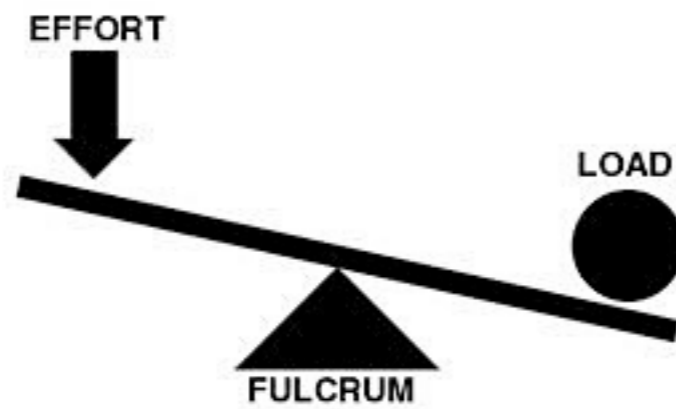
A lever can be anything from, a hammer to a handle on a water pump.

A **lever** is a simple machine made with a straight bar that moves on a fixed point called a fulcrum. A lever can also be looked as a stiff rod that rotates around a pivot point. Downward motion at one end results in upward motion at the other end. Depending on where the pivot point is located, a lever can multiply either the force applied or the distance over which the force is applied.

All levers have two parts, the bar and the fulcrum. The bar is the length of a object as it is pulled and the **fulcrum** is the point of balance.

To visualize a lever, think of a teeter-totter: the center is the fulcrum and the bar is the area you sit on.

Another example is a hammer. With a hammer you have four actions or objects. You have the bar and the fulcrum, of course, you have the load, and the force being administered to the bar. The longer the lever (bar) is, a lower amount of force will be needed to move the load.



Wedge

A wedge can be anything from a heavy axe to a small kitchen knife, to scissors, to a big working shovel.

A **wedge** is made by putting two inclined planes together. They come together to form a V-shape. The wedge is the active twin of the inclined plane. It does useful work by moving. In contrast, the inclined plane always remains stationary. This simple machine consists of a pair of inclined planes set face-to-face, that can sustain relative sliding or rolling motion.

By moving one plane relative to the other, a wedge is capable of building up enormous force in a direction perpendicular to that of the moving wedge. Force multiplication varies inversely with the size of the wedge angle; a sharp wedge (small inclined angle) yields a large force. With adequate friction at the interfaces, the wedge becomes a separating, holding and stopping device with countless mechanical applications.

A wedge may be used to do many things such as, to lift or pry apart heavy objects. A wedge can also be used to stop an object from moving.



A wedge has only one part, and that one part would be, the “wedge” the inclined plane that stops objects, or lifts them up.

Screw

Most often we think of a screw as a small nail-like device that twists into a wall or board, but a screw has many variations: it just must have the required mechanisms.

In one sense, a **screw** is not a "simple" machine at all since it depends upon another machine (the lever) for its operation. Think of it as a twisted wedge that gets its power not from being hit, but from being turned by a lever. In other words, it is a cylinder with an inclined plane wrapped around it.

The longer the screw is the closer the threads of the screw will be and the less force will be needed to move the load.

In the video to the right, see how a grain auger looks like a screw, and listen to the description of how it works.

Grain Auger

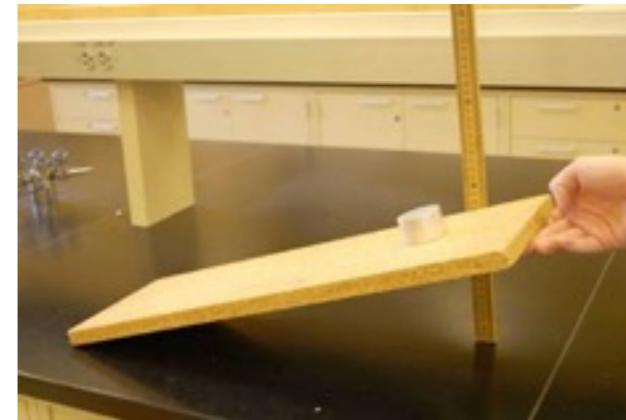


Inclined Plane

Any slanted surface is an inclined plane, although a ramp is the most common type. In simple terms, a ramp is simply a flat surface that is higher at one end than at the other.

An **inclined plane** is a slanted surface that decreases the amount of force needed to move a load.

A plane is a flat surface. For example, a smooth board is a plane. Now, if the plane is lying flat on the ground, it isn't likely to help



you do work. However, when that plane is inclined, or slanted, it can help you move objects across distances. And, that's work! A common inclined plane is a ramp. Lifting a heavy box onto a loading dock is much

easier if you slide the box up a ramp--a simple machine.

The longer the inclined plane is, the less force will be needed to move the load. Because the angle of the inclined plane (ramp) slowly inclines. So the longer it is the smaller the change in the angle.

The only part of an inclined plane is the slanted surface.

Pulley

A **pulley** is a wheel with a rope around it. The rope fits into the groove on the wheel. Because it has a groove, the rope can easily pull a heavy object.

The larger the wheel is, the less force will be needed to move the load because there is more surface area to fill with a larger wheel.

One part of the rope is attached to the load.

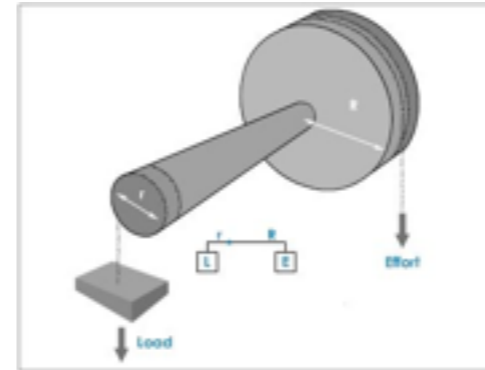
When you pull on one side of the pulley, the wheel turns and the load will move. Pulleys let you move loads up, down, or sideways. Pulleys are good for moving objects to hard to reach places. It also makes the work of moving heavy loads a lot easier. An example of a pulley is the compound bow in the above picture.

The **load** and the force move in opposite directions. First, the load is the object you are trying to move. While the **force**, is how much weight and pressure you putting on the object while moving it.



Wheel and Axle

A **wheel and axle** is made from a wheel that turns on a center post. The two parts to this simple machine are, the wheel and the center post, which is called, the axle.



The wheel, is a wheel basically. Then the center post is the axle, and the axle is the post that holds the two wheels together.

The wheel and axle simple machine is widely used. This looks like a kind of lever. The wheel and axle simple machine is made up of a large

Pulley Video



wheel which is secured to smaller wheel which is called an axle. The wheel is the larger object which turns about a smaller object called an axle. This wheel and axle is a lever that rotates in a circle around a center point or fulcrum. Since the wheel is larger than the axle, it always moves through a greater distance than the axle

The larger the wheel is, the less force needed to move the load. Also, the larger the wheel the more surface area the wheel has. So, the wheel can move faster using of rolling friction.

Compound Machines

Compound machines are machines that are made by using two or more of the six simple machines. The six simple machines being - wedge, lever, pulley, screw, inclined plane, wheel and axle.

Examples of less-complex compound machines include scissors and lighters can be some. Scissors are compound machines because they have a wedge and a lever. The scissor cuts the paper with the parts of the scissor that is sharp as it acts like a wedge

Lighters are compound machines because it has two wheels and a lever. The wheel is the one that helps the stone to scratch with each other and make a hot air. The lever is the one that makes the gas came out by pressing one side of it.

Another example of a compound machine is in the picture below. It's a skid steer, or a bulldozer-like machine. The skid steer has different attachments to do different things. This one has a bucket and a forklift. Its arms use levers to raise and lower the attachments. It also uses a pulley system with the levers. The levers and pulleys allow the forklift attachment to lift extremely heavy loads.



Machines

Question 1 of 5

What is a simple machine?

- ☐ A. A machine with lots of moving parts.
- ☒ B. An object with few or no moving parts.
- ☐ C. An object with lots of moving parts.



Check Answer

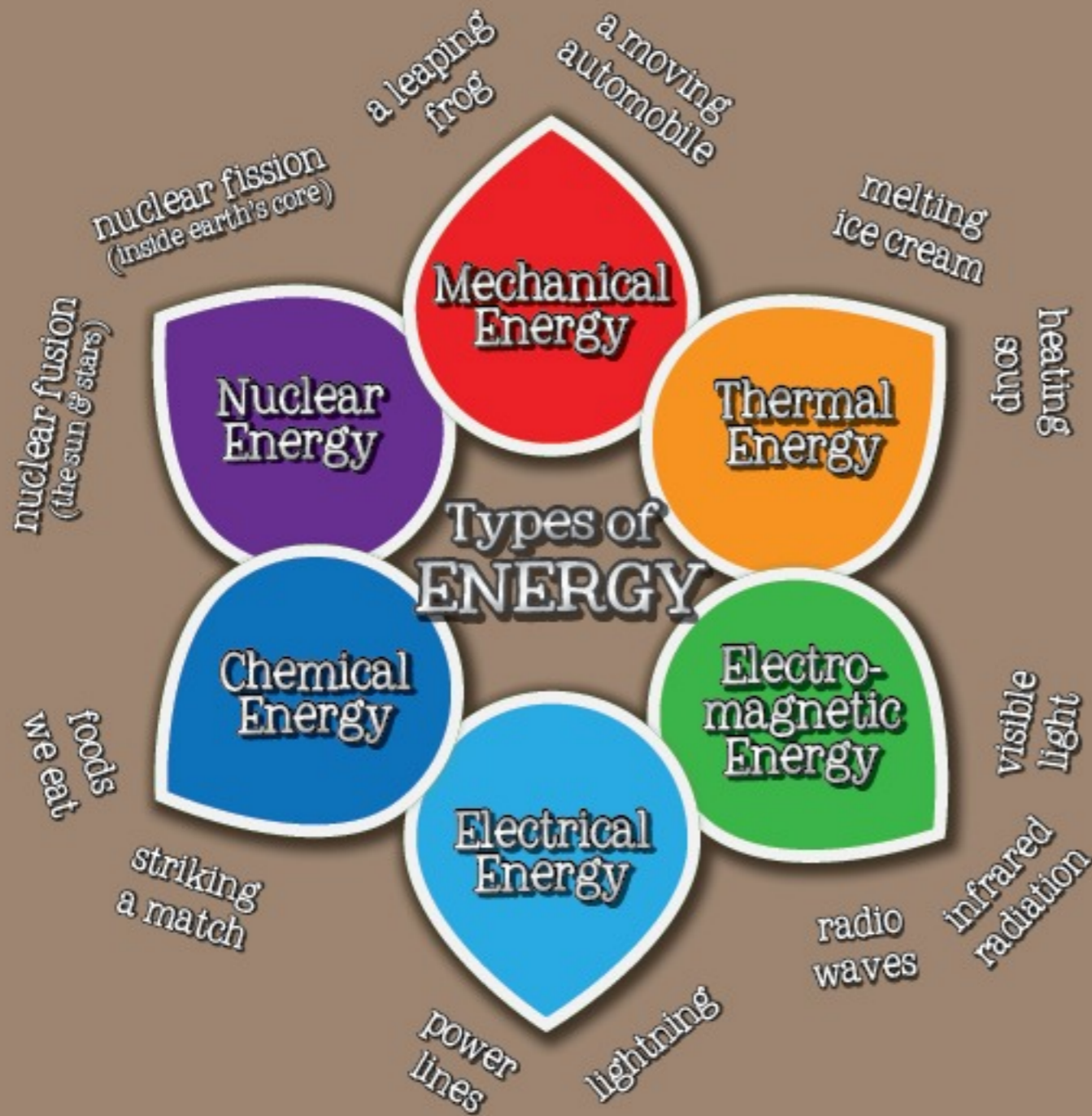


Energy



In this chapter you will learn about seven forms of energy. All seven will be described briefly, and then will go more in depth with three specific types: Kinetic, potential, and nuclear energy. You will explore how energy exists in our everyday life.

The Forms of Energy



Section Content

1. The basic types of energy.
2. A brief description of each type.
3. How the types are similar and different.

The Forms of Energy

There are many types of energy, but they are all categorized into six subsections. These subsections are called mechanical, thermal, chemical, electrical, electromagnetic, and nuclear energy. Each form is related and can be transformed into another form of **energy**.

Mechanical Energy

Mechanical energy is our every day lives, from the positions and motion of objects. This kind of energy is not limited to machines. It is also the sum of potential and kinetic energy. Mechanical energy is not like the other types of energy because it does not involve the motion or arrangement of atoms & molecules.



Thermal Energy

Look around! Matter is all around us, and all matter contains atoms. Atoms are tiny particles that are always moving in random directions. When an object's atoms or particles move faster, its thermal energy increases, because when heated, the particles are moving incredibly fast. So as the atoms gets faster and faster the object starts to emit a glow of light. This glow is shown by the image on the right.



Chemical Energy

Imagine you are camping in the dark. And the only source of light is the warm campfire. But where does the campfire get the energy? The source of energy is stored in the wood, and is called chemical energy. Chemical energy is the energy stored within chemical bonds. Chemical reaction happens when chemical bonds are broken.



Electrical Energy

Electrical energy is the energy carried by moving electrons in an electric conductor. It cannot be seen, but it is one of our most useful forms of energy because it is relatively easy to transmit and use.

All matter consists of atoms, and every atom contains one or more electrons, which are always moving. When electrons are forced along a path in a conducting substance such as a wire, the result is energy called electricity. Electrical generating plants do not create energy. They change other forms of energy into electricity.



Electromagnetic energy

Electromagnetic energy (EME) are waves of electric and magnetic energy moving together through space. EME is emitted by natural resources like the sun, the earth and the **ionosphere**. Radio frequency EME is emitted by artificial sources such as mobile phone base stations, broadcast towers, radar facilities, some types of remote control devices, and electrical and electronic equipment.



Radio frequency EME is a non-ionizing radiation. This means that it is not able to directly impart enough energy to a molecule or atom to break chemical bonds or remove electrons.

Nuclear Energy

Nuclear energy is a source of power which is created from the energy released by a nuclear reaction. The Oracle Education Foundation has an excellent description of this kind of energy: *“The sun and stars are seemingly inexhaustible sources of energy. That energy is the result of nuclear reactions, in which matter is converted*



to energy. We have been able to harness that mechanism and regularly use it to generate power. Presently, nuclear energy provides for approximately 16% of the world's electricity. Unlike the stars, the nuclear reactors that we have today work on the principle of nuclear fission. Scientists are working like madmen to make fusion reactors which have the potential of providing more energy with fewer disadvantages than fission reactors.”

Energy exists all around us in many forms. In each of the following sections you will learn about energy in more detail.

The Forms of Energy



The Forms Of Energy

Question 1 of 4

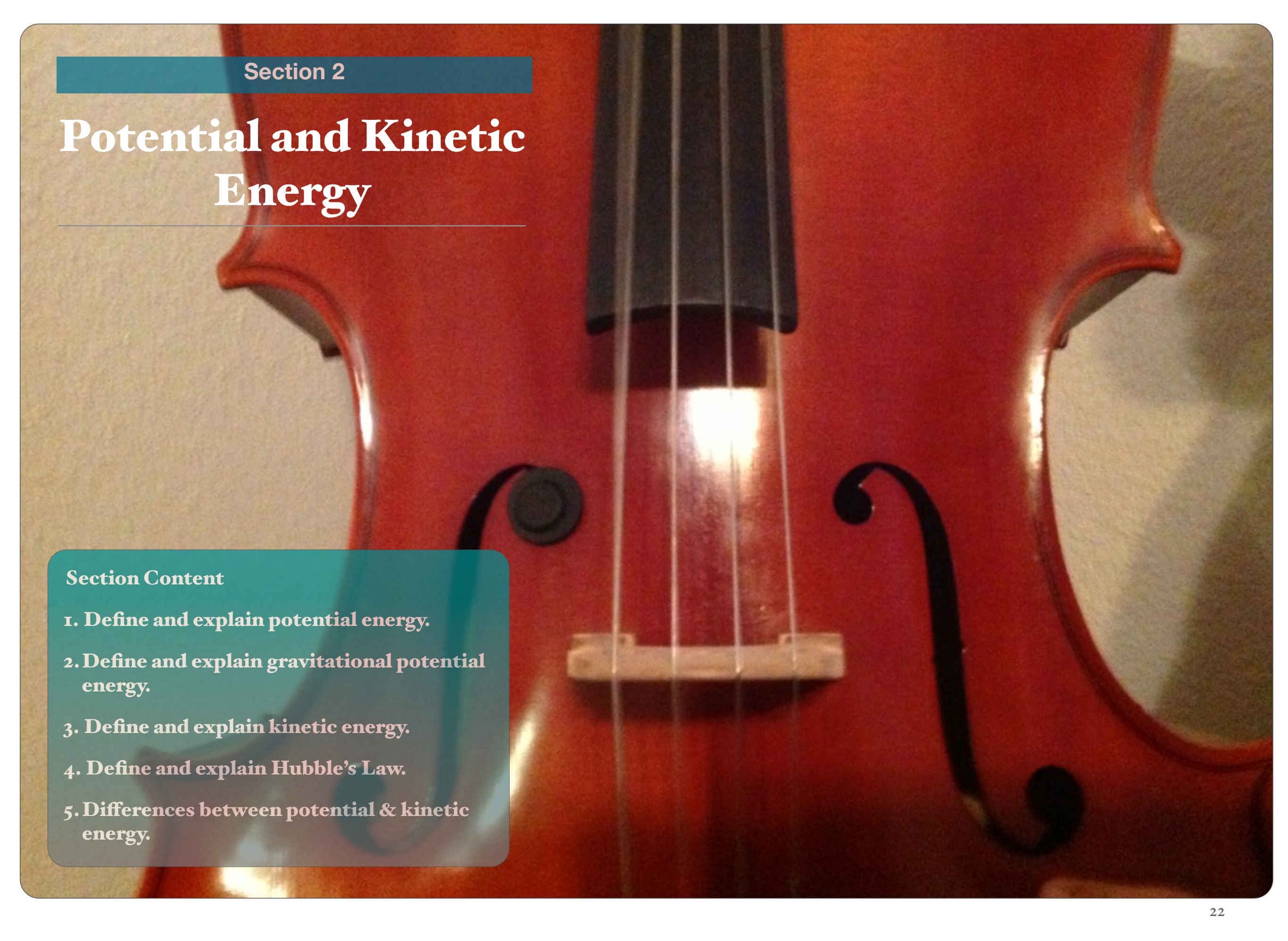
Which form of energy involves radio frequencies?

- ☐ A. Nuclear
- ☐ B. Electrical
- ☐ C. Chemical
- ☒ D. Electromagnetic
- ☐ E. Thermal
- ☐ F. Mechanical



Check Answer





Section 2

Potential and Kinetic Energy

Section Content

1. Define and explain potential energy.
2. Define and explain gravitational potential energy.
3. Define and explain kinetic energy.
4. Define and explain Hubble's Law.
5. Differences between potential & kinetic energy.

Potential Energy

Potential energy is the energy of a particle or system of particles derived from position, or condition, rather than motion.

Any raised weight, coiled spring, or charged battery has potential energy.

An object can store energy as the result of its position. For example, the heavy ball of a demolition machine is storing energy when it is held at an elevated position. This stored energy of position is referred to as

potential energy. Similarly, a drawn bow is able to store energy as the result of its position. When assuming its usual position (i.e., when not drawn), there is no energy stored in the bow. Yet when its position is altered from its usual equilibrium position, the bow is able to store energy because of its position. This stored energy of position is referred to as potential energy. Potential energy is the stored energy of position possessed by an object.



Gravitational Potential

A black hole is a star that has collapsed down to a point. Within a certain radius, known as the event horizon, the escape velocity is greater than the speed of light. Since nothing can exceed the speed of light, anything crossing over the event horizon becomes trapped forever within a black hole.

Black holes destroy volume, but not mass, energy, momentum, charge, etc.

Gravitational potential energy can also be started when someone climbs up a ladder or steps. The energy continues until it is converted to kinetic energy.



Cosmic Expansion

When scientists look at galaxies and other objects outside our own Milky Way they see that those galaxies are moving away from us and that their **recessional** velocities are proportional to their distance. In other words, the farther away a particular galaxy is from us, the faster it's running away from us. If one galaxy is twice as far away from the Milky Way as another, its' speed will also be twice as great. Three times farther away means three times faster, and so on. This observation was first made in

1929 by the American astronomer Edwin Hubble (1889-1953) and it has since become known as Hubble's Law.

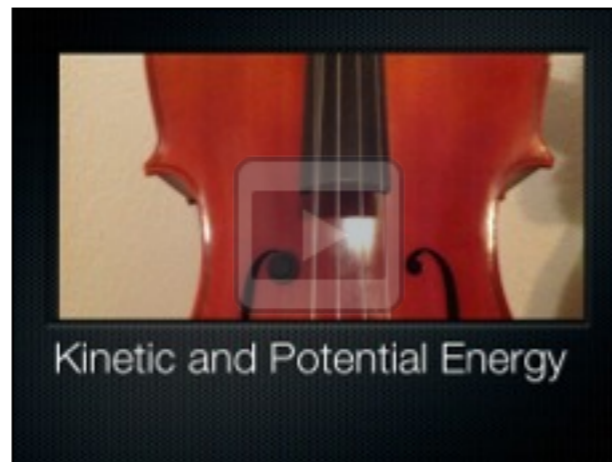
Hubble's Law is important because it tells us that the universe is expanding and if we could move backward in time, the universe was initially very tiny and dense.

Scientists believe that space-time came into being some 13.8 billion years ago, and was filled with all the mass-energy that exists now and will ever exist, and then inflated rapidly from a region far smaller than a proton to one about the size of a grapefruit in an unbelievably small time of 10^{-32} seconds. This initial out rush of space-time filled with mass-energy was carried by its own momentum until the universe grew to the dimensions we currently see — roughly 13.8 billion light years in all directions.

Kinetic Energy

The word “kinetic” is derived from the Greek word meaning to move, and the word “energy” is the ability to move. Thus, “kinetic energy” is the energy of motion -- its ability to do work.

The faster the body moves. the more kinetic energy is produced. The greater the mass and



Video of kinetic and potential energy

speed of an object. the more kinetic energy there will be.

As a train accelerates down the hill the potential energy is converted into kinetic energy. At the bottom of the hill there is a great amount of kinetic energy, and only a small amount of potential energy at the bottom of the hill, but there is a great amount of kinetic energy.

With instruments, like the violin and cello, the air or pressure of these instruments creates potential and kinetic energy,. This is created when you pull the string (potential), and release it (kinetic).



Here is an example of kinetic energy.

Kinetic and Potential Energy

Question 1 of 4

What is potential energy?

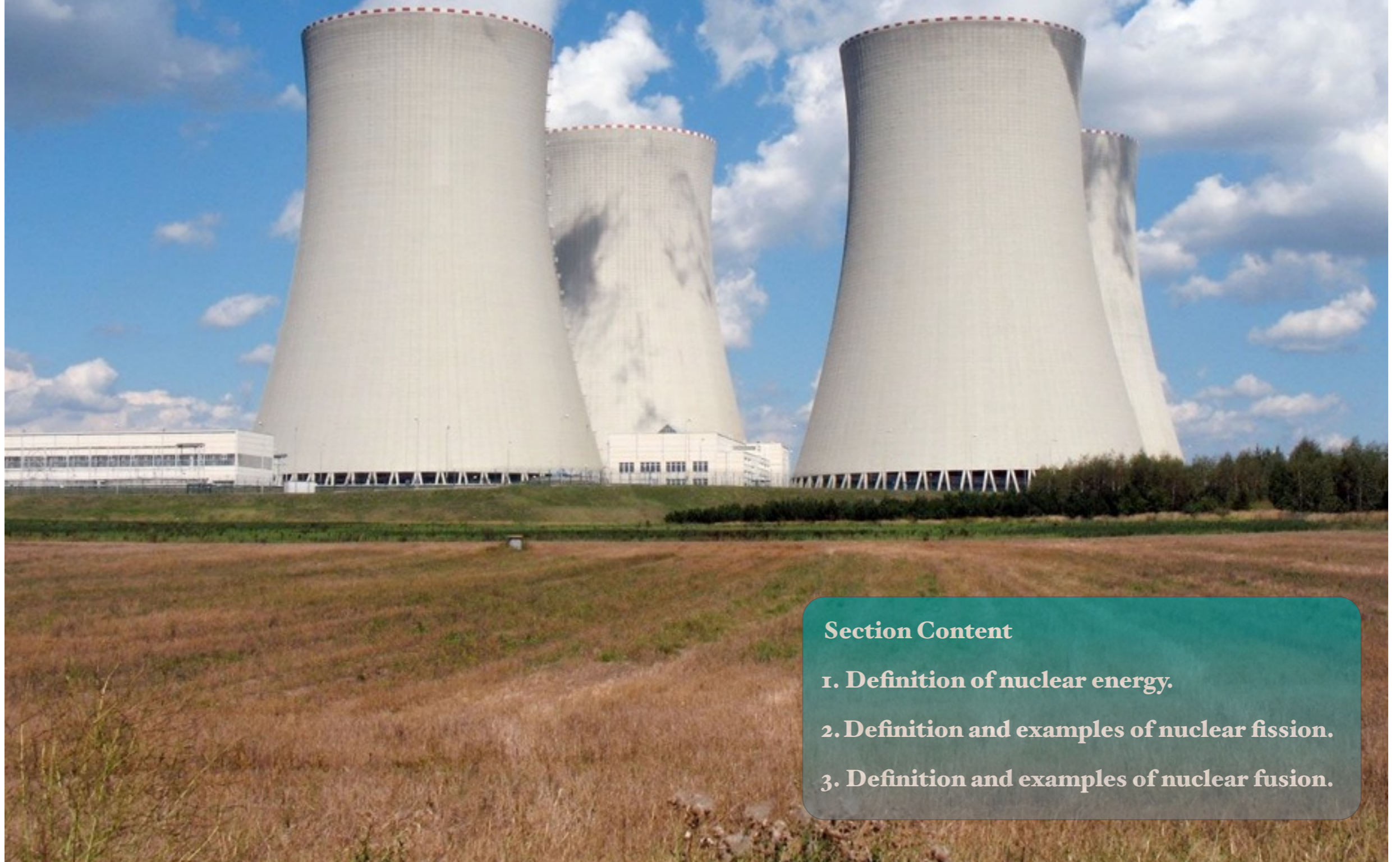
- ☐ A. Gravity
- ☐ B. Movement
- ☐ C. Pace
- ☒ D. Stored energy in an object
- ☐ E. Speed
- ☐ F. Food



Check Answer



Nuclear Energy



Section Content

1. Definition of nuclear energy.
2. Definition and examples of nuclear fission.
3. Definition and examples of nuclear fusion.

Nuclear Energy

Changes can occur in the structure of the nuclei of atoms. These changes are called nuclear reactions. Energy created in a nuclear reaction is called nuclear energy, or atomic energy. Some are made naturally and/or man made.

Naturally: Some nuclear energy is produced naturally. For example, the Sun and other stars make heat and light by nuclear reactions.

Man-Made: Nuclear energy can be man-made too. Machines called nuclear reactors, parts of nuclear power plants, provide electricity for many cities. Man-made nuclear reactions also occur in the explosion of atomic and hydrogen bombs.

Nuclear energy is produced in two different ways, in one, large nuclei are split to release energy. In the other method, small nuclei are combined to release energy. These are called nuclear fission and nuclear fusion.

The picture on the **right** is the universal warning sign, of nuclear energy. These are placed mainly at the gates of nuclear power plant warning about the extreme radiation contained in the area.



Nuclear Fission

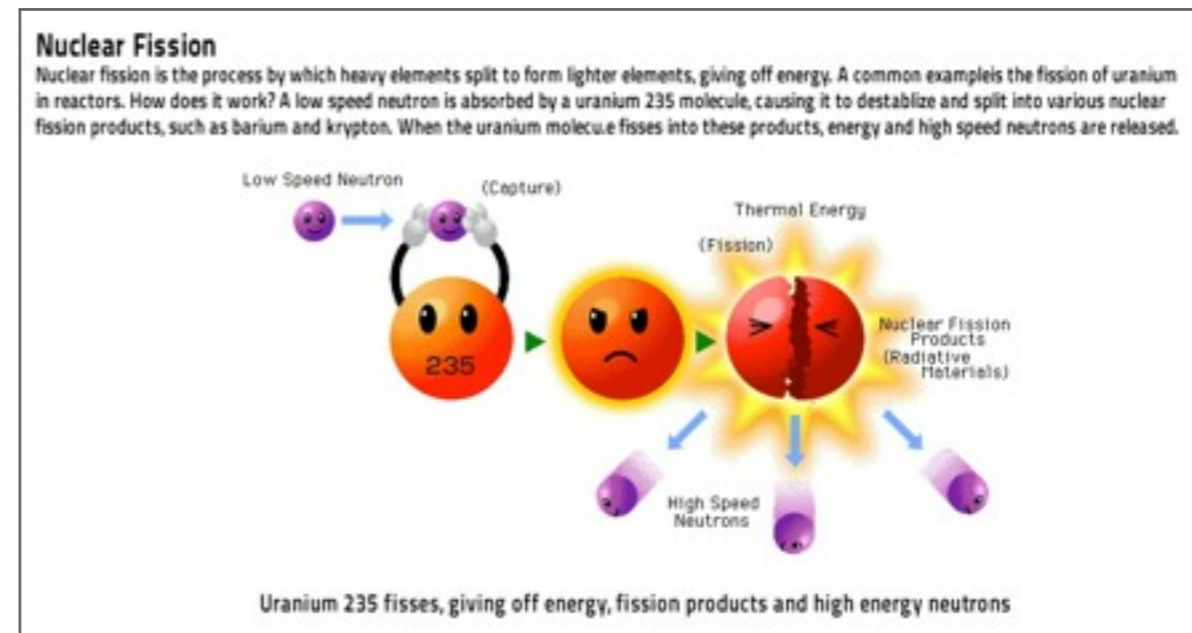
Nuclear **fission** is when the nuclei of atoms are split, causing energy to be released. The atomic bomb and nuclear reactors work



by fission. The element uranium is the main fuel used to undergo nuclear fission to produce energy since it has many favorable properties.

Uranium nuclei can be easily split by shooting neutrons at them. Also, once a uranium nucleus is split, multiple neutrons are released which are used to split other uranium nuclei. This phenomenon is known as a chain reaction.

Nuclear fission is a mature technology that has been in use for more than 50 years. The latest designs for nuclear power plants build on this experience to offer enhanced safety and performance, and are ready for wider deployment over the next few years. There is great



potential for new developments in nuclear energy technology to enhance nuclear's role in a sustainable energy future.

Nuclear Fusion

In nuclear fusion, the nuclei of atoms are joined together, or fused. This happens only under very hot conditions. The Sun, like all other stars, creates heat and light through nuclear fusion. In the Sun, hydrogen nuclei fuse to make helium.

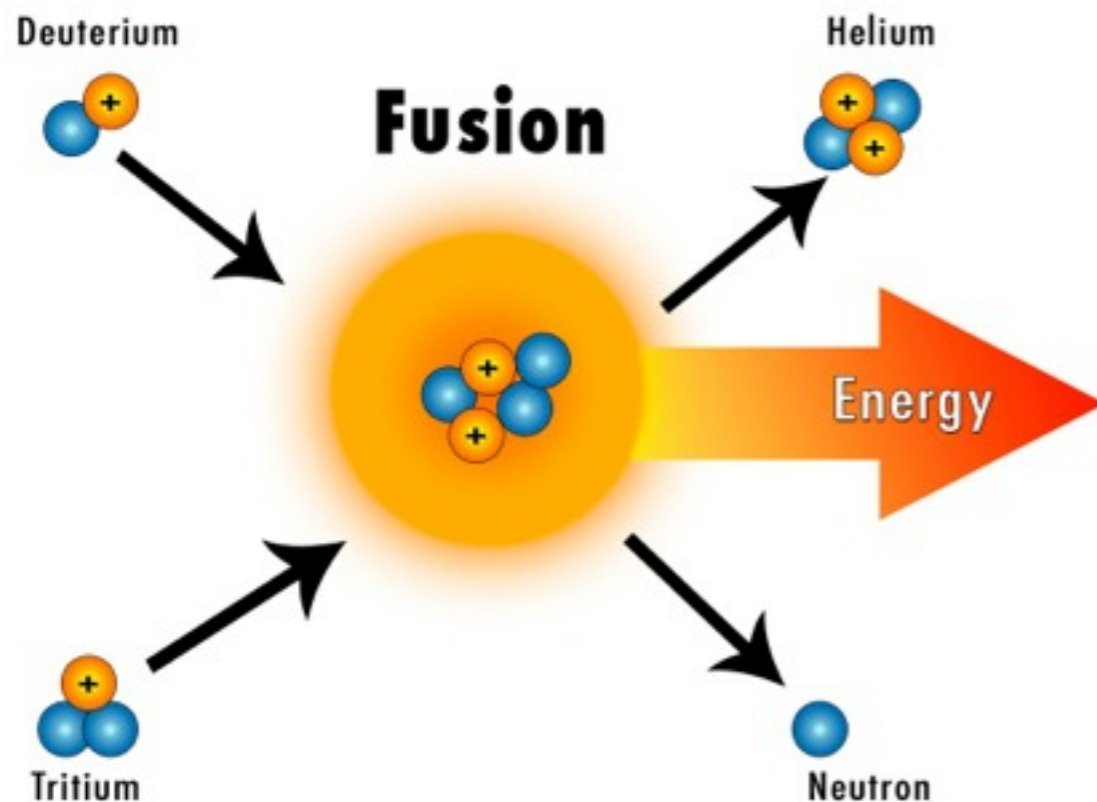
The hydrogen bomb, humanity's most powerful and destructive weapon, also works by fusion. The heat required to start the

fusion reaction is so great that an atomic bomb is used to provide it. Hydrogen nuclei fuse to form helium and in the process release huge amounts of energy thus producing a huge explosion. The heat required to start the fusion reaction is so great that an atomic bomb is used to provide it. Hydrogen nuclei fuse to form helium and in the process release huge amounts of energy thus producing a huge explosion.

When this happens a considerable amount of energy gets released at extremely high temperatures: nearly 150 million degrees Celsius. At extreme temperatures, electrons are separated from nuclei and a gas becomes a plasma—a hot, electrically charged gas.

The fuel (created when deuterium combines with tritium) is abundant; it gives off very little radioactivity; there is no need for underground storage, and there is no environmental risk of high radio-active fuel leakage in case of an accident, the plasma dissipates.

Much more work is needed to achieve deployment of fusion technologies.



Nuclear Energy

Question 1 of 4

True or False: Nuclear energy is NOT dangerous?

☐ A. True

☒ B. False



Check Answer



Section 4

Energy Conservation and Conversion

Section Content

1. Define the conservation of energy.
2. Define the conversion of energy

Energy is a constantly changing variable. Nothing about it is the same. Energy can change its form to another.

Energy Conversion

Energy conversion engineering (or heat-power engineering, as it was called prior to the Second World War), has been one of the central themes in the development of the engineering profession. It is concerned with the transformation of energy from sources such as fossil and nuclear fuels and the sun into conveniently used forms such as electrical energy, rotational and propulsive energy, and heating and cooling.

There are opposing factors to **energy conversion**, however. Among them are limited research and development funding due to budgetary constraints, emphasis on short-term rather than long-term goals because of the governments insistence on rapid payback on investment, and the management obsession with the bottom line. But more open attitudes have become established. New as well as previously shelved ideas are now being considered or reconsidered, tested, and sometimes implemented. A few examples are combined steam and gas turbine cycles, rotary combustion engines, solar and windmill power farms, stationary and vehicular gas turbine power plants, cogeneration, photovoltaic solar power, refuse-derived fuel, stratified charge engines, turbocharged engines, fluidized-bed combust ors, and coal-gasification power

plants. We are living in a rapidly changing world that requires continuing adaptation of old technologies and the development of new ones.

Energy conversion engineering is a more stimulating, complex, and viable field today because of this altered climate.



Energy Conservation

Over 90% of the energy that we use today comes from the burning of non-renewable fossil fuels such as coal, oil, and natural gas. The supply of fuels is limited and yet the demand now and in the future will continue to rise. So if we use energy more efficiently and utilize alternative and renewable resources more often, we will be using good common sense as well as:

- Saving our natural resources
 - Preserving the environment
 - Reducing carbon emissions
 - Preventing oil spills and acid rain
 - Reducing smog and global warming
- Reducing residential energy bills thus creating more disposable income.

The **conservation of energy** is a law that applies to the area of physics, and this law was first developed in the nineteenth century. The principle of the law shows that the total energy amount which is available in a system that



isolated will not decrease over time but will stay constant.

The energy in the system is conserved as time goes on, so that it will not decrease more as time passes. The energy that is in the system may change in form, but this energy can not be destroyed and additional energy can not be created in the system from the initial energy involved.

While energy is conserved in an isolated system, the same is not true of matter. What this means is that any perpetual motion machine must follow the laws of physics.

Windmill Movie



Review 2.1

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- ☒ A. Answer 1
- ☐ B. Answer 2
- ☐ C. Answer 3
- ☐ D. Answer 4

Check Answer

Chapter 3

Waves

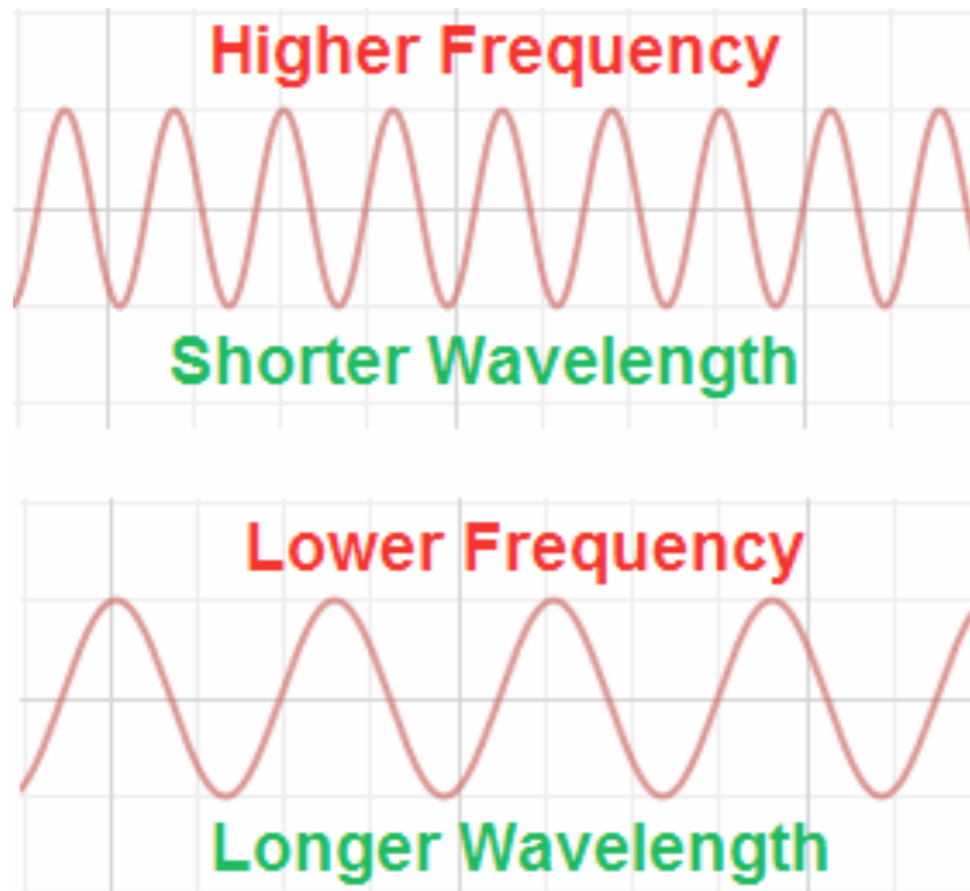
In this chapter you will learn about mechanical and electromagnetic waves, including their properties and spectrums.

Mechanical Waves



Section Content

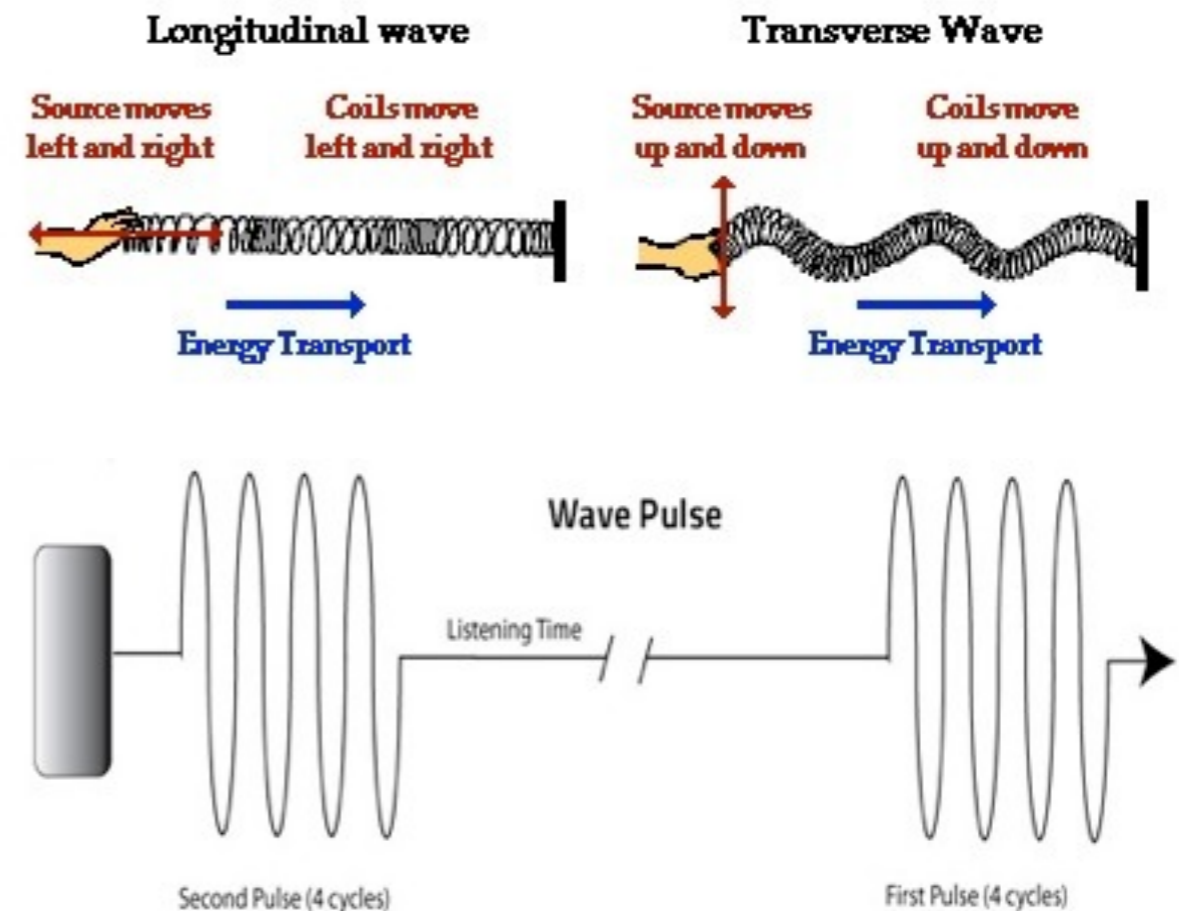
1. Properties of mechanical energy.
2. The behaviors of waves.
3. Properties of sound waves.
4. Practical uses of waves.



Properties of Mechanical Waves

There are five properties of mechanical energy. These properties are called: period, frequency, wavelength, speed, and amplitude. Each property has a different part to the mechanical waves.

There are also mechanical wave motions, like that of water waves, sound waves, and the waves traveling down a spring or rope, requires a medium such as water, air, springs or ropes.



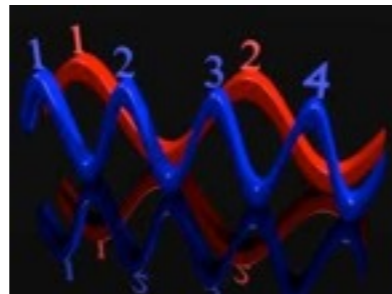
- 🔊 A **transverse wave** causes the particles of the medium to vibrate perpendicularly to the direction of the wave motion.
- 🔊 A **longitudinal wave** causes the particles of a medium to move parallel to the direction of the wave motion.
- 🔊 A **surface wave** is a mixture of transverse and longitudinal waves.
- 🔊 Each wave pulse is a single disturbance through a medium.

Period

The **period** is a motion that occurs periodically, or at a certain time. With any motion that happens at regular intervals is called periodic motion. When the cycle is over and the motion returns to the starting point is a full period. Continuous / Periodic Wave is caused by continuous/periodic disturbance: called **oscillations**.

Frequency

Any and every periodic motion has a frequency. **Frequency** is a number of complete cycles in a certain amount of time that is given. This is measured in **hertz**, and a hertz is cycled by the second.



Speed



The **speed** of an object refers to how fast an object is moving and is usually expressed as the distance traveled per time of travel. In the case of a wave, the speed is the distance traveled by a given point on the wave (such as a crest) in a given interval of time. In equation form, $\text{speed} = \text{distance} / \text{time}$.

If the **crest** of an ocean wave moves a distance of 20 meters in 10 seconds, then the speed of the ocean wave is 2 m/s. On the other hand, if the crest of an ocean wave moves a distance of 25 meters in 10 seconds (the same amount of time), then the speed of this ocean wave is 2.5 m/s. The faster wave travels a greater distance in the same amount of time.

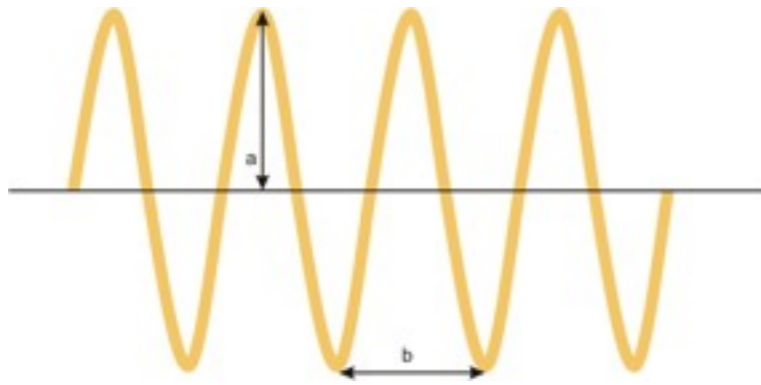


Mechanical Waves

Wavelength

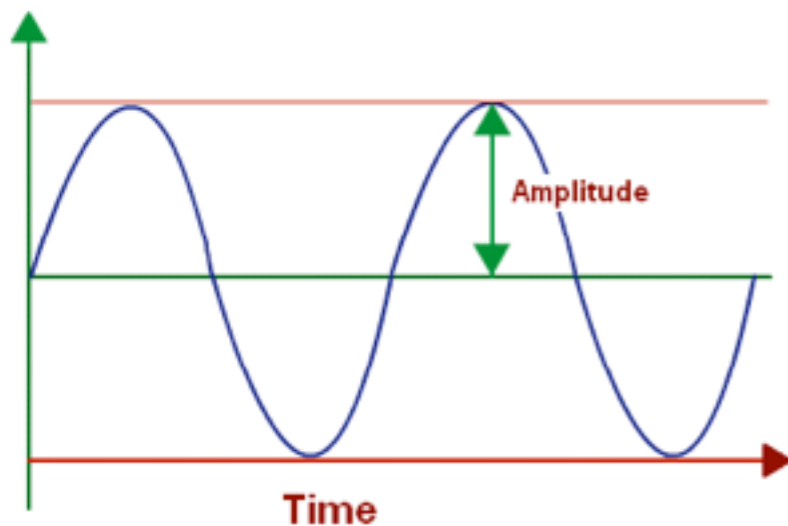
A wave is produced when a vibrating source periodically disturbs the first particle of a medium. This creates a wave pattern that begins to travel along the medium from particle to particle. The

frequency at which each individual particle vibrates is equal to the frequency at which the source vibrates. Similarly, the period of vibration of each individual particle in the medium is equal to the period of vibration of the source. In one period, the source is able to displace the first particle upwards from rest, back to rest, downwards from rest, and finally back to rest. This complete back-and-forth movement constitutes one complete wave cycle.



Amplitude

The amount of energy carried by a wave is related to the amplitude of the wave. A high energy wave is characterized by a



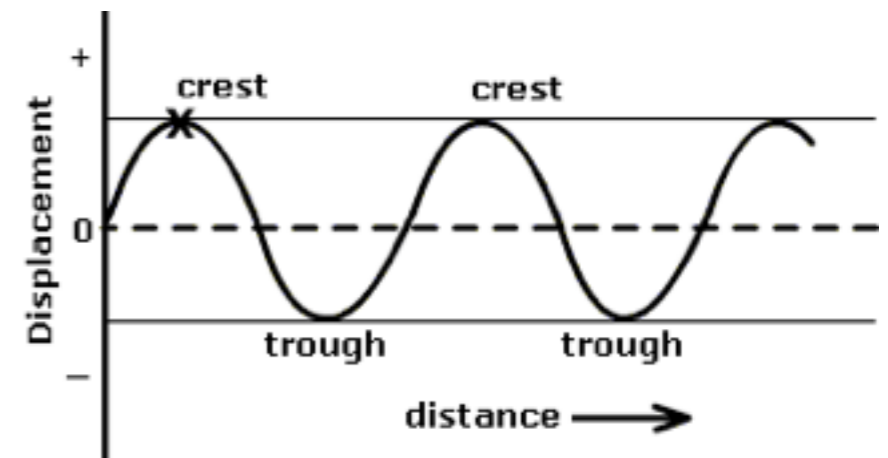
high amplitude; a low energy wave is characterized by a low amplitude.

The amplitude of a wave refers to the maximum amount of displacement of a particle on the medium from its

rest position. Here's another way to describe amplitude using a slinky as the wave.

If a slinky is stretched out in a horizontal direction and a transverse pulse is introduced into the slinky, the first coil is given an initial amount of **displacement**. The displacement is due to the force applied by the person upon the coil to displace it a given amount from rest. The more energy that the person puts into the pulse, the more work that he/she will do upon the first coil. The more work that is done upon the first coil, the more

displacement that is given to it. The more displacement that is given to the first coil, the more



amplitude

that it will have. So in the end, the amplitude of a transverse pulse is related to the energy which that pulse transports through the medium. Putting a lot of energy into a transverse pulse will not affect the wavelength, the frequency or the **speed of the pulse**. The energy imparted to a pulse will only affect the amplitude of that pulse.

Mechanical Wave Quiz

Question 1 of 5

There are five properties to waves. Which one of these is NOT a property

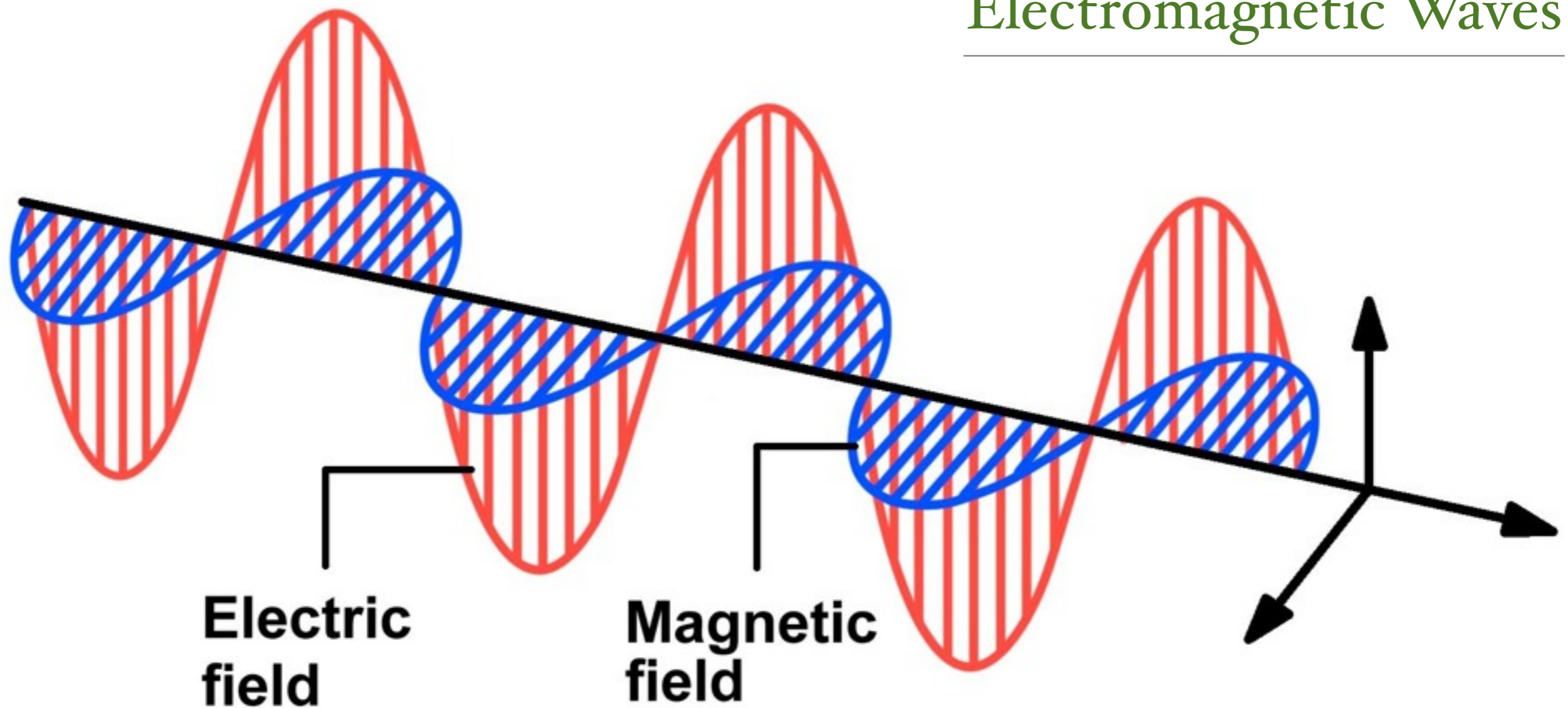
- ☐ A. Frequency
- ☐ B. Period
- ☒ C. Displacement
- ☐ D. Amplitude
- ☐ E. Speed
- ☐ F. Wavelength



Check Answer



Electromagnetic Waves



Section Content

1. Define electromagnetic waves.
2. Define an electromagnetic wave spectrum.



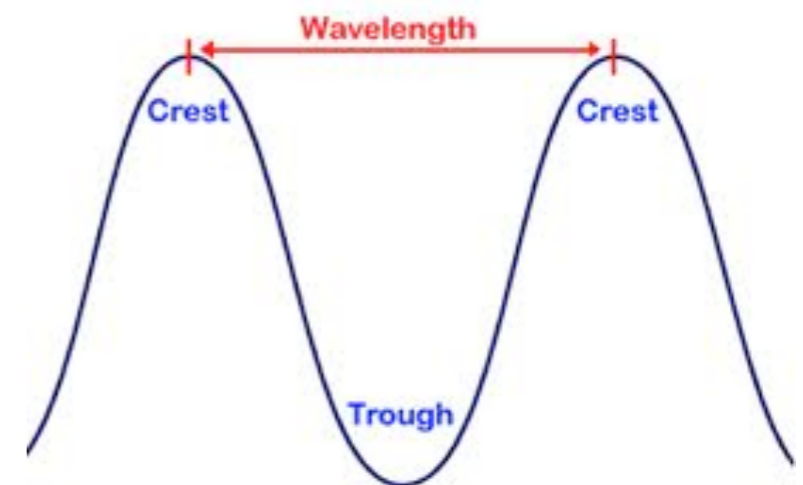
The Waves

Electromagnetic Waves have different wavelengths.

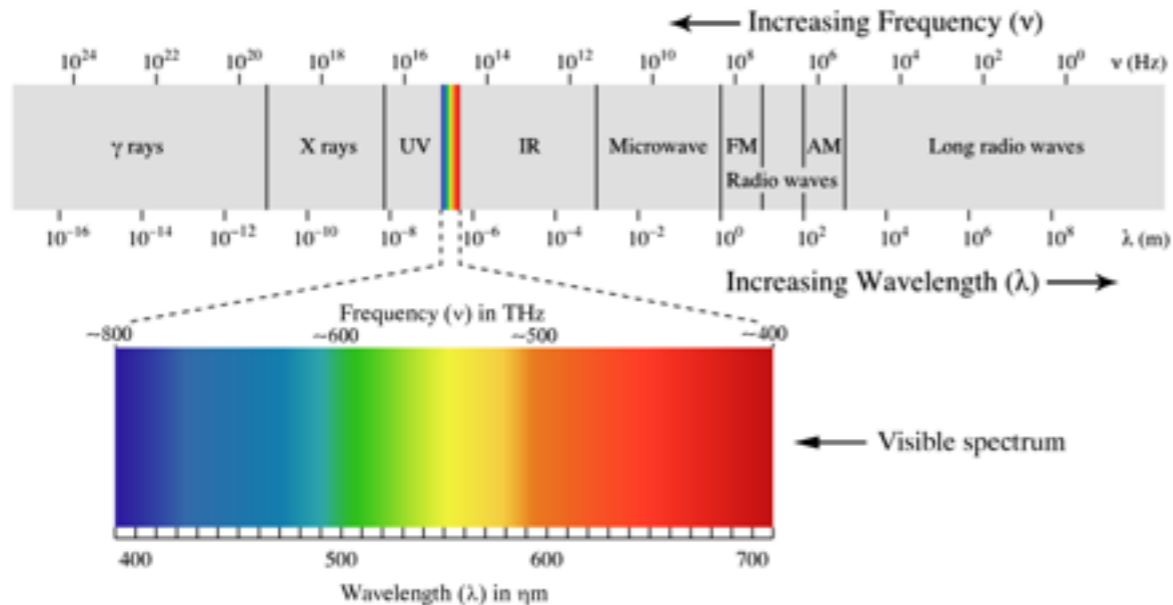
Light, microwaves, x-rays, and TV and radio transmissions are all kinds of electromagnetic waves. They are all the same kind of wavy disturbance that repeats itself over a distance called the wavelength.

Radio waves, television waves, and microwaves are all types of electromagnetic waves. They differ from each other in wavelength. Wavelength is the distance between one wave crest to the next.

They have a crest and trough. Throughout the entire wavelength. When the length of the wave gets shorter and longer the crests and troughs get smaller and bigger.



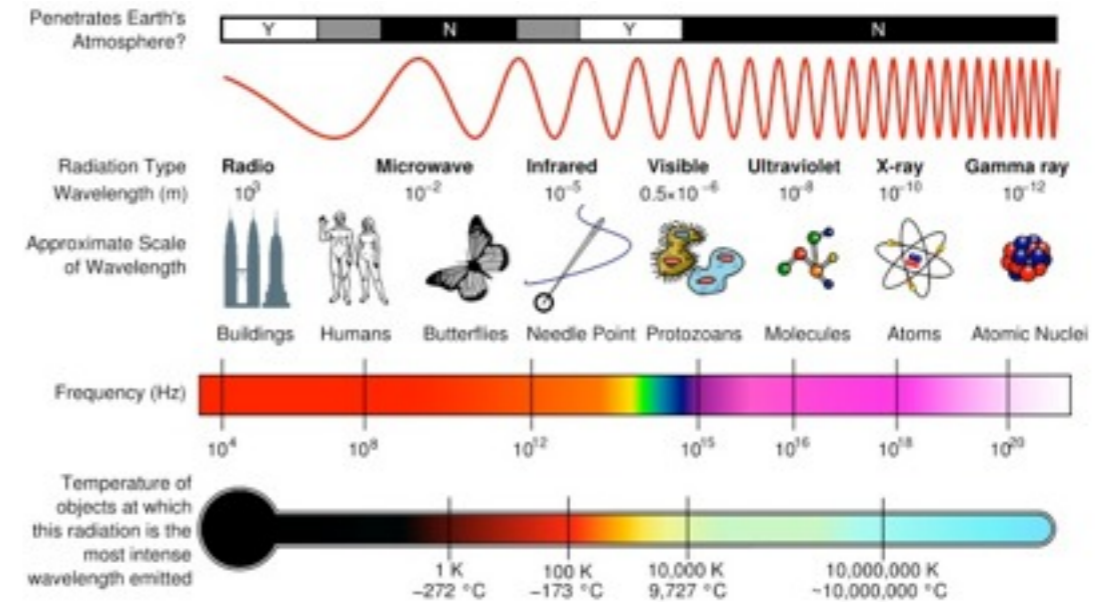
Electromagnetic Spectrum



Waves in the **electromagnetic spectrum** vary in size from very long radio waves the size of buildings, to very short gamma-rays smaller than the size of the nucleus of an atom.

Did you know that electromagnetic waves can not only be described by their wavelength, but also by their energy and frequency? All three of these things are related to each other mathematically. This means that it is correct to talk about the energy of an X-ray or the wavelength of a microwave or the frequency of a radio wave. The electromagnetic spectrum includes, from longest wavelength to shortest: radio waves, microwaves, infrared, optical, ultraviolet, X-rays, and gamma-rays.

The picture to the right helps present a more visual idea of these waves.



Electromagnetic Radiation

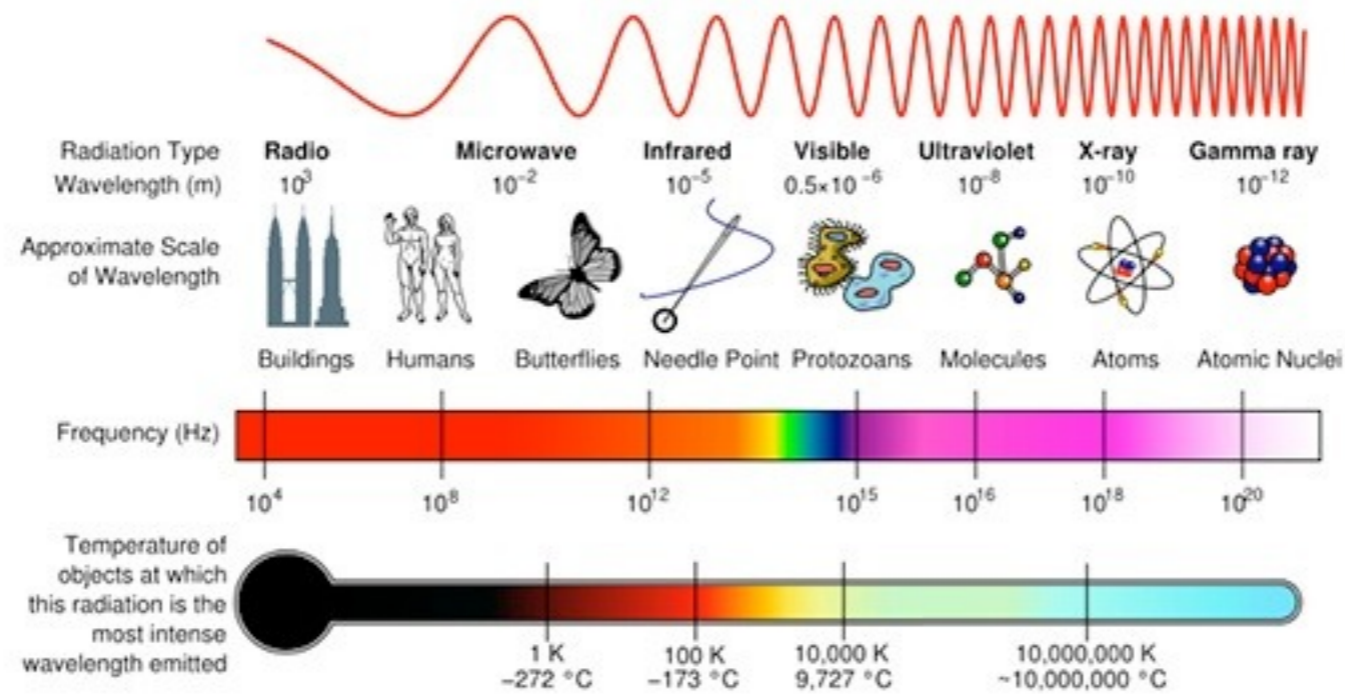
Electromagnetic waves are produced by the motion of electrically charged particles. These waves are also called “electromagnetic radiation” because they radiate from the electrically charged particles. They travel through empty space as well as through air and other substances.

Scientists have observed that **electromagnetic radiation** has a dual “personality.” Besides acting like waves, it acts like a stream of particles (called “photons”) that have no mass. The photons with the highest energy correspond to the shortest wavelengths.

Electromagnetic Waves Quiz

Question 1 of 5

Using the chart below, what size object are visible waves compared to?



- ☐ A. Buildings
- ☐ B. Humans
- ☐ C. Atoms
- ☒ D. Protozoans



Check Answer



Electricity and Magnetism



In this chapter, you will learn about electricity and its properties, circuits and how they form, and magnetism: how it works, forms, and its properties.

Electricity

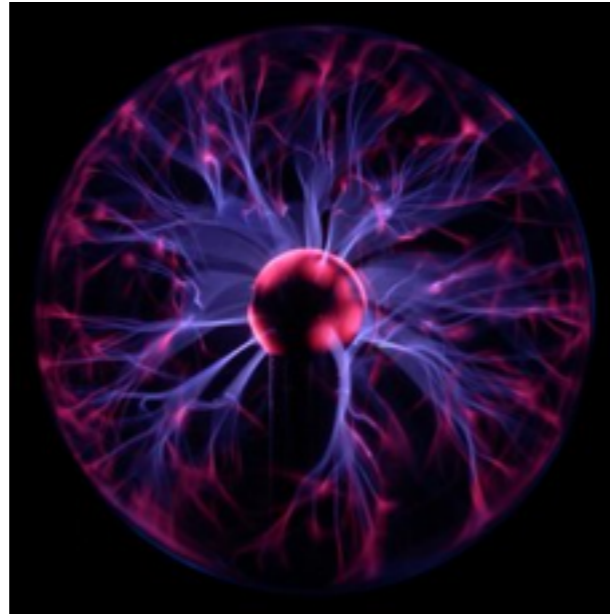
Section Content

1. Define electricity.
2. Define electrical charge.
3. Define electrical current.

Electricity

Electricity is a is the flow of electrons. All matter is made up of atoms, and an atom has a center, called a nucleus.

The nucleus contains positively charged particles called protons and **uncharged** particles called neutrons. The nucleus of an atom is surrounded by negatively charged particles called electrons. The negative charge of an electron is equal to the positive charge of a proton, and the number of electrons in an atom is usually equal to the number of protons.



When the balancing force between protons and electrons is upset by an outside force, an atom may gain or lose an electron. When electrons are “lost” from an atom, the free movement of these electrons constitutes an electric current.

Electricity is a basic part of nature and it is one of our most widely used forms of energy. We get electricity, which is a secondary energy source, from the conversion of other sources of energy, like coal, natural gas, oil, nuclear power and other natural sources, which are called primary sources.

Electricity



Many cities and towns were built alongside waterfalls (a primary source of mechanical energy) that turned water wheels to perform work. Before the electricity generation began slightly over 100 years ago, houses were lit with kerosene lamps, food was

cooled in iceboxes, and rooms were warmed by wood-burning or coal-burning stoves. Beginning with Benjamin Franklin’s experiment with a kite one stormy night in Philadelphia, the principles of electricity gradually became understood. In the mid-1800s, everyone's life changed with the invention of the electric light bulb. Prior to 1879, electricity had been used in arc lights for outdoor lighting. The lightbulb's invention used electricity to bring indoor lighting to our homes.

Today, the United States’ electric power industry is organized to ensure that an adequate supply of electricity is available to meet the growing demand for electricity.



Generated?

An electric generator is a device for converting mechanical energy into electrical energy. The process is based on the relationship between magnetism and electricity. When a wire or any other electrically conductive material moves across a magnetic field, an electric current occurs in the wire. The large



generators used by the electric utility industry have a stationary conductor. Which creates a electric current, and this current is what is used for electric power.

An electric utility power station uses either a turbine, engine, water wheel, or other similar

machine to drive an electric generator or a device that converts mechanical or chemical energy to electricity. Steam turbines, internal-combustion engines, gas combustion turbines, water turbines, and wind turbines are the most common methods to generate electricity.

Natural gas, in addition to being burned to heat water for steam, can also be burned to produce hot combustion gases that pass directly through a turbine, spinning the blades of the turbine to generate electricity. Gas turbines are commonly used when electricity utility usage is in high demand. In 1998, 15% of the nation's electricity was fueled by natural gas.



Petroleum can also be used to make steam to turn a turbine. Residual fuel oil, a product refined from crude oil, is often the petroleum product used in electric plants that use petroleum to make steam. Petroleum was used to generate less than three percent (3%) of all electricity generated in the U.S.



Nuclear power is a method in which steam is produced by heating water through the process of nuclear fission. In a nuclear power plant, a reactor contains a core of nuclear fuel, primarily enriched uranium. In this continuous fission can take place, forming a chain reaction releasing heat. The heat is used to turn water into steam, that, in turn, spins a turbine that generates electricity. Nuclear power is used to generate 19% of all the country's electricity.

Hydropower, the source for 9% of U.S. electricity generation, is a process in which flowing water is used to spin a turbine connected to a generator. There are two basic types of hydroelectric systems that produce electricity. In the first system, flowing water accumulates in reservoirs created by the use of dams. The water falls through a pipe called a penstock and applies pressure against the turbine blades to drive the generator to produce electricity. In the second system, called run-of-river, the force of the river current (rather than falling water) applies pressure to the turbine blades to produce electricity.



Electricity Quiz

Question 1 of 5

Is all electricity in the world generated by hydropower?

- ☐ A. Yes
- ☒ B. No
- ☐ C. Maybe
- ☐ D. I don't know



Check Answer



Circuits

Section Content

- 1. Learn the basics of a circuit.**
- 2. Demonstrate how circuits are put together by creating your own circuit.**

The Basics

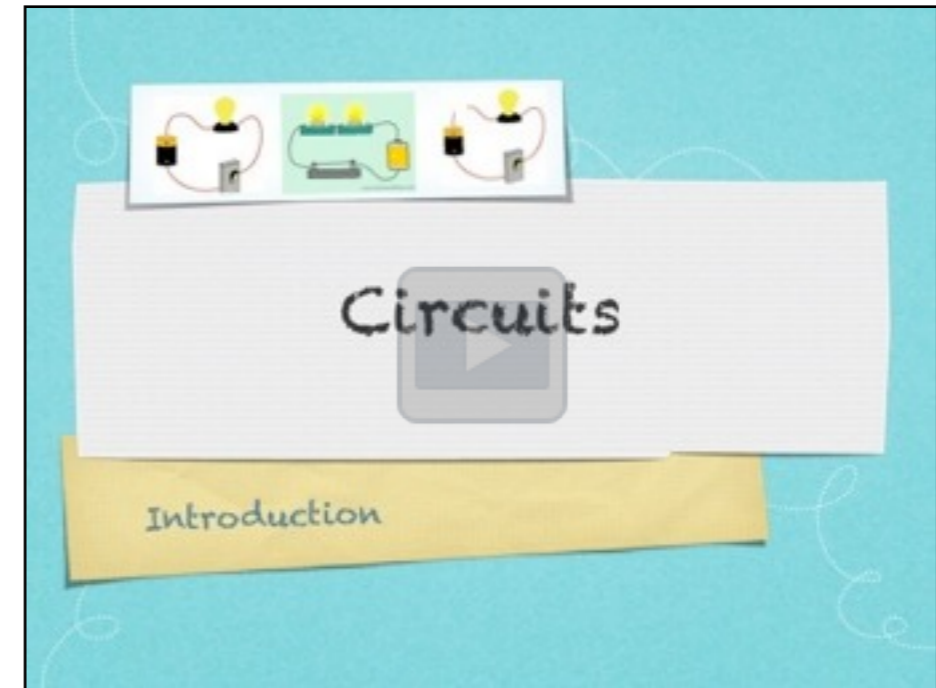
Electrical circuits involve 3 basic components:

Voltage is the force created by the separation of charges. Kind of like when two opposite poles of a magnet are put close together, but are separated by a short distance. A force tries to pull them together. When there are more negative charges on the inside of the membrane of a cell, there is a force driving positive charges inward to neutralize them. The unit of voltage is the **volt** and it is represented by the symbol V. Voltage is also called "potential" or "potential difference".



Resistance is a measure of how hard it is for charges to move in the system. In a cell, the lipid portion of the membrane is impermeable to ions, so the resistance to current across the membrane is determined by the opening and closing of ion channels. When the channels open, the resistance decreases. When they close, resistance increases, because ions can't move through the membrane. The units of resistance are ohms and it is represented by the symbol R.

Current is the **movement** of charges. In an electrical circuit, electrons move from the negative pole to the positive pole. Although electrical current is defined as the movement of positive charges, so current is said to go from the positive pole to negative pole.



Now that we know the basics we can move on to see how to build one.

Here is what you will need:

A flashlight bulb

A light bulb holder

A flashlight battery (a D battery or two double A batteries)

Two wires

Electrical tape

On the following page you will find the steps to build your own circuit. Remember to have your parent or teacher present while you work!

1. Screw the light bulb into the light bulb holder.
2. Tape the end of one wire to the bottom of the battery.
3. Screw the other end of the wire to the bulb holder.
4. Tape the end of the second wire to the top of the battery.
5. Touch the loose end of the wire to the screw on the bulb holder. See what happens!
6. Take away the loose wire so that it no longer touches the light bulb holder. What happens? The light goes out. Why does this happen? When you touch the loose wire to the bulb holder, you close the circuit. The light bulb lights. When you take away the loose wire, you break the circuit. The bulb does not light!
7. Extra challenge! You will probably need two pairs of hands for this. It is possible to make the light shine using just one battery, one piece of wire and one bulb.
8. See if you and your parent can do this! How does it work?

Circuits Quiz

Question 1 of 4

What is circuit charged by?

- ☐ A. Resistance
- ☒ B. Voltage
- ☐ C. Current



Check Answer



Magnetism

Section Content

1. Define electricity.
2. Define an electrical charge.
3. Define an electrical current.

Magnetism

Magnetism is a force of attraction or repulsion that acts at a distance. It is due to a magnetic field, which is caused by moving electrically charged particles. It is also inherent in magnetic objects such as a magnet.

A magnet is an object that exhibits a strong magnetic field and will attract materials like iron to it. Magnets have two poles, called the north (N) and south (S) poles.



Movie 4.1



Two magnets will be attracted by their opposite poles, and each will repel the like pole of the other magnet. Magnetism has many uses in modern life.

Because the electron has both an electric charge and a spin, it can be called a **charge in motion**. This charge in motion gives rise to a tiny magnetic field. In the case of many atoms, all the electrons are paired within **energy levels**, according to the exclusion principle, so that the electrons in each pair have opposite (antiparallel) spins and their magnetic fields cancel. In some atoms, however, there are more electrons with spins in one direction than in the other, resulting in a net magnetic field for the atom as a whole; this situation exists in a paramagnetic substance. If such a material is placed in an external field, (E.G.), the field created by an electromagnet, the individual atoms will tend to align their fields with the external one. The alignment will not be complete, due to the disruptive effect of thermal vibrations. Because



of this, a paramagnetic substance is only weakly attracted by a magnet.

In a ferromagnetic substance, there are also more electrons with spins in one direction than in the other. The individual magnetic fields of the atoms in a given region tend to line up in the same direction, so that they reinforce one another. Such a region is called a domain.

When the domains in all other directions have vanished, the remaining domains are rotated so that their direction are exactly the same as the external field. After this rotation is complete. The cycle starts all over again.

Magnetism Quiz

Question 1 of 4

Can magnetism repel metal or another magnet?



A. Yes



B. Maybe



C. No



Check Answer



Amplitude

The amount of energy carried by a wave.

Related Glossary Terms

Drag related terms here

Index

Charge in motion

Electrons that pair off and create a negative charge.

Related Glossary Terms

Uncharged

Index

Conservation of energy

Energy can not be created nor destroyed

Related Glossary Terms

Drag related terms here

Index

Crest

The hill of the wave.

Related Glossary Terms

Drag related terms here

Index

Current

The flow of motion.

Related Glossary Terms

Drag related terms here

Index

Direction

North, South, East, And West.

Related Glossary Terms

Distance, Motion, Work

Index

Chapter 1 - Work

Displacement

The amount of space between each wave.

Related Glossary Terms

Drag related terms here

Index

Distance

How far an object moves in length.

Related Glossary Terms

Direction, Motion, Work

Index

Chapter 1 - Work

Electricity

A form of energy resulting from the existence of charged particles

Related Glossary Terms

Energy levels

Index

Electromagnetic radiation

Electromagnetic waves, (basically)

Related Glossary Terms

Electromagnetic spectrum, Electromagnetic Waves

Index

Chapter 3 - Electromagnetic Waves

Electromagnetic spectrum

The visible light spectrum where the energy lis shown in levels.

Related Glossary Terms

Electromagnetic radiation, Electromagnetic Waves

Index

Electromagnetic Waves

A wave of energy consisting of electric and magnetic fields, oscillating at right angles to each other

Related Glossary Terms

Electromagnetic radiation, Electromagnetic spectrum

Index

Energy

The power derived from the utilization of physical or chemical resources, esp. to provide light and heat or to work machines.

Related Glossary Terms

Mechanical energy

Index

Chapter 2 - The Forms of Energy

Energy conversion

$E=mc^2$

Related Glossary Terms

Drag related terms here

Index

Energy conversion engineering

How energy conversion was started.

Related Glossary Terms

Drag related terms here

Index

Chapter 2 - Energy Conservation and Conversion

Energy levels

The levels where electron are fond in a atom.

Related Glossary Terms

Electricity

Fission

The action of dividing or splitting something into two or more parts

Related Glossary Terms

Nuclear energy

Index

Chapter 2 - Nuclear Energy

Force

Strength or energy that is exerted through physical action or movement.

Related Glossary Terms

Drag related terms here

Index

Chapter 1 - Machines

Frequency

The tone, and pitch of a wave.

Related Glossary Terms

Hertz

Index

Fulcrum

The point which a lever rests on.

Related Glossary Terms

Lever, Screw

Index

Chapter 1 - Machines

Fusion

The process or result of joining two or more things together to form a single entity

Related Glossary Terms

Horsepower, Nuclear energy

Index

Gravitational potential energy

Potential energy that occurs when gravity is pulling the object downward.

Related Glossary Terms

Drag related terms here

Index

Hertz

The measurement used with frequency.

Related Glossary Terms

Frequency

Index

Horsepower

A common unit of power related to the mot

Related Glossary Terms

Fusion, Inclined plane, Power

Index

Chapter 1 - Power

Hydropower

Flowing water is used to spin a turbine connected to a generator

Related Glossary Terms

Drag related terms here

Index

Inclined plane

A slanted surface used to make work easier.

Related Glossary Terms

Horsepower

Index

Ionosphere

A spce in the atmosphere between the top two layers.

Related Glossary Terms

Drag related terms here

Index

Joules

The SI unit of work or energy, equal to the work done by a force of one newton when its point of application moves one meter in the direction of action of the force,

Related Glossary Terms

Work

Index

Chapter 1 - Work

Kilowatt

The measurement of which electricity is measured in.

Related Glossary Terms

Drag related terms here

Index

Lever

A simple machine with a bar and a fulcrum.

Related Glossary Terms

Fulcrum, Load, Screw

Index

Chapter 1 - Machines

Load

A heavy or bulky thing that is being carried or is about to be carried

Related Glossary Terms

Lever

Longitudinal wave

A wave that creates parallel waves.

Related Glossary Terms

Drag related terms here

Index

Mechanical energy

It is the energy a substance or system has because of its motion.

Related Glossary Terms

Energy

Index

Motion

The amount of movement an object has.

Related Glossary Terms

Direction, Distance, Movement, Work

Index

Chapter 1 - Work

Movement

The amount an object moves.

Related Glossary Terms

Motion

Index

Natural gas

Comes naturally without the use of the fossil fuels.

Related Glossary Terms

Drag related terms here

Nuclear energy

Radiation.

Related Glossary Terms

Fission, Fusion

Index

Nuclear power

Power that comes from nuclear fission and fusion.

Related Glossary Terms

Drag related terms here

Index

Oscillations

Movement back and forth at a regular speed.

Related Glossary Terms

Drag related terms here

Index

Chapter 3 - Mechanical Waves

Period

A motion that appears periodically.

Related Glossary Terms

Drag related terms here

Index

Petroleum

A source of energy that creates electricity.

Related Glossary Terms

Drag related terms here

Index

Power

It is the rate of doing work.

Related Glossary Terms

Horsepower

Index

Chapter 1 - Power

Pulley

A wheel and rope pulled together to lift extreme loads.

Related Glossary Terms

Screw

Index

Recessional

Happens one after another. (straight in a row)

Related Glossary Terms

Drag related terms here

Index

Resistance

Part of the wave.

Related Glossary Terms

Drag related terms here

Index

Screw

A simple machine with, a series of wedges and inclined planes.

Related Glossary Terms

Fulcrum, Lever, Pulley, Wedge, Wheel and axle

Index

Find Term

Chapter 1 - Machines

Speed

The rate of movement.

Related Glossary Terms

Drag related terms here

Index

Speed of the pulse

The rate of movement in a pulse.

Related Glossary Terms

Drag related terms here

Index

Surface wave

A mixture of longitudinal and transverse waves.

Related Glossary Terms

Drag related terms here

Index

Transverse wave

A wave that creates perpendicular waves.

Related Glossary Terms

Drag related terms here

Index

Uncharged

Particles in electrical uses that have not yet been magnetized.

Related Glossary Terms

Charge in motion

Volt

The SI unit for electromotive force.

Related Glossary Terms

Drag related terms here

Index

Voltage

The amount of watts an object can hold.

Related Glossary Terms

Drag related terms here

Index

Wedge

A V-shaped inclined plane used to hold, a cut.

Related Glossary Terms

Screw

Wheel and axle

A wheel that turns on a center post.

Related Glossary Terms

Screw

Work

A transfer of energy.

Related Glossary Terms

Direction, Distance, Joules, Motion
