7.6 Conservation of Energy

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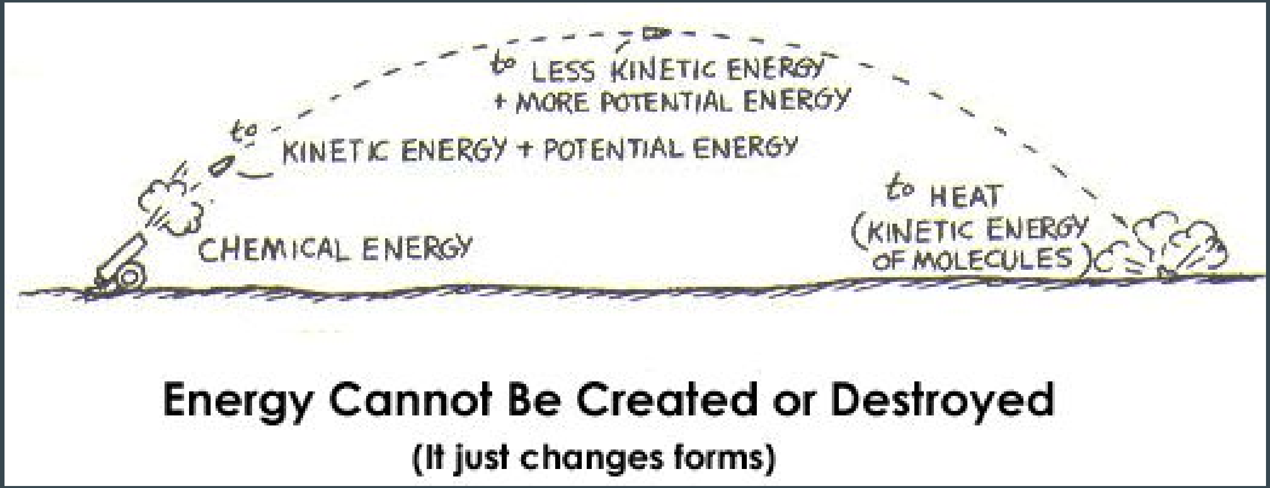
Learning Objectives

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 traction 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-

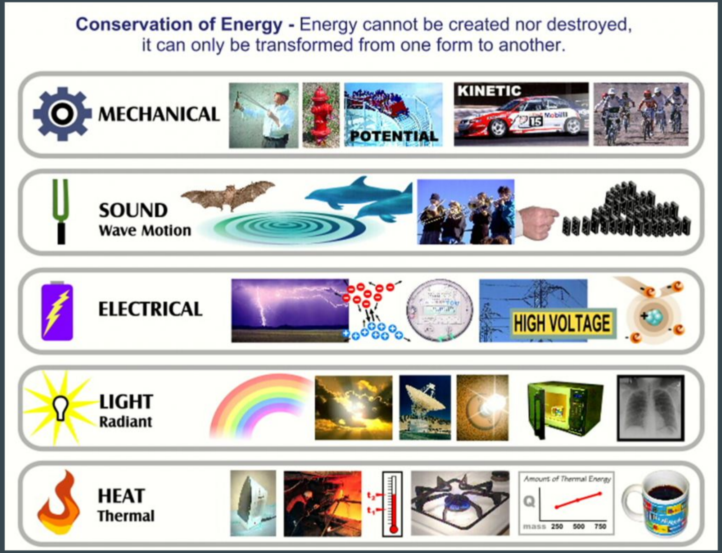
chemical energy used when moving→ KE

person changes altitude → PE

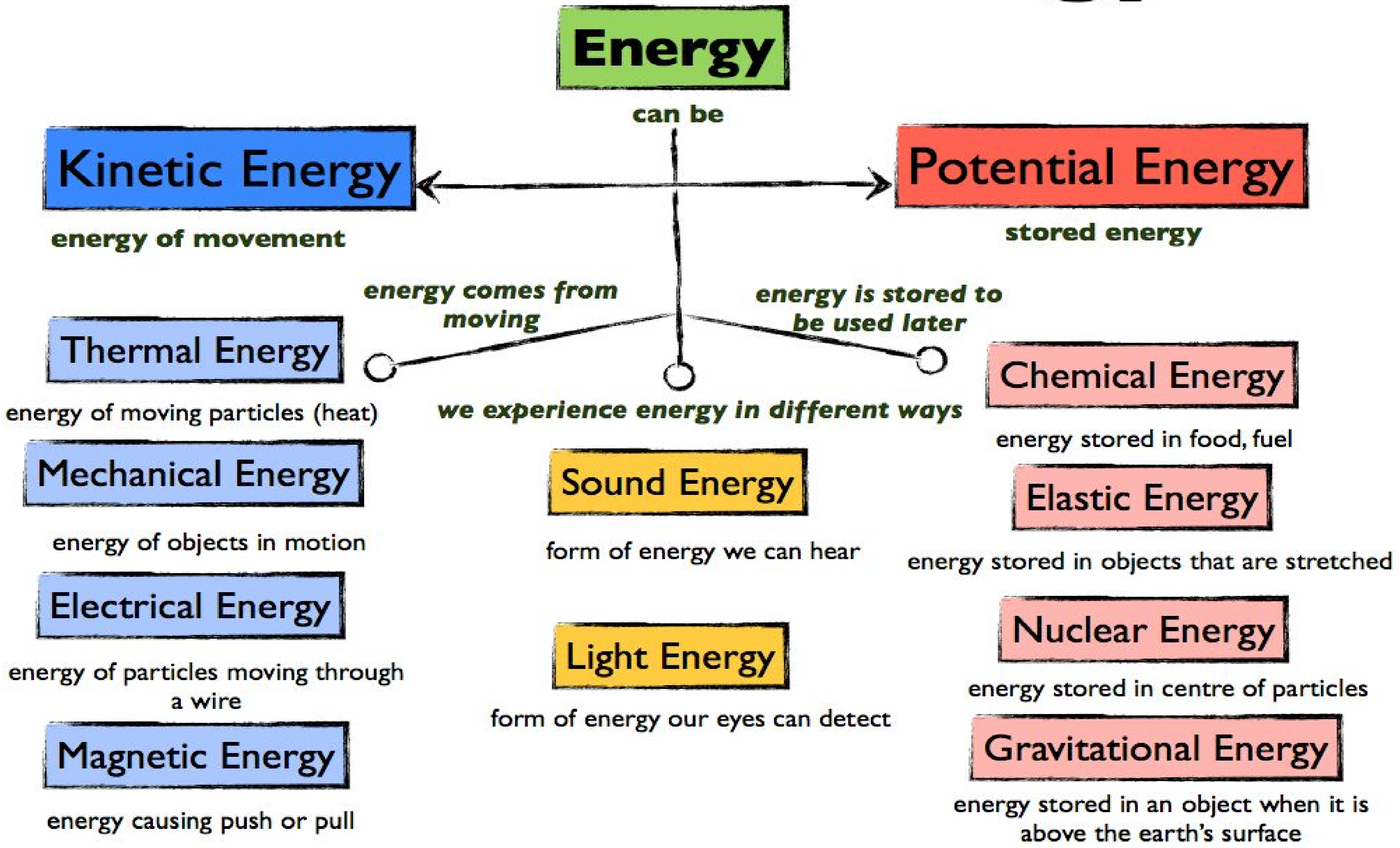
thermal energy → OE

Forms of Other Energy (OE)

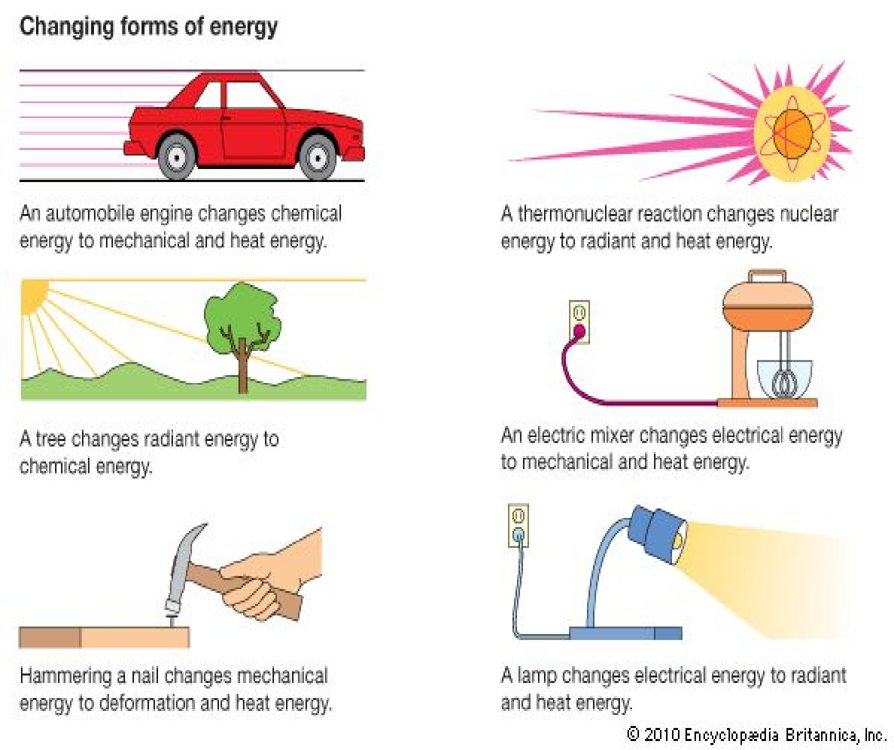
- Electrical Energy
- Chemical Energy
  - transferred to a system through oxidation
- Radiant Energy
  - electromagnetic radiation
- Nuclear Energy
  - mass is converted into energy
- Thermal Energy



Forms of Energy



Transformation of Energy



more examples!

1. chemical energy in food

↓

thermal energy through metabolism

2. light energy

↓

chemical energy through photosynthesis

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

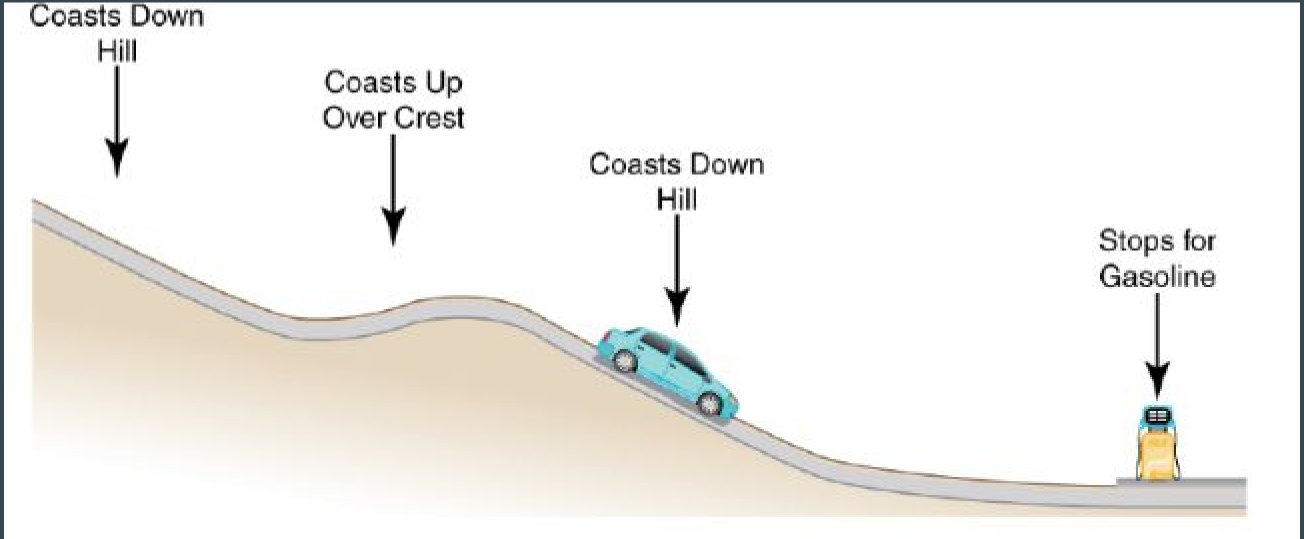
Activity/device	Efficiency (%)[1]
Cycling and climbing	20
Swimming, surface	2
Swimming, submerged	4
Shoveling	3
Weightlifting	9
Steam engine	17
Gasoline engine	30
Diesel engine	35
Nuclear power plant	35
Coal power plant	42
Electric motor	98
Compact fluorescent light	20
Gas heater (residential)	90
Solar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

sing along

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

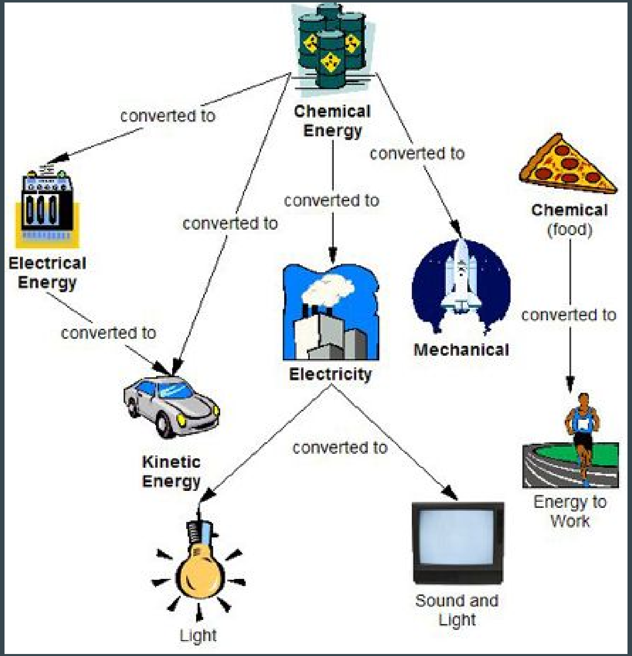
Textbook Problems (Conceptual)

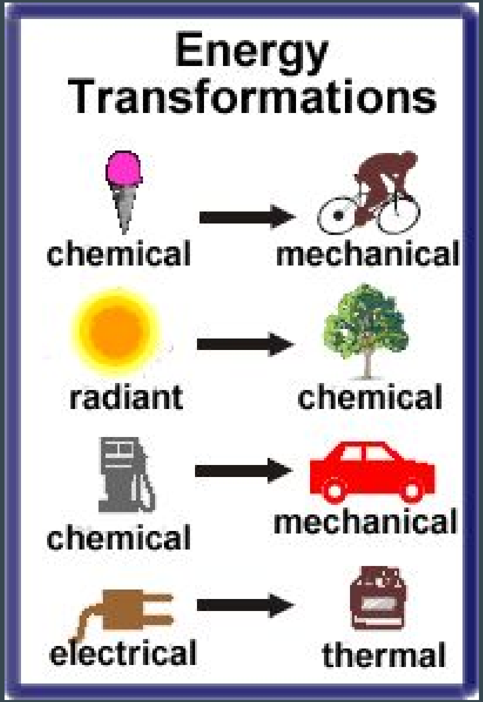
13) A car for which friction is not negligible accelerates from rest down a hill, running out of gasoline after a short distance. The driver lets the car coast farther down the hill, then up over a small crest. He then coasts down the hill into a small gas station, where he brakes to a stop and fills 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)?

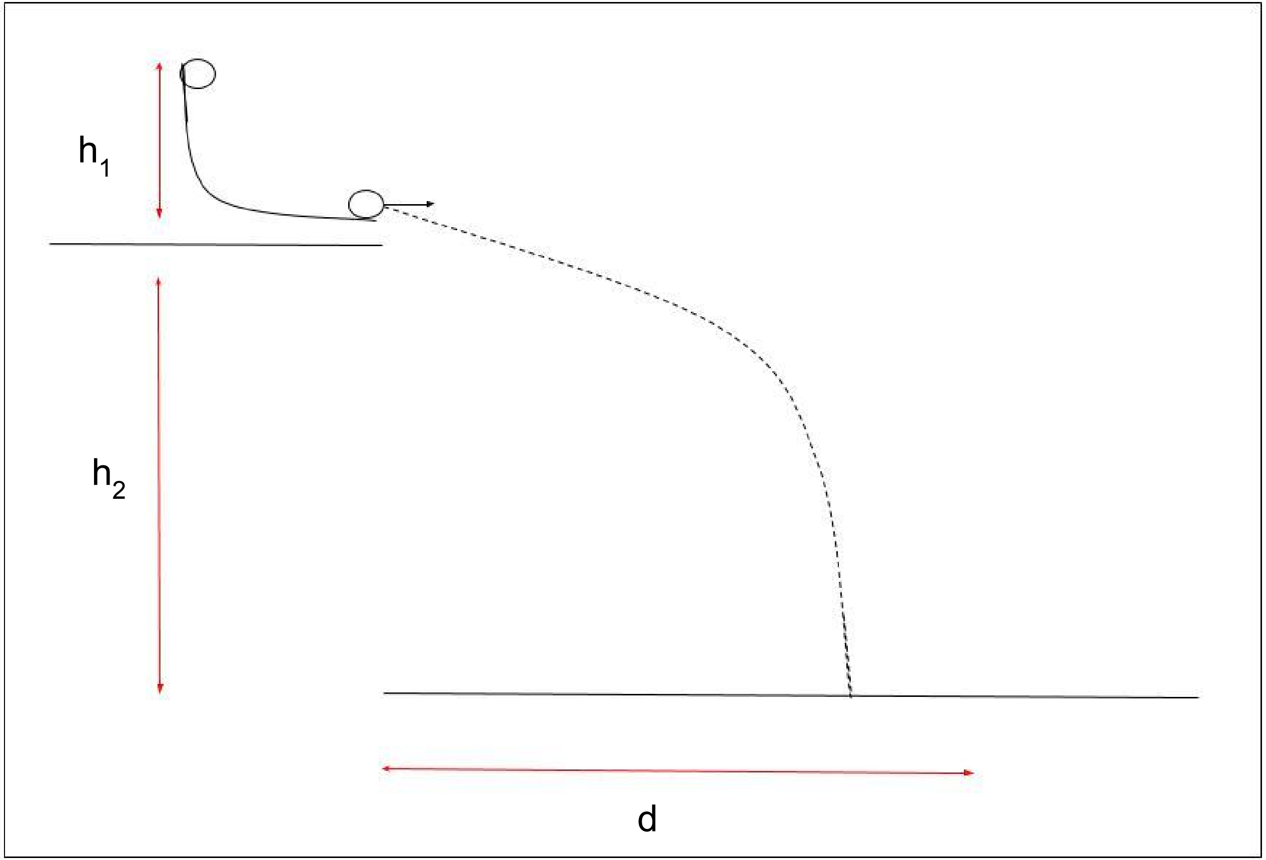
Table 7.1 Energy of Various Objects and Phenomena

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?