UNIT 2

Different Forms of Energy

1. Start up

1. Name some forms of energy you are familiar with
2. What is the relationship between energy and motion?
3. Can one form of energy be converted into another form of energy?
4. Is there any form of energy in an atom?

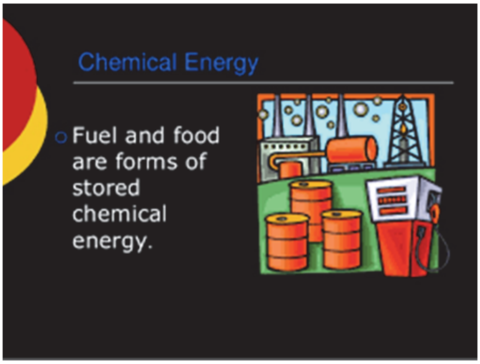
2. Reading

Energy has a number of different forms, all of which measure the ability of an object or system to do work on another object or system. In other words, there are different ways that an object or a system can possess energy. Energy is a common measure for various forms of motion. It is a scalar quantity. In order to provide quantitative characteristics of the qualitatively different forms of motion dealt with in physics, appropriate kinds of energy have been introduced. All forms of energy fall under two categories: Potential and kinetic energy

A. POTENTIAL ENERGY (stored energy and the energy of position)

Consider a book sitting on a table. The book is said to have "potential energy" because if it is nudged off, gravity will accelerate the book, giving the book kinetic energy. Because the Earth's gravity is necessary to create this kinetic energy, and because this gravity depends on the Earth being present, we say that the "Earth-book system" is what really possesses this potential energy, and that this energy is converted into kinetic energy as the book falls.

1. Chemical Energy:



Consider the ability of your body to do work. The glucose (blood sugar) in your body is said to have "chemical energy" because the glucose releases energy when chemically reacted (combusted) with oxygen. Your muscles use this energy to generate mechanical force and also heat. Chemical energy is really a form of microscopic potential energy, which exists because of the electric and magnetic forces of attraction exerted between the different parts of each molecule - the same attractive forces involved in thermal vibrations. These parts get rearranged in chemical reactions, releasing or adding to this potential energy.

2. Nuclear Energy:

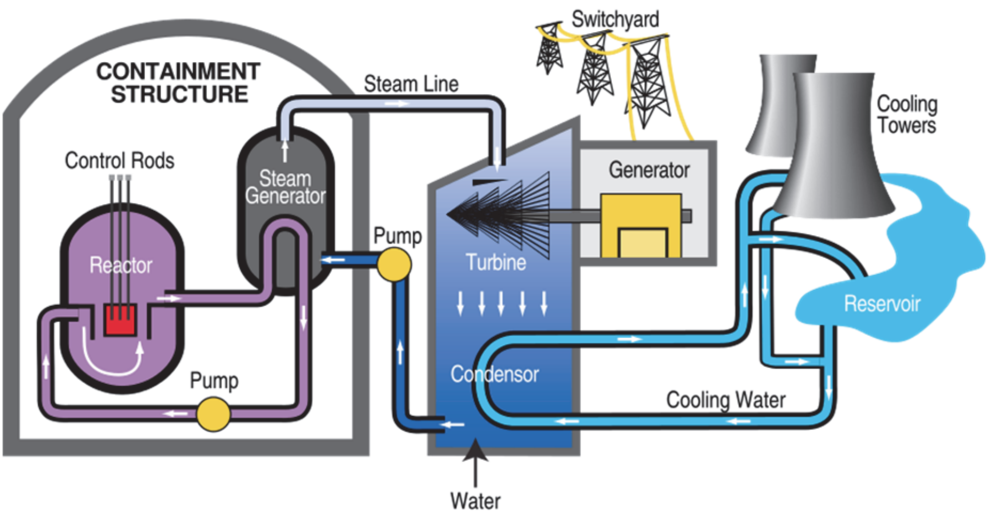
The Sun, nuclear reactors, and the interior of the Earth, all have "nuclear reactions" as the source of their energy, that is, reactions that involve changes in the structure of the nuclei of atoms. In the Sun, hydrogen nuclei fuse (combine) together to make helium nuclei, in a process called fusion, which releases energy. In a nuclear reactor, or in the interior of the Earth, Uranium nuclei (and certain other heavy elements in the Earth's interior) split apart, in a process called fission. If this didn't happen, the Earth's interior would have long gone cold! The energy released by fission and fusion is not just a product of the potential energy released by rearranging the nuclei. In fact, in both cases, fusion or fission, some of the matter making up the nuclei is actually converted into energy. How can this be? The answer is that matter itself is a form of energy! This concept involves one of the most famous formulas in physics, the formula,

$$E=mc^2$$

This formula was discovered by Einstein as part of his "Theory of Special Relativity". In simple words, this formula means:

The energy intrinsically stored in a piece of matter at rest equals its mass times the speed of light squared.

When we plug numbers in this equation, we find that there is actually an incredibly huge amount of energy stored in even little pieces of matter (the speed of light squared is a very very large number!). For example, it would cost more than a million dollars to buy the energy stored intrinsically stored in a single penny at our current (relatively cheap!) electricity rates. To get some feeling for how much energy is really there, consider that nuclear weapons only release a small fraction of the "intrinsic" energy of their components.

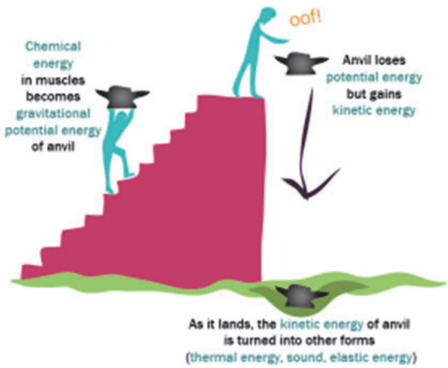


3. Stored mechanical energy:

energy stored in objects by application of a force. Compressed springs and stretched rubber bands are examples of stored mechanical energy.

4. Gravitational energy:

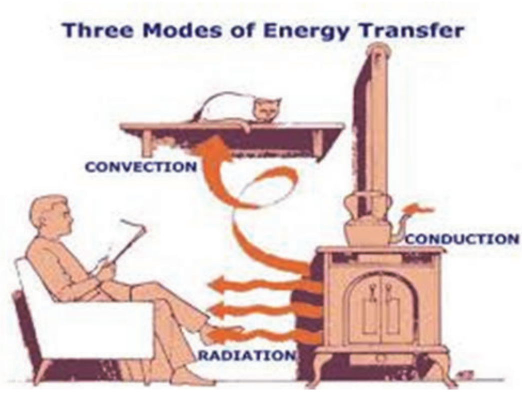
energy of place or position. Water in a reservoir behind a hydropower dam is an example of gravitational potential energy. When the water is released to spin the turbines, it becomes motion energy.



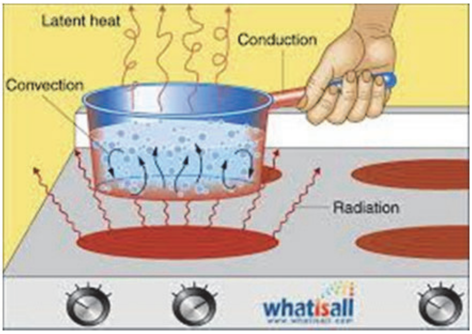
B. KINETIC ENERGY (kinetic energy is motion- the motion of waves, electrons, atoms, molecules and substances)

Consider a baseball flying through the air. The ball is said to have "kinetic energy" by virtue of the fact that it's in motion relative to the ground. You can see that it has energy because it can do "work" on an object on the ground if it collides with it (either by pushing on it and/or damaging it during the collision).

1. Thermal or heat energy:



Consider a hot cup of coffee. The coffee is said to possess "thermal energy", or "heat energy" which is really the collective, microscopic, kinetic and potential energy of the molecules in the coffee (the molecules have kinetic energy because they are moving and vibrating, and they have potential energy due to their mutual attraction for one another - much the same way that the book and the Earth have potential energy because they attract each other). Temperature is really a measure of how much thermal energy something has. The higher the temperature, the faster the molecules are moving around and/or vibrating, i.e. the more kinetic and potential energy the molecules have.



2. Electrical Energy

All matter is made up of atoms, and atoms are made up of smaller particles, called protons (which have positive charge), neutrons (which have neutral charge), and electrons (which are negatively charged). Electrons orbit around the center, or nucleus, of atoms, just like the moon orbits around the earth. The nucleus is made up of neutrons and protons.

Some materials, particularly metals, have certain electrons that are only loosely attached to their atoms. They can easily be made to move from one atom to another if an electric field is applied to them. When those electrons move among the atoms of matter, a current of electricity is created.

This is what happens in a piece of wire when an electric field, or voltage, is applied. The electrons pass from atom to atom, pushed by the electric field and by each other (they repel each other because like charges repel), thus creating the electrical current. The measure of how well something conducts electricity is called its conductivity, and the reciprocal of conductivity is called the resistance. Copper is used for many wires because it has a lower resistance than many othermetals and is easy to use and obtain. Most of the wires in your house are made of copper. Some older homes still use aluminum wiring.

The energy is really transferred by the chain of repulsive interactions between the electrons down the wire - not by the transfer of electrons per se. This is just like the way that water molecules can push on each other and transmit pressure (or force) through a pipe carrying water. At points where a strong resistance is encountered, its harder for the electrons to flow - this creates a "back pressure" in a sense back to the source. This back pressure is what really transmits the energy from whatever is pushing the electrons through the wire. Of course, this applied "pressure" is the "voltage".

As the electrons move through a "resistor" in the circuit, they interact with the atoms in the resistor very strongly, causing the resistor to heat up - hence delivering energy in the form of heat. Or, if the electrons are moving through the wound coils of a motor, they create a magnetic field, which interacts with other magnets in the motor, and hence turns the motor.

3. Electrochemical Energy:

Consider the energy stored in a battery. Like the example above involving blood sugar, the battery also stores energy in a chemical way. But electricity is also involved, so we say that the battery stores energy "electro-chemically"

4. Electromagnetic Energy (light):

Consider the energy transmitted to the Earth from the Sun by light (or by any source of light). Light, which is also called "electro-magnetic radiation". Why the fancy term? Because light really can be thought of as oscillating, coupled electric and magnetic fields that travel freely through space (without there having to be charged particles of some kind around).

It turns out that light may also be thought of as little packets of energy called photons (that is, as particles, instead of waves). The word "photon" derives from the word "photo", which means "light". Photons are created when electrons jump to lower energy levels in atoms, and absorbed when electrons jump to higher levels. Photons are also created when a charged particle, such as an electron or proton, is accelerated, as for example happens in a radio transmitter antenna.

But because light can also be described as waves, in addition to being a packet of energy, each photon also has a specific frequency and wavelength associated with it, which depends on how much energy the photon has (because of this weird duality - waves and particles at the same time - people sometimes call particles like photons "wavicles"). The lower the energy, the longer the wavelength and lower the frequency, and vice versa. The reason that sunlight can hurt your skin or your eyes is because it contains "ultraviolet light", which consists of high energy photons. These photons have short wavelength and high frequency, and pack enough energy in each photon to cause physical damage to your skin if they get past the outer layer of skin or the lens in your eye. Radio waves, and the radiant heat you feel at a distance from a campfire, for example, are also forms of electro-magnetic radiation, or light, except that they consist of low energy photons (long wavelength and high frequencies - in the infrared band and lower) that your eyes can't perceive. This was a great discovery of the nineteenth century - that radio waves, x-rays, and gamma-rays, are just forms of light, and that light is electro-magnetic waves

5. Sound Energy:

Sound waves are compression waves associated with the potential and kinetic energy of air molecules. When an object moves quickly, for example the head of drum, it compresses the air nearby, giving that air potential energy. That air then expands, transforming the potential energy into kinetic energy (moving air). The moving air then pushes on and compresses other air, and so on down the chain. A nice way to think of sound waves is as "shimmering air".

3. Comprehension and vocabulary exercises

A. Match the nouns with their definitions:

1. Scalar quantity	**a.** the splitting of the nucleus of an atom
2. Fusion	**b.** a barrier against the passage of water
3. Fission	**c.** melting, a nuclear reaction releasing energy
4. Spring	**e.** it connects two shafts together
5. Dam	**f.** a twisted or coiled piece of metal
6. Coupling	**g.** any number that gives you the size or magnitude

B. Match the verbs with their definition:

1. Nudge off	**a.** to insert in an appropriate place
2. Combust	**b.** to push with the elbow to get attention
3. Shimmer	**c.** to turn around
4. Perceive	**d.** to shine with a subdued flickering light
5. Plug	**e.** to catch fire, ignite
6. Spin	**f.**to become aware of (something) through the senses

C. Answer the questions according to the text:

1. How can sunlight burn our skin?
2. What does “ultraviolet light" consist of?
3. Why can light be described as waves?
4. What happens when electrons move through resistors?
5. What do water molecules transmit when pushed on each other?
6. How can you define “conductivity”?
7. When are photons created?

D. Decide whether the following statements are true or false:

1. A battery stores electro-chemical energy ❑
2. All materials have certain electrons that are loosely attached to their atoms ❑

3. The ultraviolet light photons have short wavelength and high frequency ☐
4. Air molecules have both potential and kinetic energy ☐
5. Chemical energy is really a form of microscopic potential energy ☐
6. The reciprocal of conductivity is called the pressure ☐

4. Language Development

A. Use the following verbs (right form) in the sentences below. Some verbs are used more than once.

perceive ,shimmer, oscillate, plug, spin, combust

1. Warren's racist father will ……………..a person as dangerous for no reason other than skin
2. The moonlight is …………………..on the lake.
3. Even though you think you are a nice-looking man, you must understand many women ………………….you as quite unattractive.
4. The musician watched the metronome …………………back and forth, using it to keep himself from playing too quickly.
5. After drinking 7 beers, her head was ………….. and she felt sick to her stomach.
6. The children ……………………their ears with their fingers while the airplane was taking off
7. I have a bad cold. My head is aching, my nose is ……………… and I have a sore throat.
8. After being presented with new evidence, he could not help but ……………………..somewhat on his opinion.
9. The defendant ………………when he heard the verdict.
10. We can't put a lamp in the hallway because there is no outlet to …………… it in.
11. The car hit a telephone pole, and …………………… around in circles before finally coming to a stop in the opposite lane.
12. The fire started when a pile of oily rags spontaneously………………...

B. Choose the correct meaning of the underlined verb:

1. The fire started when a pile of oily rags spontaneously combusted.
   - **a.** To undergo combustion; burn
   - **b.** To become suddenly angry or agitated
2. The defendant combusted when he heard the verdict.
   - **a.** To undergo combustion; burn
   - **b.** To become suddenly angry or agitated
3. The jewelry was cheap and had no intrinsic value
   - **a.** natural
   - **b.** innate
   - **c.** true
4. The intrinsic factor protein helps the body to absorb and use vitamin B
   - **a.** natural
   - **b.** innate
   - **c.** true
5. As the fuels were combusting they gave off noxious vapors
   - **a.** To undergo combustion; burn
   - **b.** To become suddenly angry or agitated

C. Write a paragraph about the pros and cons of nuclear energy

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