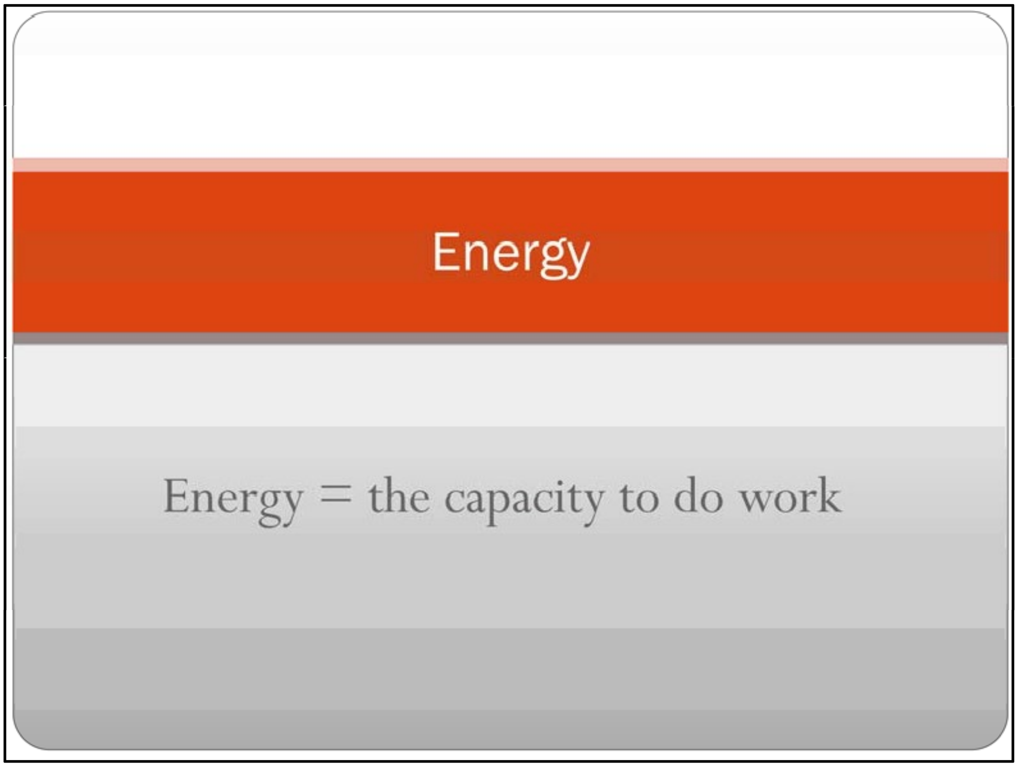
Module 4: Energy

Topic 2 Content: Energy Presentation Notes



Energy is defined as the capacity to do work. As you know, energy can take many

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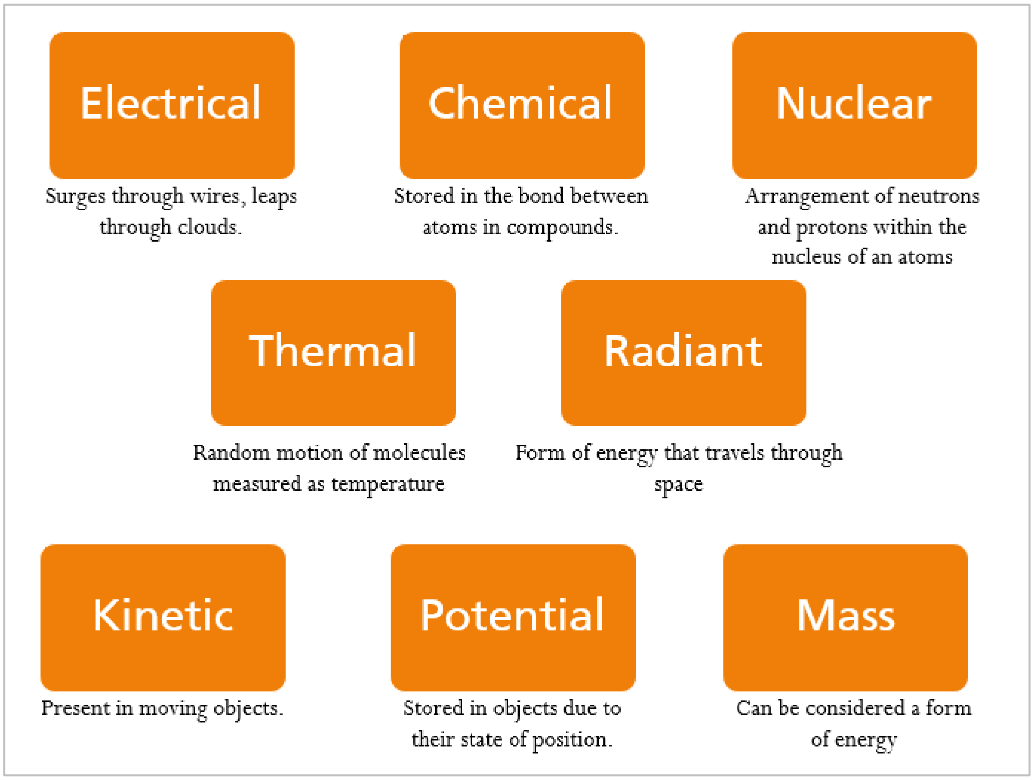
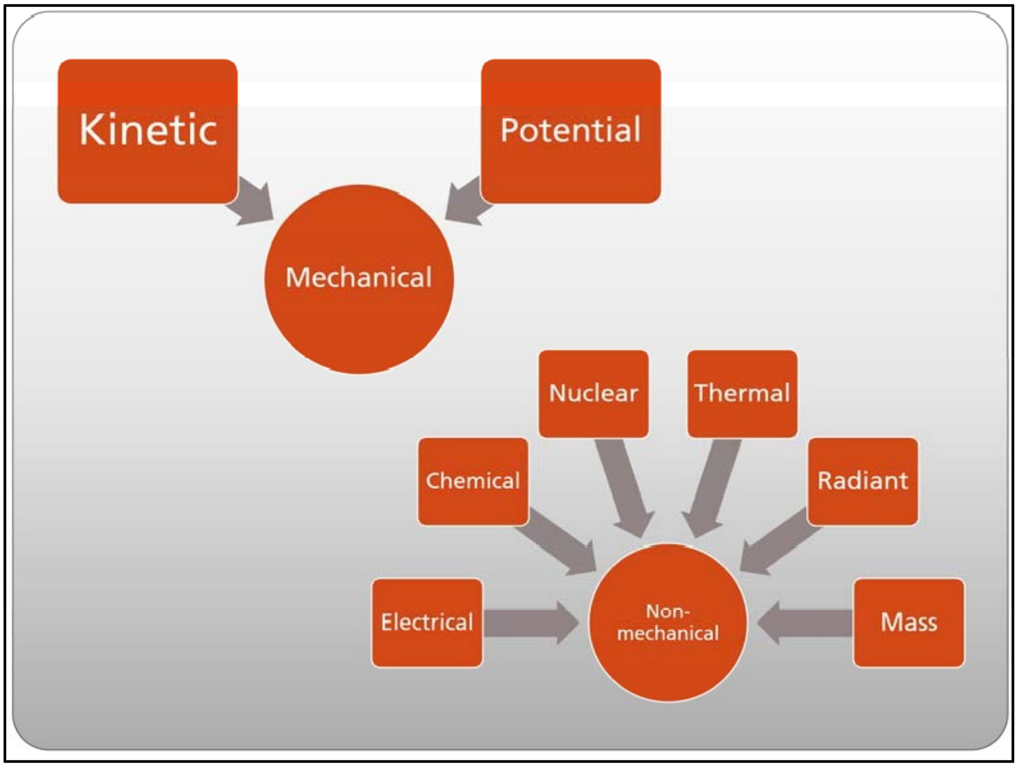
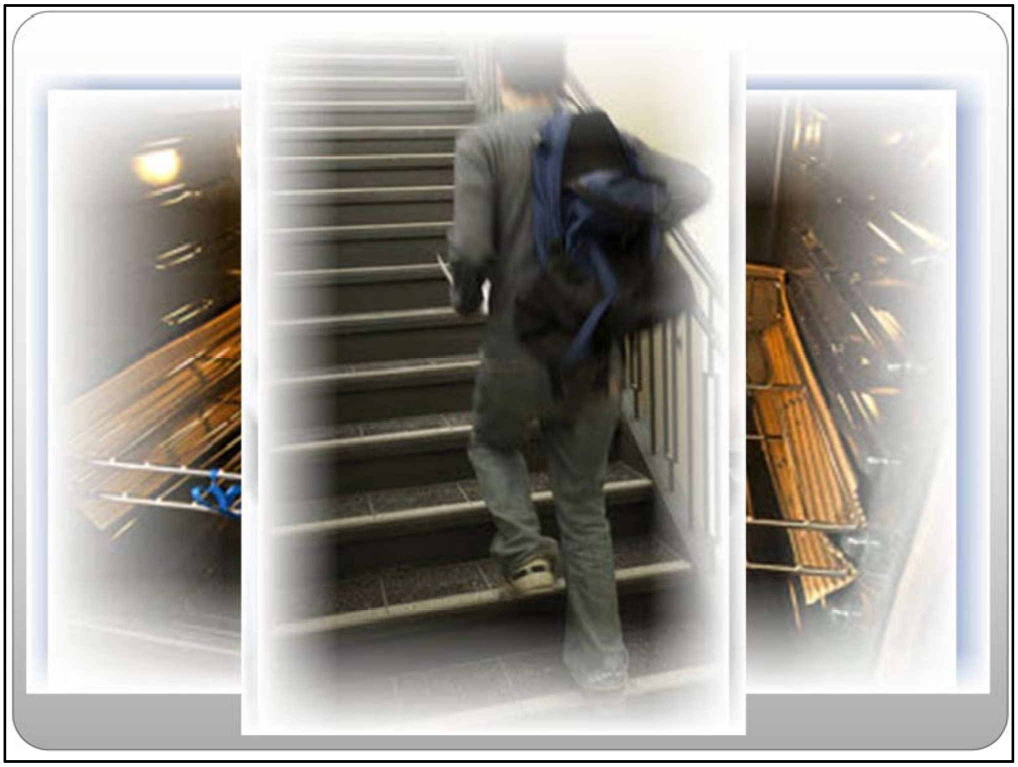


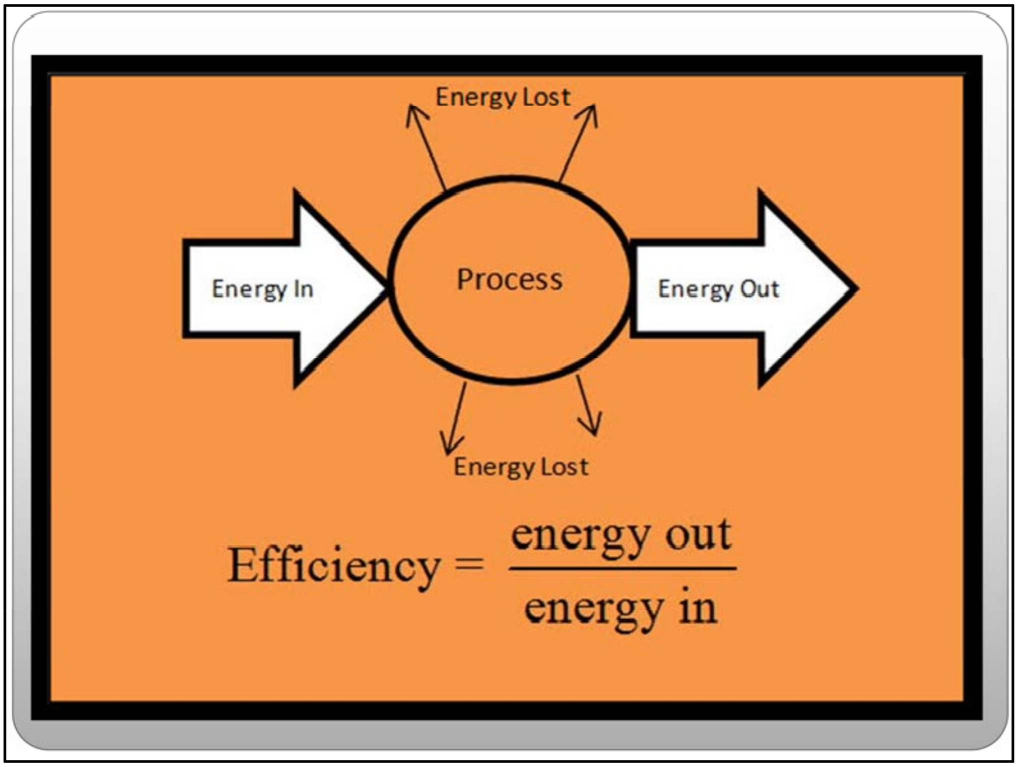
Electrical energy surges through wires to your house and leaps from clouds to the ground as lightning. The bonds between atoms in compounds store chemical energy, and the arrangement of the neutrons and protons within the nucleus of atoms store nuclear energy. The random motion of molecules is thermal energy which we measure as temperature, and light is a form of energy that travels through space. Kinetic energy is present in moving objects and potential energy is stored in objects due to their state or position. Finally, Einstein showed us that even mass can be considered a form of energy. Drag your mouse over each statement to see what type of energy is defined.



In this topic, you will be focusing on just a few of these forms that fall in the category of mechanical energy. These are kinetic energy and potential energy. The other forms we will simply call non-mechanical energy.

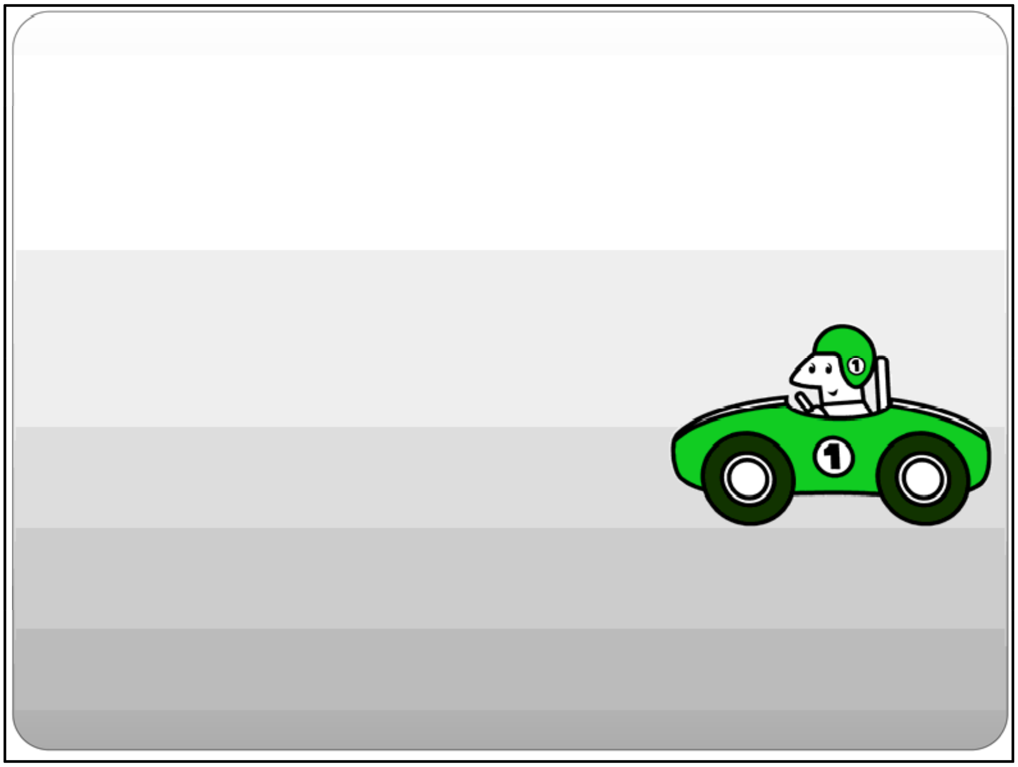


Each of these types of energy can be transformed from one to another. For example, the air particles in the wind strike a turbine and set the blades in motion. As the blades turn, loops of wire spin near magnets. In this way, some of the mechanical energy of the wind is converted to electrical energy. This energy is transported to your home where you turn on your oven, turning some of the electrical energy into thermal energy. When you place a pizza in the oven, some of the thermal energy is converted into chemical energy within the bonds of the cooking food. Eating the pizza transfers some of the chemical energy of the food into a form of chemical energy that you store in your body as fats and carbohydrates. Finally, you transfer some of this chemical energy into kinetic and potential energy as you run up the stairs.



None of these transformations is perfect. Some of the energy is transformed into the desired form, but some always is lost through friction and other mechanisms, usually heating up the surrounding air.

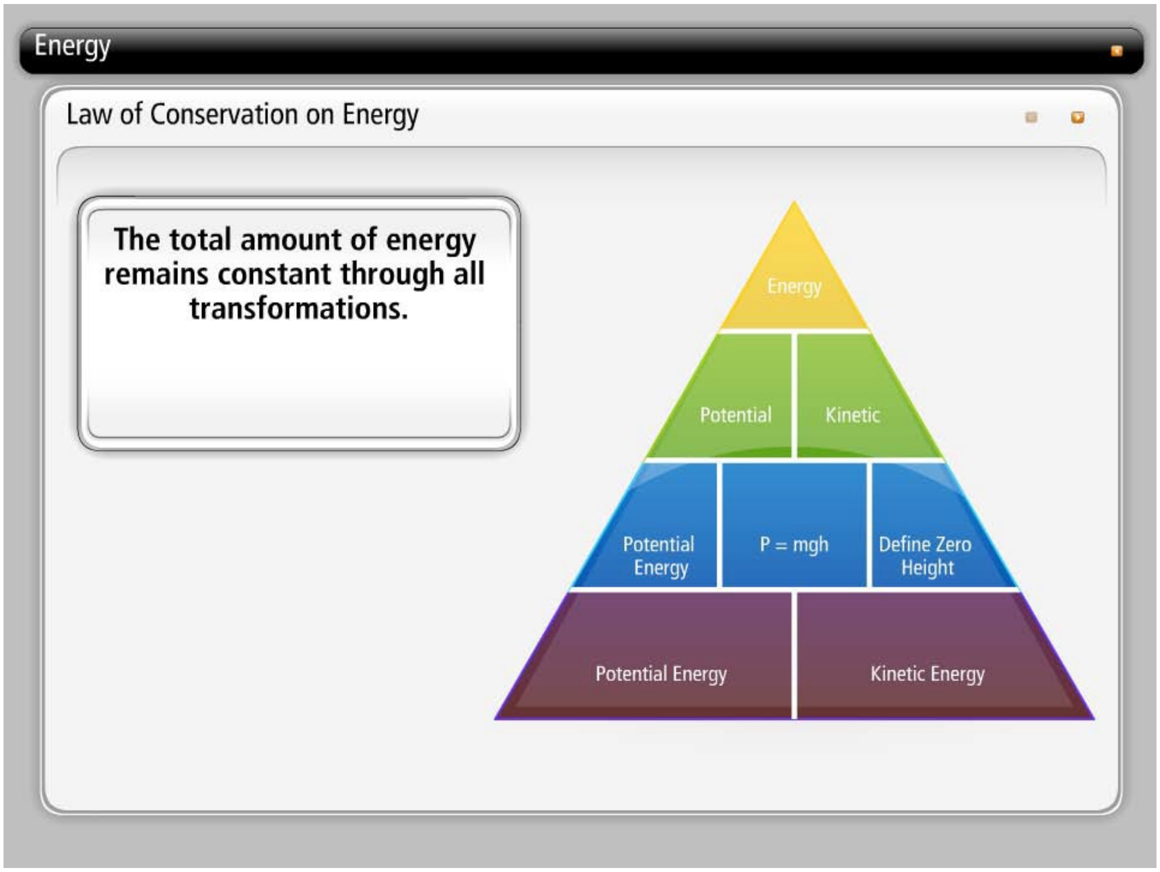
We define the percentage of energy that is transformed to the desired state as the efficiency of the process and calculate it by dividing the energy output by the energy input.



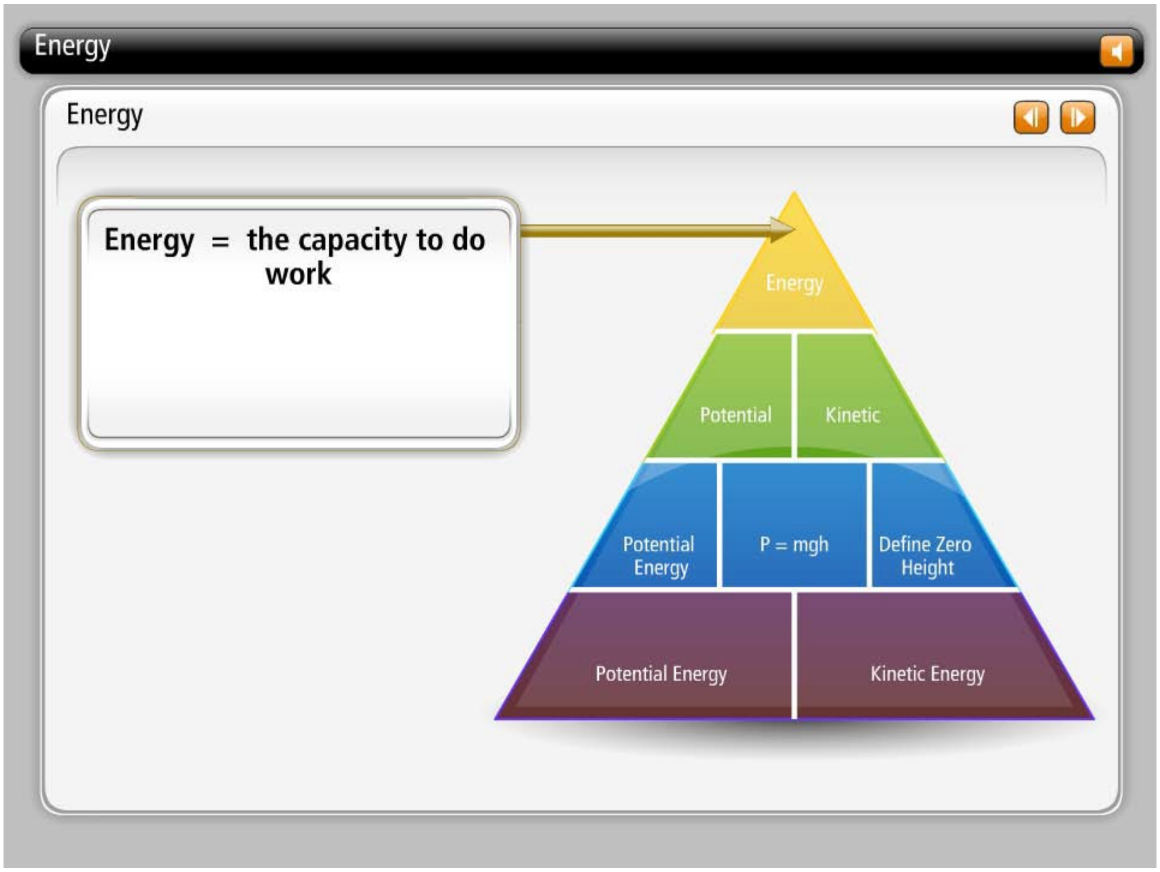
If you think about driving your car, the gasoline you put in the tank has a certain amount of chemical energy stored in the molecular bonds. As the gasoline is burned in the engine, some energy is released to push the pistons, which make several mechanical connections, eventually turning the wheels, which move the car forward.

Through this process, only a small percentage of the original energy in the gasoline ends up as energy of motion of the car. The rest is lost in various ways. Incomplete combustion results in some chemical energy getting sent out the exhaust. The engine, drive train, muffler and exhaust air all heat up tremendously, leaking heat to the surroundings. Friction between the tires and the road heats up the road, and the motion of the car pushing through the air heats up the air. Some of the energy is sent through the electrical system of the car, being used for your radio, headlights and windshield wipers, but along this path, much is wasted as it heats up the wires, the headlights and the wiper motor.

In all, it is estimated that today's automobiles have only about fifteen to twenty five percent efficiency in converting gasoline to motion.



Despite the fact that no transformation can be one hundred percent efficient, it is true that in each of these transformations, the total amount of energy remains constant. A careful accounting of all the inflows and outflows shows that the total amount of energy must not change. This is known as the law of conservation of energy.



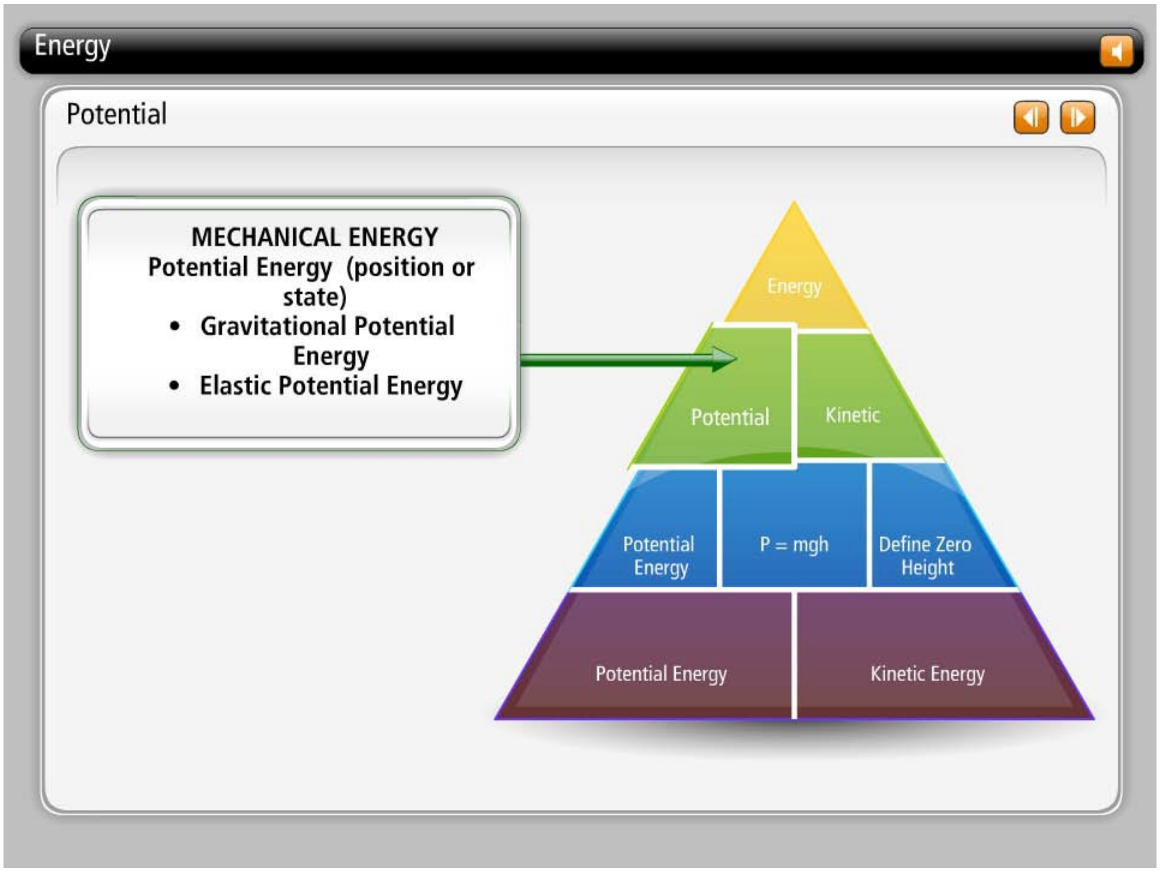
Each time energy is transferred from one type to another, or from one object to another, there is the capacity to accomplish work.

Energy is a scalar quantity. It has magnitude but not direction.

Energy, like work, is measured in Joules, which allows for direct comparisons of work done and energy transferred.

You are currently interested in seeing how this energy can be used to apply a force to an object over a distance, causing the object's mechanical energy to change.

So first, you must take a look at the types of mechanical energy.



There are two categories of mechanical energy.

Potential energy is the energy an object has due to its position or state.

An example of potential energy due to position is a book on the shelf. The book has potential energy due to its position above the earth. This is gravitational potential energy.

Gravitational potential energy represents the capacity of the gravitational force do to work. If the book falls off the shelf, the force of gravity will pull it to the ground.

Any time two masses are separated, there is an increase in gravitational potential energy. You already know that there is gravitational attraction between any two masses. So if masses are separated, when they are released the gravitational force will pull them toward each other.

An example of potential energy due to state is a stretched rubber band or compressed spring. Each has elastic potential energy due to its ability to return to its original shape when released. The elastic potential energy represents the capacity of the elastic or spring force to do work.

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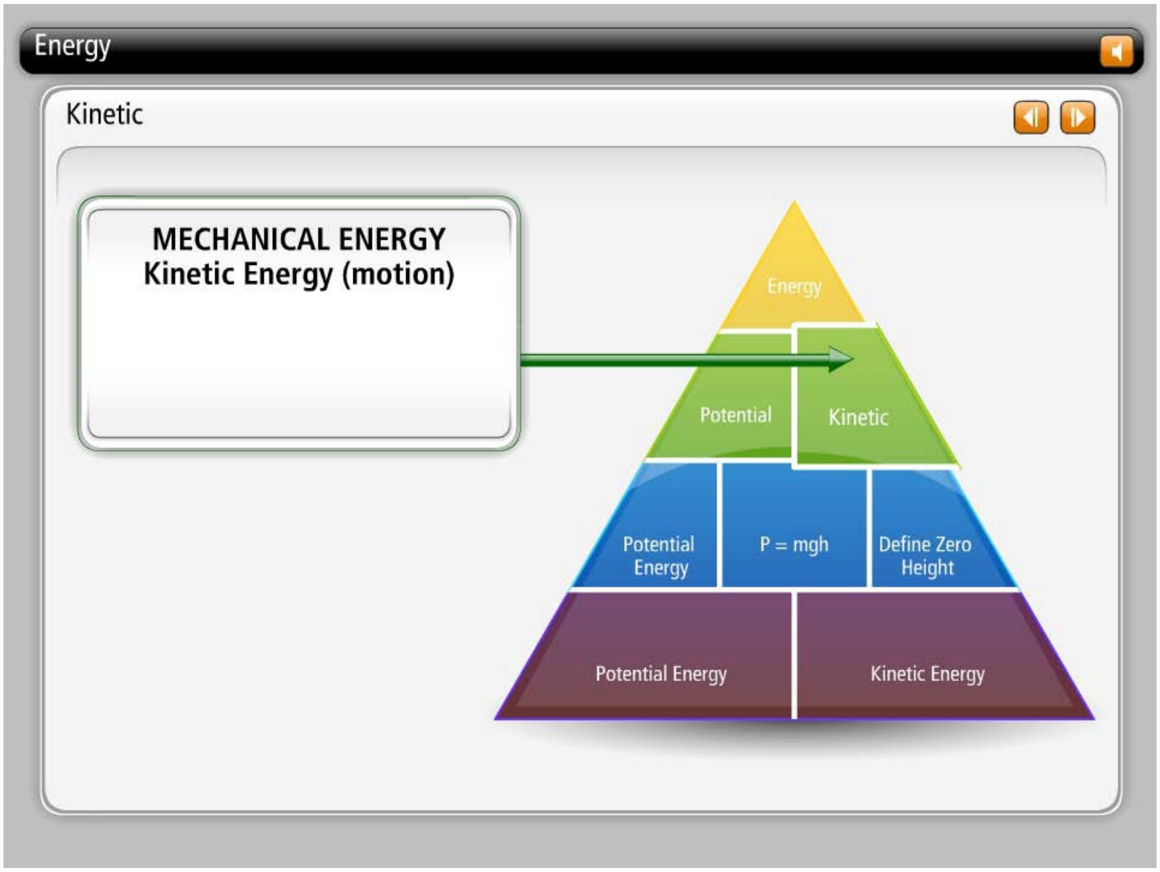

The other main category of mechanical energy is kinetic energy, which is the energy of motion. Any mass moving at any speed has kinetic energy.

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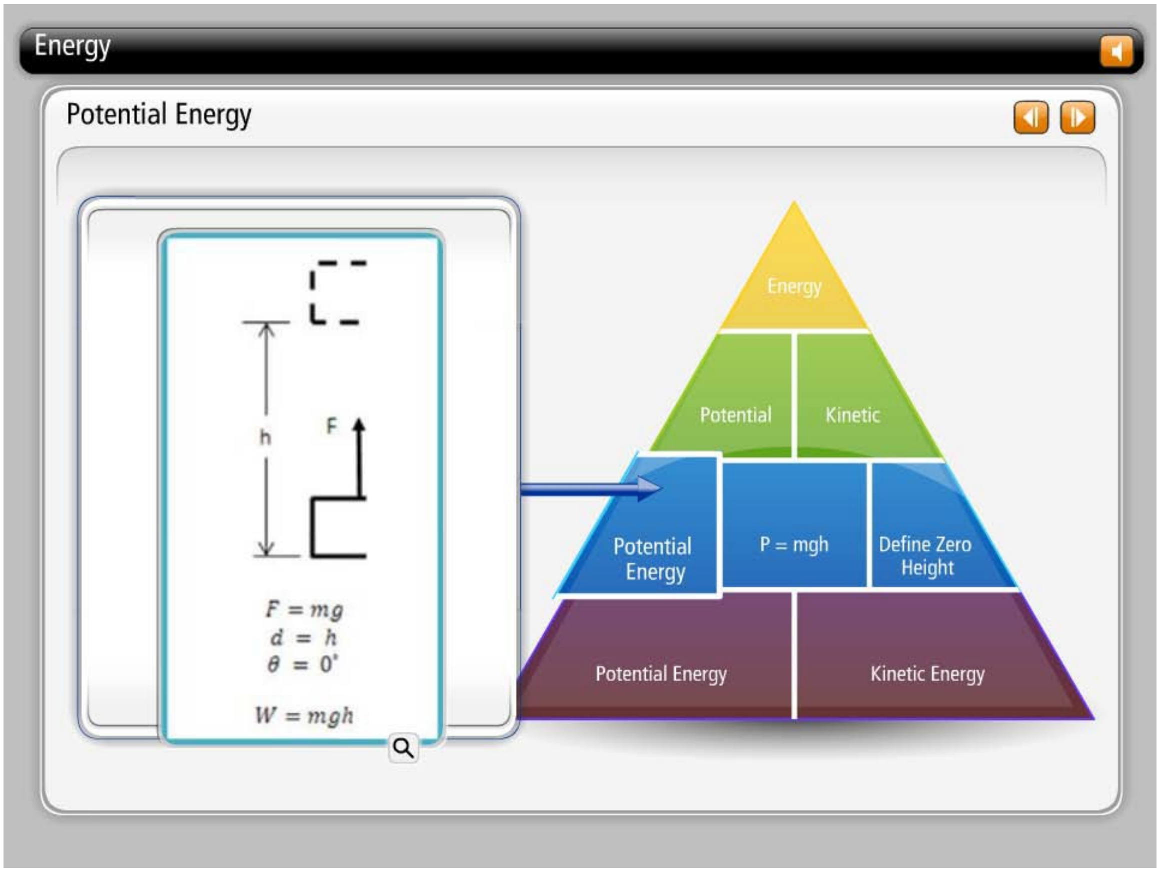


Now, let's take a closer look at gravitational potential energy. Since it is the one type of potential energy we are going to explore in depth, you will simply refer to it as potential energy. You would only specifically call it gravitational potential energy if there were another type of potential energy involved.

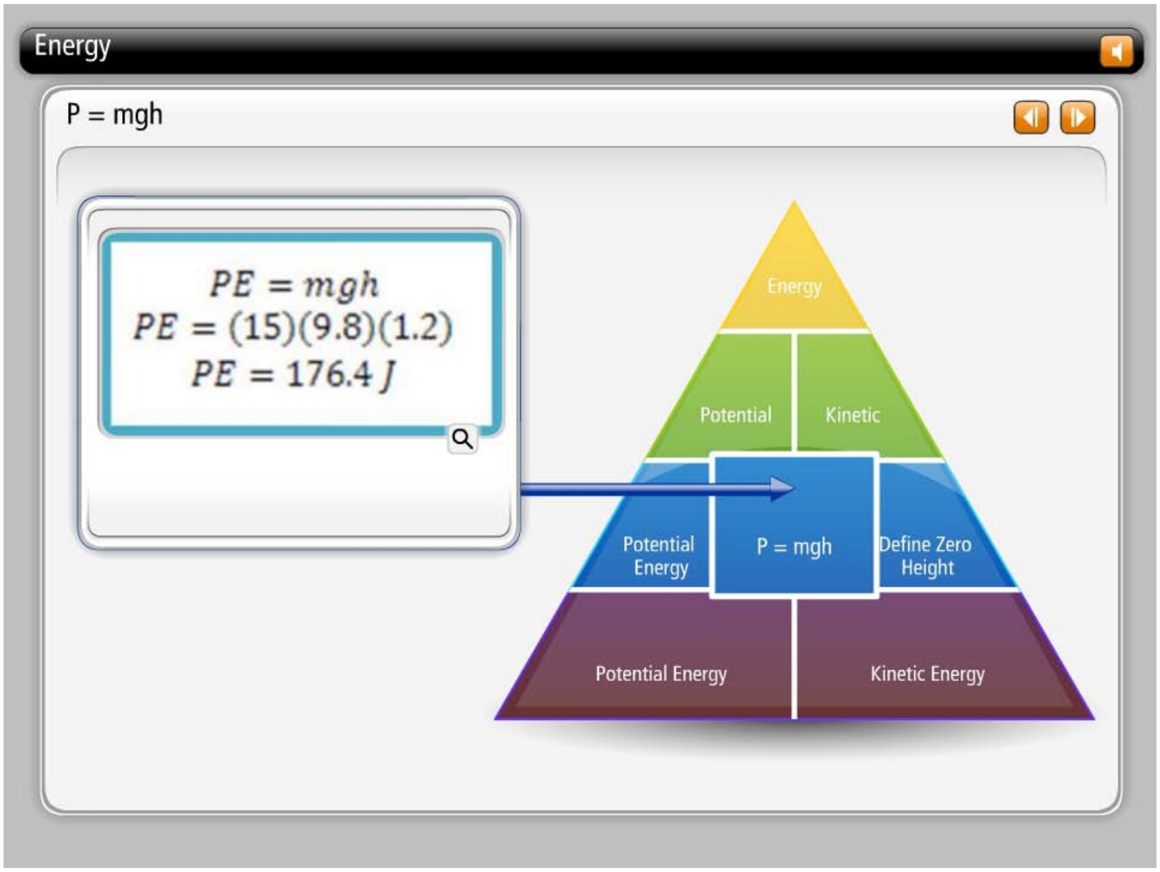
In an earlier lesson you looked at the work done by a boy lifting a box to a shelf.

The force that the boy had to apply was equal and opposite to the gravitational force on the box, m g. The distance that the box moved was the height of the shelf, which you'll now call h.

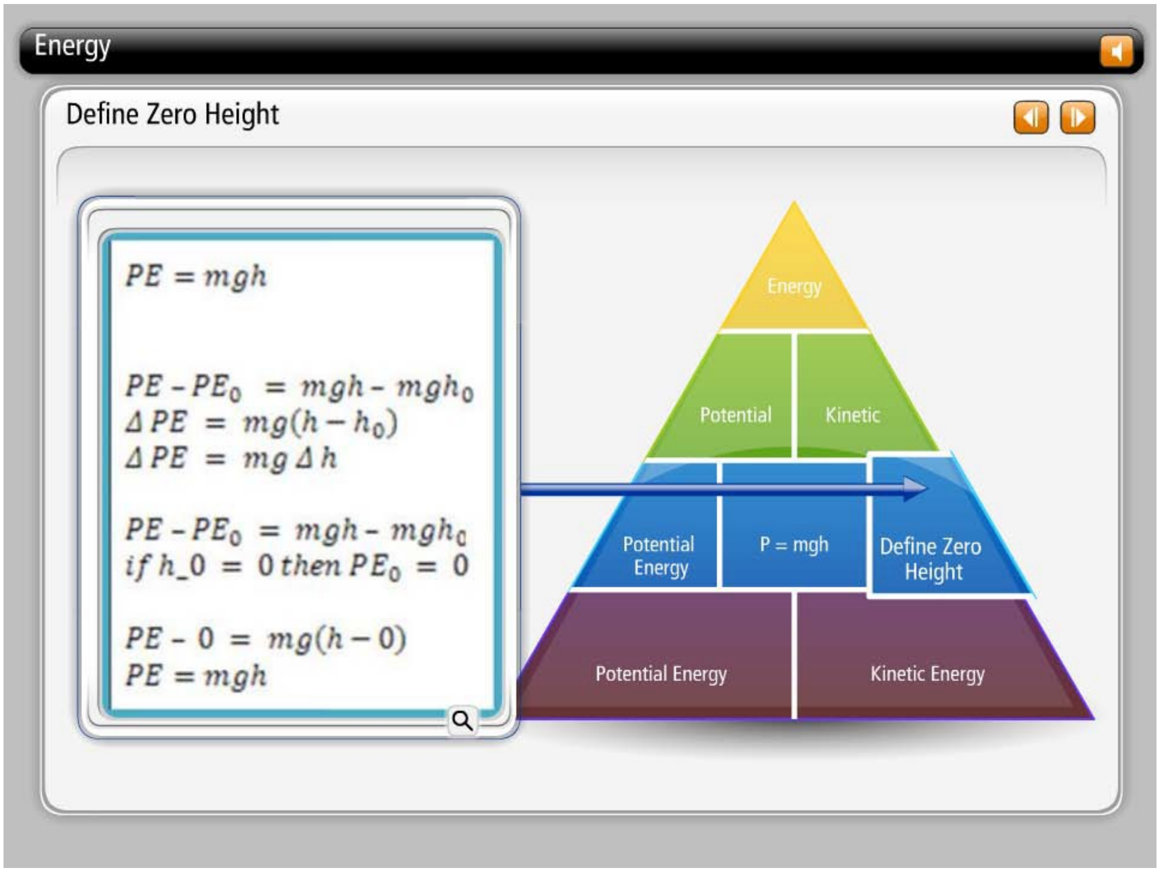
When lifting an object straight up, the work you do to it is equal to the force times the distance, which is the same as m g h. Now that the box is at a higher position, it has gained potential energy.

The amount of potential energy it has gained is equal to the work done on it against the opposing force of gravity, which is m g h.

You use the letters P E for potential energy. So you can write the equation for potential energy as P E equals m g h.



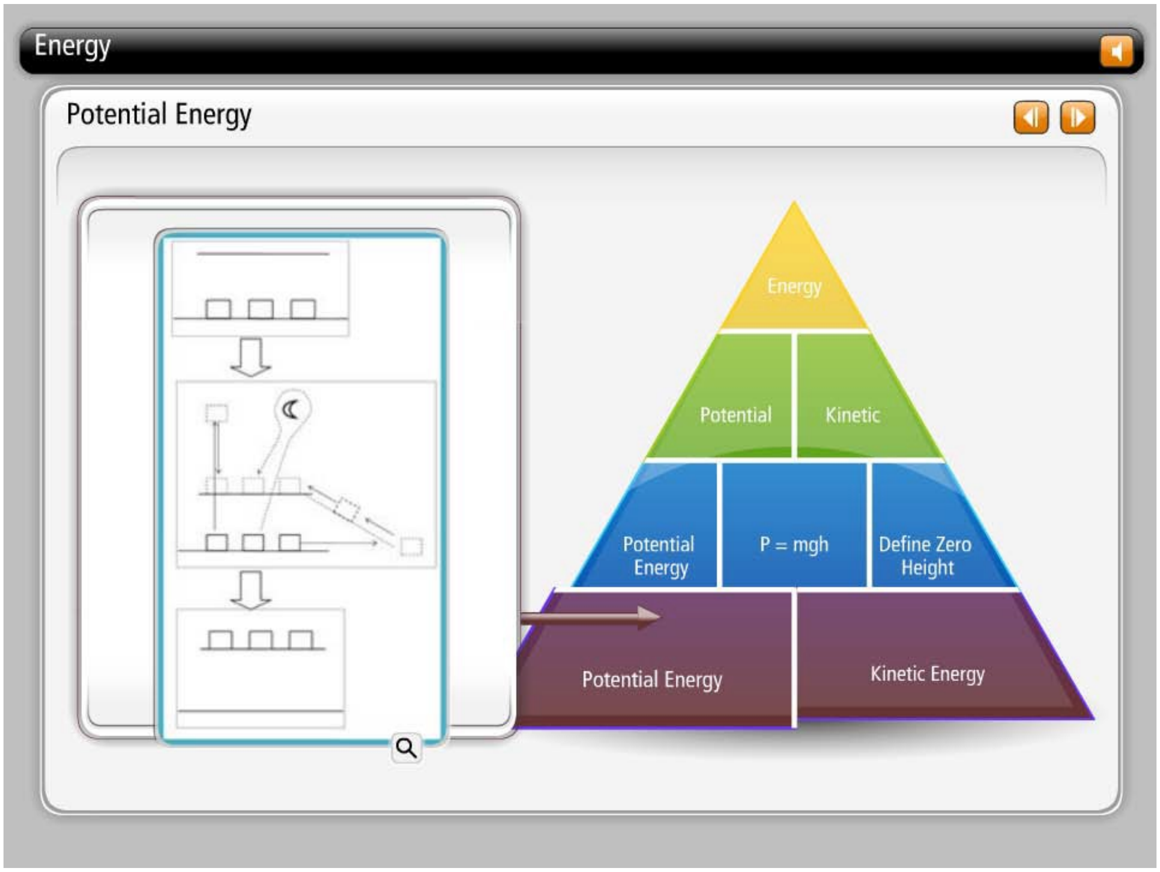
Again, if the box is fifteen kilograms, and it is lifted to a shelf that is one point five meters above the floor, you'd calculate the potential energy with the equation PE equals m g h. Substituting and solving, you find the potential energy on the shelf to equal one hundred seventy six point four Joules. This is the same amount you calculated earlier using Work.



It is important to note that in this example, you were considering the height of the floor to be zero, so the height of the shelf was considered h.

To be more precise, we would say that the change in potential energy is equal to the work done against gravity, which is the mass times the gravitational acceleration times the change in height.

When solving physics problems, you are free to choose where to define zero height to make the problem easier to work through, as long as you are consistent about your choice for that problem. If it is not specified, you should assume that the floor is at a height of zero. When this is the case, the potential energy is m g h.



Potential energy is a state function. This means that it doesn't matter how the box got from the floor to the shelf.

If it had zero potential energy on the floor, and it has the quantity m g h of potential energy on the shelf, then no matter what the path from the floor to the shelf, the potential energy on the shelf is the same.

Imagine you see three boxes on the floor. You leave the room. Then one box was lifted high above the shelf then lowered back to the shelf, the second box was pushed along the floor to a ramp, then pushed up the ramp to the shelf, and the third box was put on a spaceship, travelled around the moon and returned to land on the shelf. When you return to the room, you would see three identical boxes sitting side by side on the shelf.

Each box now has the same potential energy.

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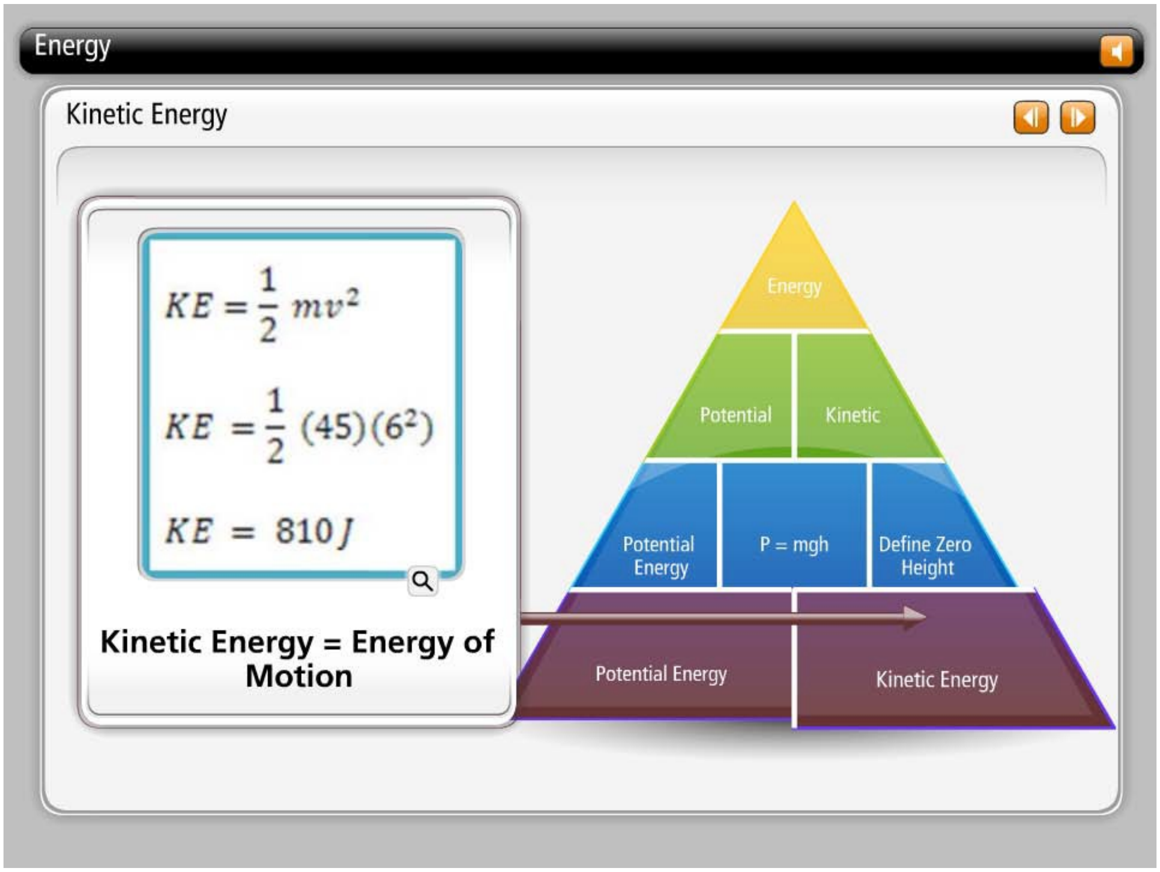

Kinetic energy is the energy of motion. When an object is moving it has kinetic energy. When you do work on an object and it speeds up, the object has gained kinetic energy.

Kinetic energy is proportional to the mass and the square of the speed, and the equation for kinetic energy is K E equals one half mass times speed squared.

If a forty five kilogram go cart is moving at six meters per second, the kinetic energy can be calculated using our formula.

K E equals one half m v squared. Substituting and solving we see that the kinetic energy is equal to eight hundred ten Joules.

What if the cart were moving in the other direction? The velocity could be considered to be negative six meters per second, but the speed remains positive.

Kinetic energy is a scalar quantity, not a vector, so the direction of motion does not matter when calculating kinetic energy.

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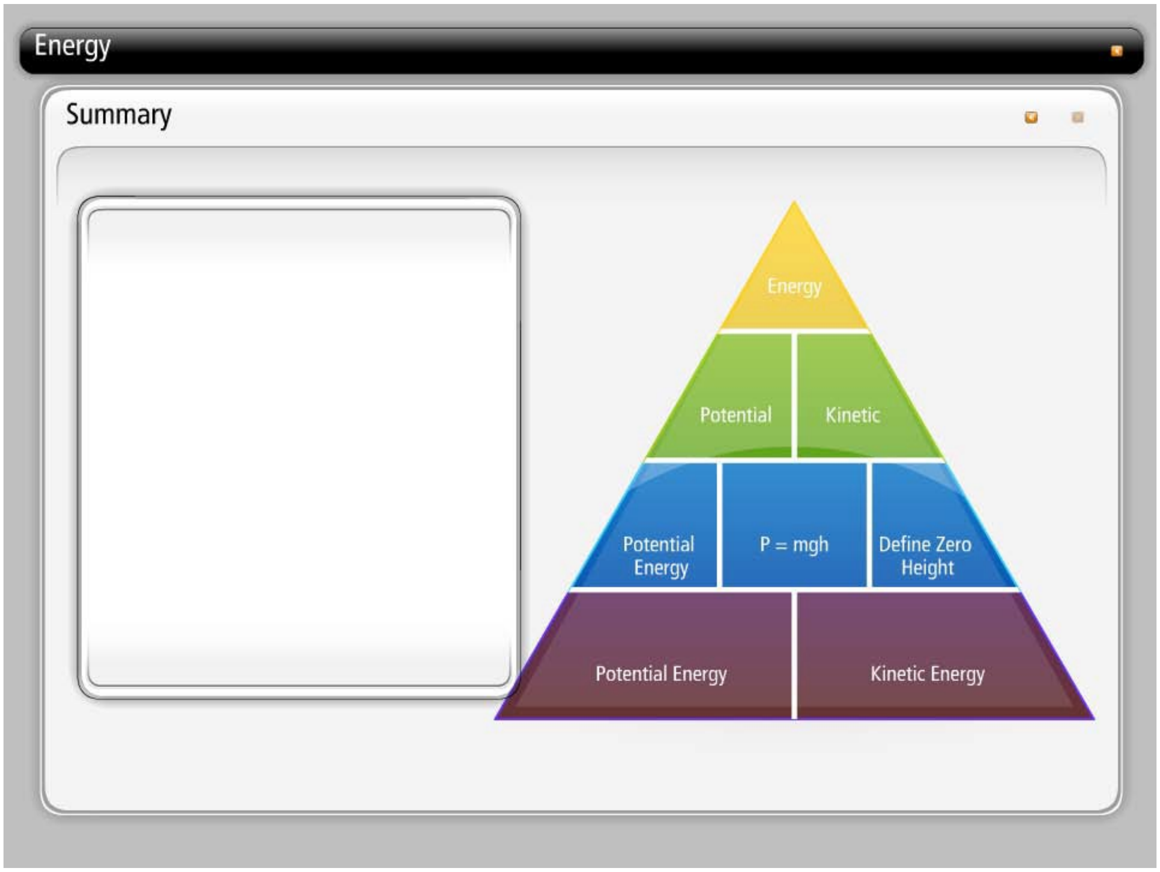

In summary, energy is defined as the capacity to do work. Energy takes many forms and can be changed from one form to another. However, during these transformations, the total amount of energy remains the same.

Just like work, energy is measured in Joules.

Potential energy is the energy that an object has due to its position or state. One type of potential energy is gravitational potential energy which is equal to the mass of the object times the gravitational acceleration times the height above some specified point.

Kinetic energy is the energy of motion and is equal to one half of the product of the mass of the object times the speed squared.

Both potential and kinetic energy are types of mechanical energy.