

7.6 Conservation of Energy



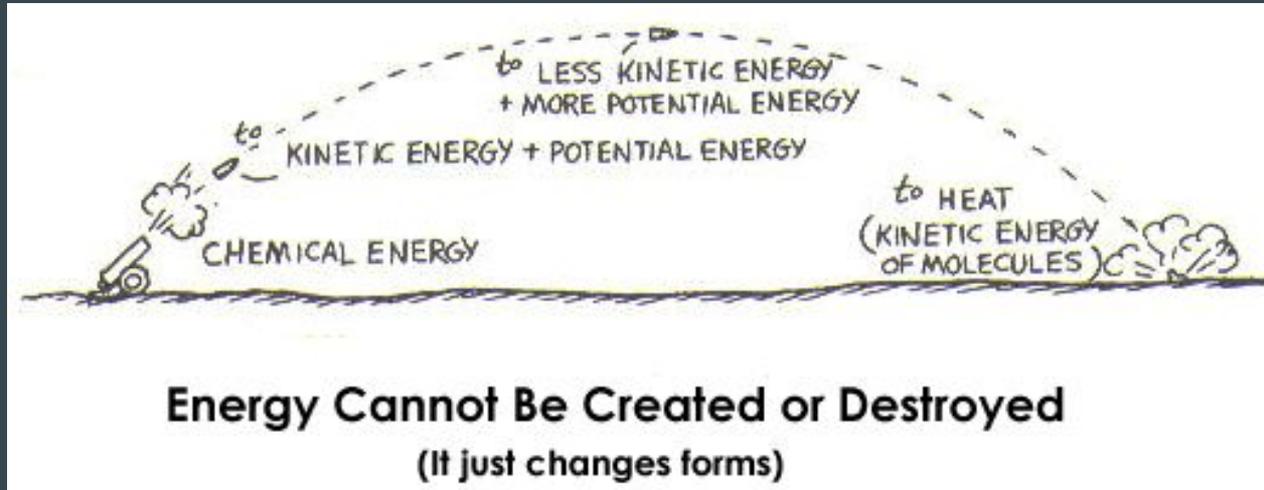
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Learning Objectives

1. Explain the law of the conservation of energy.
2. Describe some of the many forms of energy.
3. Define efficiency of an energy conversion process as the fraction left as useful energy or work, rather than being transformed, for example, into thermal energy.

Law of Conservation of Energy

Total energy is constant in any process, it may change in form or be transferred from one system to another, but the total remains the same.



Major Forms of Energy

- Mechanical Energy (KE + PE)
- Energy transferred via work done by non-conservative forces (W_{NC})
 - example: friction
 - Forces that do not store energy
- Other energy (OE)

As total energy is constant, this would mean:

$$KE_i + PE_i + W_{NC} + OE_i = KE_f + PE_f + OE_f$$

- KE= kinetic energy
- PE= work done by conservative energy
- W_{NC} = work done by non-conservative forces
- OE= all other energy besides mechanical energy

When does Other Energy (OE) play a role?

Example:

When a person eats-

chemical energy used when moving → KE

person changes altitude → PE

thermal energy → OE

Forms of Other Energy (OE)

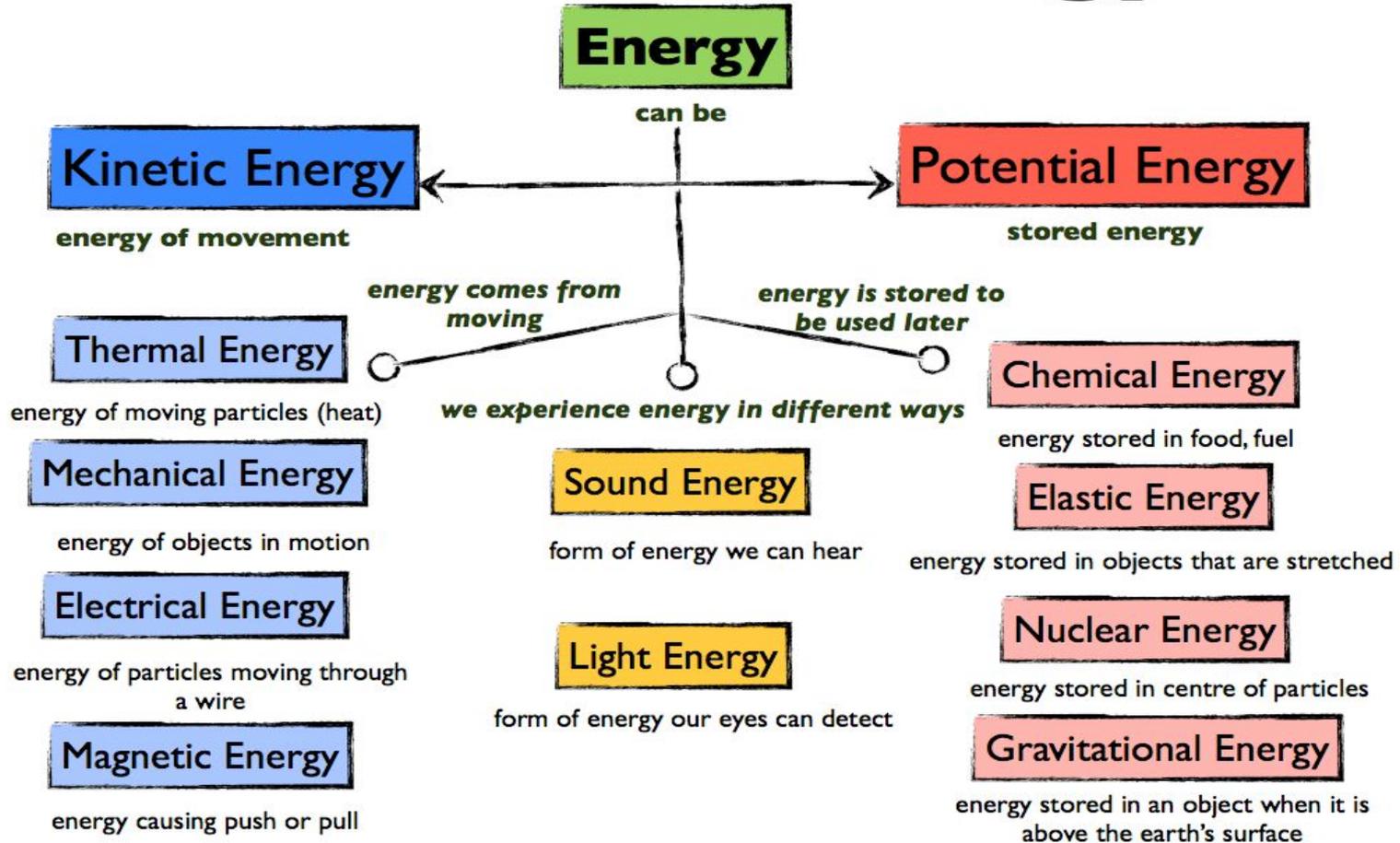
- Electrical Energy
- Chemical Energy
 - transferred to a system through oxidation
- Radiant Energy
 - electromagnetic radiation
- Nuclear Energy
 - mass is converted into energy
- Thermal Energy

Conservation of Energy - Energy cannot be created nor destroyed, it can only be transformed from one form to another.

The infographic is organized into six horizontal rows, each representing a different form of energy. Each row contains a title, an icon, and several small images illustrating that energy form.

- MECHANICAL**: Represented by a gear icon. Images include a person swinging a golf club, a person in a red shirt, a roller coaster, a red race car, and a group of cyclists.
- SOUND**: Represented by a tuning fork icon. Images include a bat, a dolphin, a group of people, a hand clapping, and a stack of books.
- ELECTRICAL**: Represented by a lightning bolt icon. Images include a lightning storm, a molecular model, a globe, a high-voltage power line, and a circuit board.
- LIGHT**: Represented by a lightbulb icon. Images include a rainbow, a sunset, a satellite dish, a lightbulb, a box, and an X-ray.
- HEAT**: Represented by a flame icon. Images include a candle, a fire, a thermometer, a gas stove, a graph titled 'Amount of Thermal Energy' showing a red line on a coordinate plane with axes labeled 'mass' and '200 500 750', and a mug of coffee.

Forms of Energy



Transformation of Energy

more examples!

1. chemical energy in food



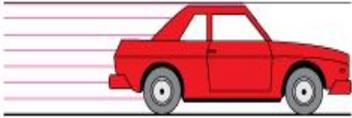
thermal energy through metabolism

2. light energy

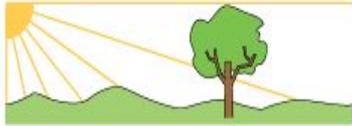


chemical energy through photosynthesis

Changing forms of energy



An automobile engine changes chemical energy to mechanical and heat energy.



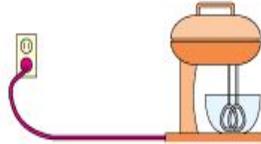
A tree changes radiant energy to chemical energy.



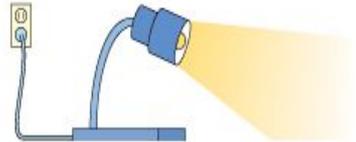
Hammering a nail changes mechanical energy to deformation and heat energy.



A thermonuclear reaction changes nuclear energy to radiant and heat energy.



An electric mixer changes electrical energy to mechanical and heat energy.



A lamp changes electrical energy to radiant and heat energy.

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Efficiency

Equation:

$$\text{Efficiency (Eff)} = \frac{\text{useful energy or work output}}{\text{total energy input}} = \frac{W_{\text{out}}}{E_{\text{in}}}$$

Efficiency Example

Coal Power Plant → 42% efficient

About 40% of the chemical energy in coal becomes useful electrical energy. The other 60% transforms into other (maybe less useful) energy forms, such as thermal energy which is released to the environment.

Table 7.2 Efficiency of the Human Body and Mechanical Devices

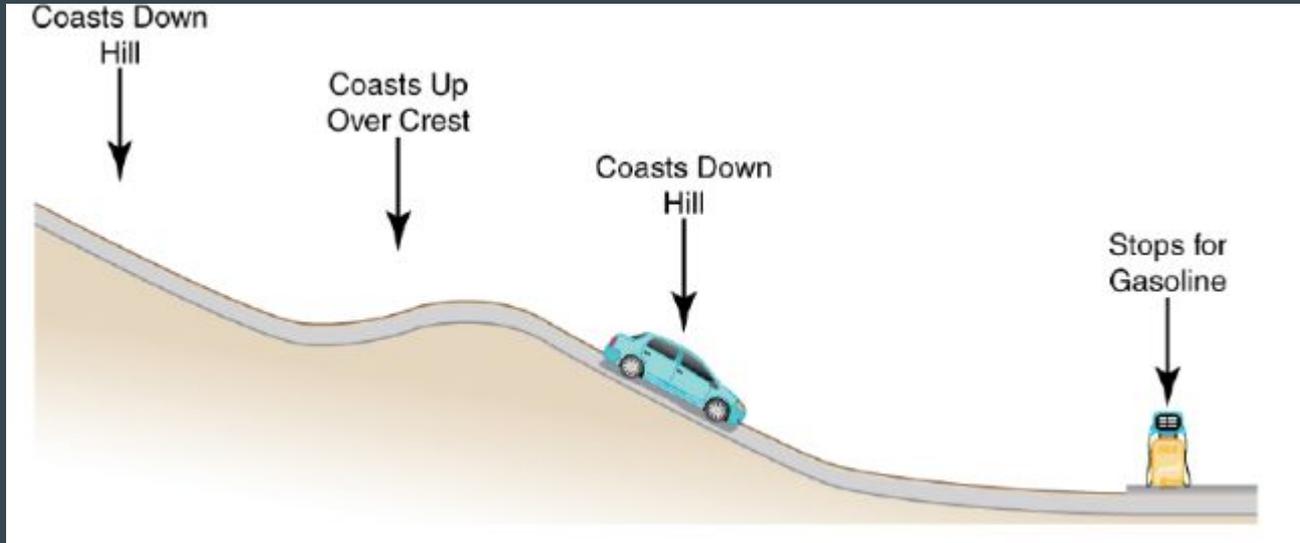
| Activity/device | Efficiency (%) ^[1] |
|---------------------------|-------------------------------|
| Cycling and climbing | 20 |
| Swimming, surface | 2 |
| Swimming, submerged | 4 |
| Shoveling | 3 |
| Weightlifting | 9 |
| Steam engine | 17 |
| Gasoline engine | 30 |
| Diesel engine | 35 |
| Nuclear power plant | 35 |
| Coal power plant | 42 |
| Electric motor | 98 |
| Compact fluorescent light | 20 |
| Gas heater (residential) | 90 |
| Solar cell | 10 |

sing along

<https://www.youtube.com/watch?v=k60jGJfV8oU>

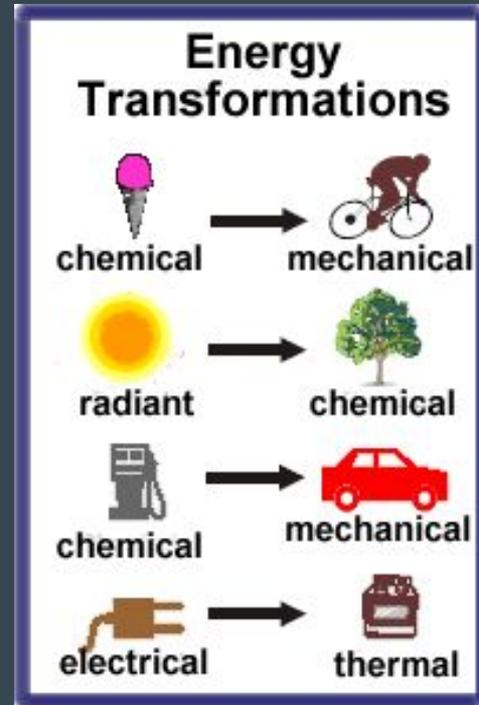
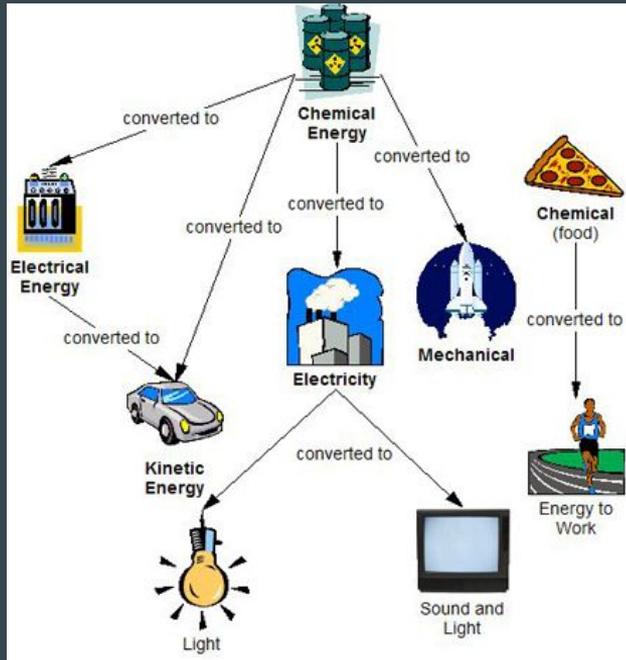
Textbook Problems (Conceptual)

13) A car for which friction is not negligible accelerates from rest down a hill, running out of gasoline after a short distance. The driver lets the car coast farther down the hill, then up over a small crest. He then coasts down the hill into a small gas station, where he brakes to a stop and fills the car with gas. Identify the forms of energy the car has, and how they are changed and transferred in this series of events.



Textbook Problems (Conceptual)

16) List four different forms or types of energy. Give one example of a conversion from each of these forms to another form.



Textbook Problems (Problems & Exercises)

28) If the energy in fusion bombs were used to supply the energy needs of the world, how many of the 9-megaton variety would be needed for a year's supply of energy (using Table 7.1)?

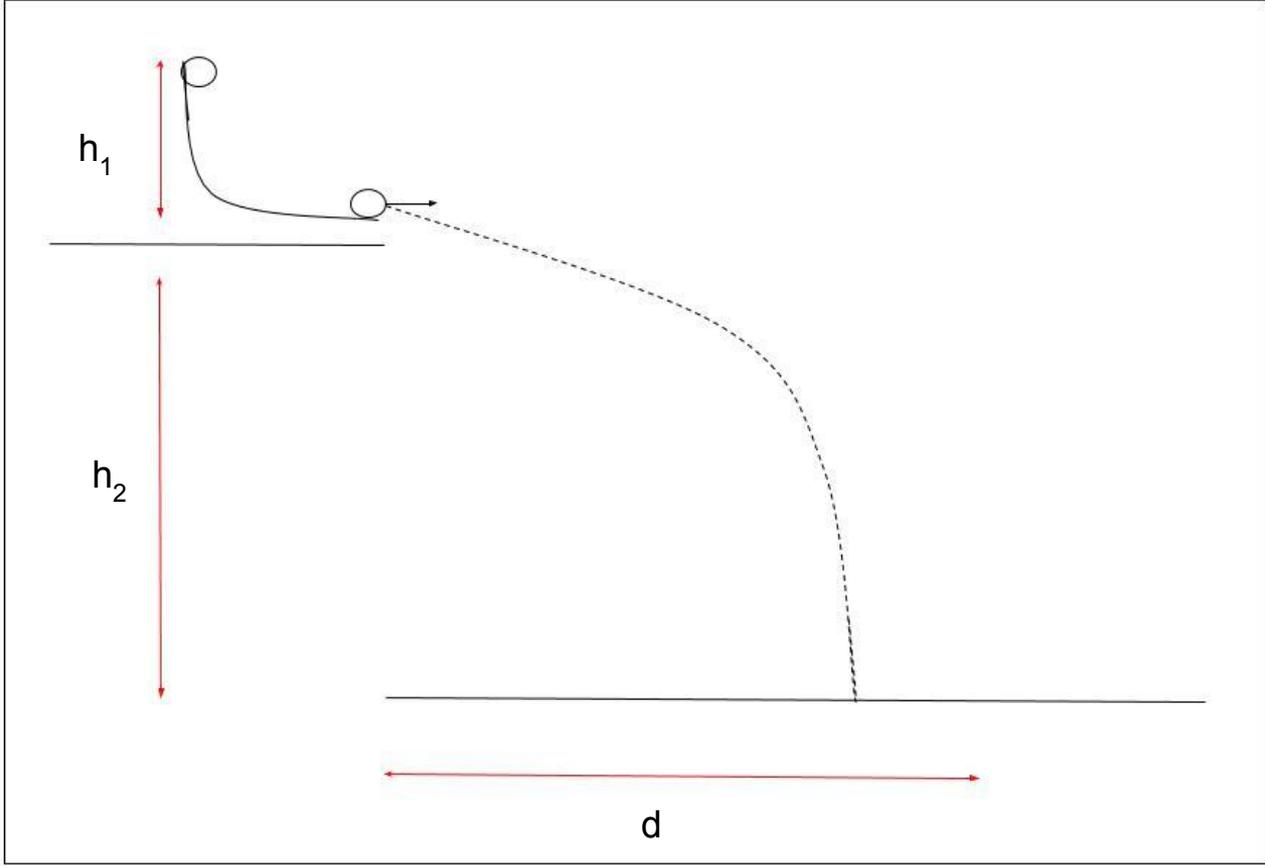
Table 7.1 Energy of Various Objects and Phenomena

| Object/phenomenon | Energy in joules |
|--|----------------------|
| Big Bang | 10^{68} |
| Energy released in a supernova | 10^{44} |
| Fusion of all the hydrogen in Earth's oceans | 10^{34} |
| Annual world energy use | 4×10^{20} |
| Large fusion bomb (9 megaton) | 3.8×10^{16} |

$$\frac{4 \times 10^{20}}{3.8 \times 10^{16}} = 10526.3$$

10527 Fusion bombs would be needed annually.

Conservation of Energy Lab



DATA TABLE



| | |
|----------------|-------------|
| Ramp Height | .135 meters |
| Table Height | .78 meters |
| Mass o' Marble | 0.0069 kg |
| Distance | .48167 m |
| | |

Calculation Time

1. Calculate the average horizontal distance (meters) traveled by the marble.
2. Calculate the time elapsed (seconds) from when the ball left the ramp until it hit the floor using where g is the acceleration due to gravity.
3. Calculate the horizontal velocity (m/s) of marble when it's at the bottom of the ramp using
4. Calculate the potential energy (mJ) of the marble at the top of the ramp where g is the acceleration due to gravity and m is the mass in grams.
5. Calculate the kinetic energy (mJ) of the marble at the bottom of the ramp

| | |
|---------------------|-----------|
| Average Distance | .48167 m |
| Time Elapsed | 0.39 sec |
| Horizontal Velocity | 1.2 m/s |
| Potential Energy | 0.009 J |
| Kinetic Energy | 0.00502 J |

Conclusions

If mechanical energy was conserved as the marble went down the ramp, how should the amount of potential energy at the top of the ramp compare to the amount of kinetic energy at the bottom of the ramp? (At the top of the ramp, KE was zero. At the bottom of the ramp, PE was zero.)

- Find the difference between your calculated values for potential and kinetic energy. How close were these two values? Was mechanical energy conserved?
- Explain how your lab results can be consistent with the law of conservation of energy. Where did the missing energy go?