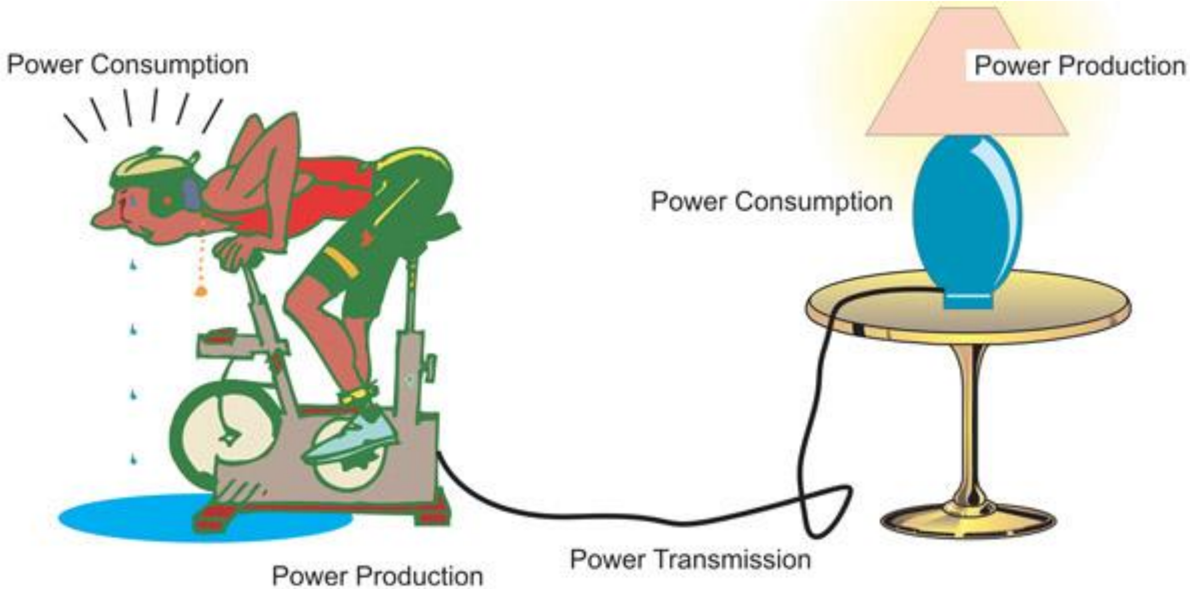
Power & Efficiency



Part I - Power

Power

POWER: the rate of doing work or transforming energy

Example: Two students (both mass 65 kg) run up the CN tower (342m high) in the CN stair climb. Student A finishes in 16 minutes and student B finishes in 22 minutes.

Who exerted more power?

Both have done the same amount of WORK To increase their gravitational potential energy!!

Student A has done the work faster!!!

We say that A is more POWERFUL!

POWER: the rate of doing work or transforming energy

$$P = \frac{Work\ done}{time\ taken} = \frac{W}{\Delta t}$$

OR

$$P = \frac{Energy\ Transformed}{time\ taken} = \frac{\Delta E}{\Delta t}$$

Units of Power: Joules/Second or Watt

1 J/s = 1 Watt

1 Watt is a very small power output! We commonly use a larger unit of kilowatt

1 kW = 1000 W

Back to our example…

Two students (both mass 65 kg) run up the CN tower in the CN stair climb. Both climb a distance of 342 m but student A finishes in 16 minutes and student B finishes in 22 minutes.

How much power did each student develop?

Work done = ΔE_g= $mg\Delta h$

$$P = \frac{Work\ done}{time\ taken} = \frac{W}{\Delta t}$$

Answer: Power Student A = 2.27 x 10^2 W,

Power Student B = 1.65 x 10^2 W

Sample Power Questions

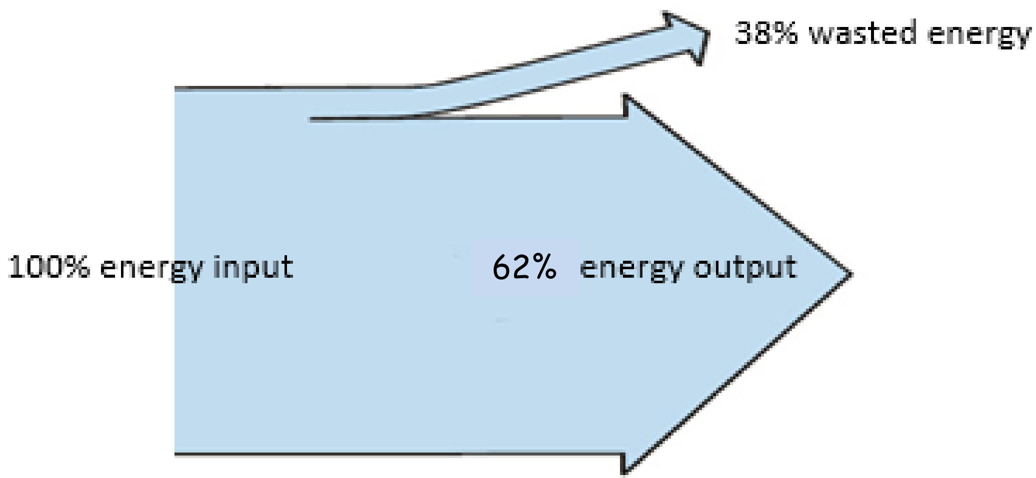
1. What is the power of an elevator motor if it uses 2.9×10^5 J to lift an elevator car one story in 16 s?
   - $P = \Delta E / \Delta t$
   - $P = 2.9\times10^5 \text{ J} / 16 \text{ s} = 1.8\times10^4 \text{ J/s} = 1.8\times10^4 \text{ W}$

2. If a 60 W light bulb is left on for ten hours (3.6×10^4 s), how much energy is transformed?
   - $P = \Delta E / \Delta t$ or $\Delta E = P \times \Delta t$
   - $\Delta E = 60 \text{ W} \times 3.6\times10^4 \text{ s} = 2.2\times10^6 \text{ J}$

Part II - Efficiency

Efficiency: every device when it transforms energy “wastes” energy by converting it into unwanted forms

e.g. a light bulb produces waste heat



No real system is 100% efficient

- Some percentage of energy is always converted to an non-useful form
  - E.g. Noise, heat, friction, etc.

- For example, A standard light bulb
  - 95% energy wasted as heat
  - Only 5% useful light

- A compact fluorescent light bulb is better
  - 20 % useful light, 80% wasted heat

- Led light bulbs are the future
  - 75 % useful light, 25% wasted heat

Efficiency: of a device is the ratio of the useful energy output to the energy input

$$\% \, Efficiency = \frac{Useful\ Energy\ Output}{Energy\ Input} \ x\ 100\%$$

$$= \frac{Eout}{Ein} \ x\ 1oo\%$$

**Note:* E_{out} *is* <u>*always*</u> *less than* E_{in}

Example:

A fluorescent light bulb converts 180 J of input electrical energy into 36 J of radiant energy. What is the percent efficiency of a fluorescent light bulb?

$$\%\, Efficiency = \frac{Useful\ Energy\ Output}{Energy\ Input}\ x\ 100\%$$

Efficiency Questions

1. Fireflies use chemical energy to create a glow in their abdomen. What is a firefly's efficiency if it transforms 4.13 J of chemical energy into 3.63 J of radiant energy?
   - efficiency = 87.9 %

2. What is the efficiency of a pulley system if 1.93×10^3 J of mechanical energy is used to lift a 20 Kg mass to a height of 7.5 m?
   - efficiency = 76.3%