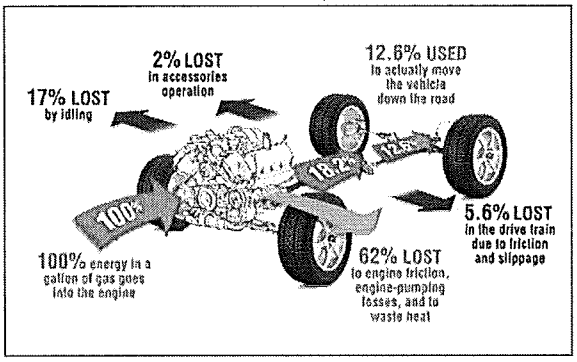
Lesson 9: Efficiency

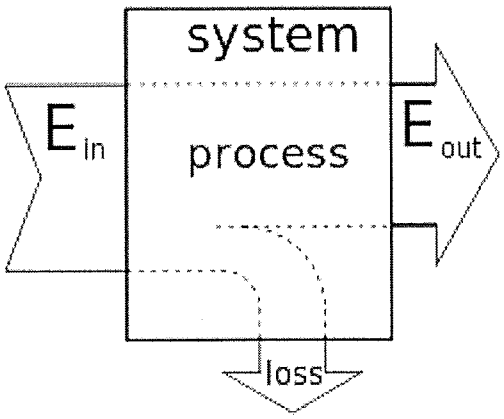
What is Thermal Energy?

The law of conservation of Energy states that in any transfer or transformation of energy, the total amount of energy remains constant. Unfortunately the energy may not be in the form that we desired.



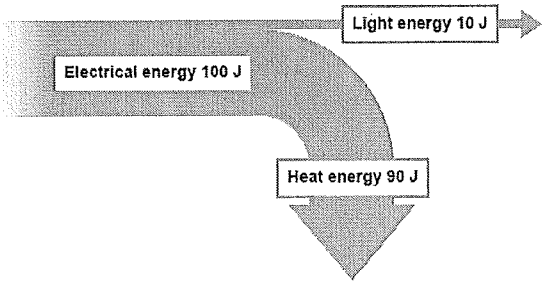
This diagram illustrates the paths of energy through a typical gas-powered vehicle in city driving.

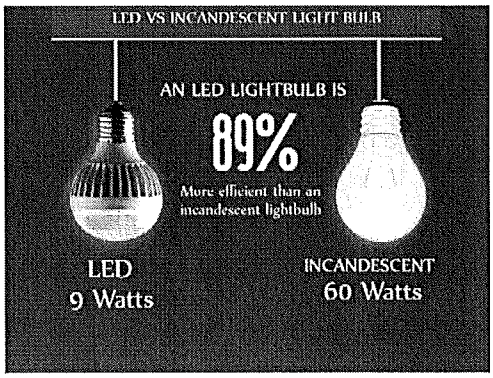
People use machines to transform or transfer energy. Unfortunately they will never be 100% efficient. The efficiency of any machine can be determined by the following:



$$\text{Efficiency} = \frac{\text{useful energy output}}{\text{energy input}} \times 100\%$$

A typical light bulb is very inefficient





Example: A 1500W kettle heats 1.5kg of water from 18°C to 59°C in 3.0 minutes.

A) How much electrical energy did the kettle use?

$P = W/t$ or $W = P \times t$

$W = 1500W \times 180s$

Work done by kettle = $2.7 \times 10^5 J$

B) How much heat energy was delivered to the water?

$\Delta E_h = mc\Delta T$

$\Delta E_h = 1.5kg \times 4200J/kg°C \times (59 - 18)°C$

$\Delta E_h = 2.6 \times 10^5 J$

C) What is the efficiency of the kettle?

$$\text{Efficiency} = \frac{\text{useful energy output}}{\text{energy input}} \times 100\%$$

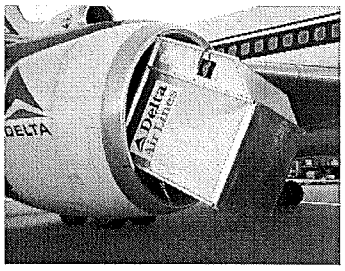
$$\text{Efficiency} = \frac{2.6 \times 10^5 J}{2.7 \times 10^5 J} \times 100\%$$

Efficiency = 96%

Example: A rocket engine takes in 800J of chemical energy and changes this into 480J of kinetic energy and 320J of heat energy.

$$\text{Eff} = \frac{480J}{800J} \times 100\% = 60\%$$

Example: A jet engine gas turbine takes in 1200J of chemical energy and gives out 960J of kinetic, 180J of heat and 60J of sound energy.



$$\text{Eff} = \frac{960J}{1200J} \times 100\% = 80\%$$

Example: A TV takes in 600J of electrical energy and gives out 300J of light, 240J of sound and 60J of heat energy

$$\text{Eff} = \frac{(300J + 240J)}{600J} \times 100\%$$

$$= 90\%$$

Additional Practice:

1. What is the law of conservation of energy?

The total amount of energy remains constant.

2. What is the formula for calculating the efficiency of a system?

$$\text{Efficiency} = \frac{\text{useful energy output}}{\text{energy input}} \times 100\%$$

3. What does most of the energy of a system usually transform into?

Heat

4. What is the efficiency of a car if the car uses 1000 J of chemical potential energy and only 100J of kinetic energy is produced?

$$\text{Eff} = \frac{100\text{J}}{1000\text{J}} \times 100\% = 10\% \text{ efficient}$$

5. If an electric car is 80% efficient then how much electric potential energy is used by the car when 333 J of kinetic energy is produced?

$$\text{Eff} = \frac{\text{output}}{\text{input}} \times 100\%$$

$$80\% = \frac{333\text{J}}{\text{input}} = (\text{input}) \times 0.80 = 333\text{J}$$

$$\text{input} = \frac{333\text{J}}{.80}$$

$$= 416.25\text{ J}$$