Power

→ the rate at which work is done or energy is transformed

ex → a fast car consumes alot of gas (energy) quickly

→ a fast car converts chemical energy into mechanical energy quickly

$$\boxed{\text{Power} = \frac{\text{Work}}{\text{time}}} = \frac{\text{energy transformed}}{\text{time}} = \frac{J}{s}$$

→ the power of a horse refers to how much work it can do per unit of time

→ the power rating of a motor can refer to how much chemical energy can be transformed into mechanical energy per unit of time

Ex. A 70 kg jogger runs up a long flight of stairs, a vertical height of 4.5 m, in 4.0 seconds. What was the joggers power output

The work done is against gravity $W = mgh$

$$P = \frac{W}{t} = \frac{mgh}{t} = \frac{(70\,kg)(9.8\,\frac{N}{kg})\,4.5\,m}{4.0\,s}$$

$$= 770\,W$$

humans cannot do work at this rate for very long but a horse can!

Units of ~~Work~~ Power

Since $= \frac{W}{t}$ then the units are $\frac{J}{s}$

$1 \frac{J}{s} = 1 \text{ Watt } (W)$

Other units → Kw, hp (horsepower)

$1 \text{ hp} = 746 \text{ W}$

It is often convenient to write power in terms of the net force (F) applied to an object and its speed (v).

Since $P = \frac{W}{t}$ and $W = Fd$

then $P = \frac{Fd}{t}$ and $v = \frac{d}{t}$

so $\boxed{P = Fv}$

Efficiency

the ease at which a machine transfers its power

or

the ratio of output work to input work

$$Eff = \frac{W_O}{W_I} \quad \text{or} \quad Eff = \frac{P_O}{P_I}$$

Efficiency can be expressed as a decimal or a percent

$$0.75 = 75\%$$

P_I = the power rating of the machine
ie the hair dryer is 1200 W

P_O = the observed power of the machine
ie must be calculated from observations

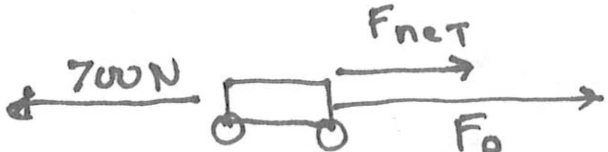
1) What is the efficiency of an elevator system that can lift a combined weight of 2600 N to a height of 35 m in 15 seconds if the power rating of the motor is 75 hp?

$$P_I = 75\,hp \times 746\,\frac{W}{hp} = 55950\,W$$

$$P_O = \frac{W}{t} = \frac{mgh}{t} = \frac{2600\,N\ 35\,m}{15\,s} = 6066.7\,N$$

$$Eff = \frac{P_O}{P_I} = \frac{6066.7\,W}{55950\,W} = 0.11$$

2) What is the efficiency of a 1400 kg. 110 hp car that can accelerate from 90 to 110 Km/h in 6.0 s against frictional forces of 700 N?



$$90\,\frac{Km}{h} \rightarrow 25.0\,m/s$$

$$110\,\frac{Km}{h} \rightarrow 30.6\,m/s$$

$$a = \frac{v_2 - v_1}{t} = \frac{30.6\frac{m}{s} - 25.0\frac{m}{s}}{6.0\,s}$$

$$a = 0.93\ m/s^2$$

$$F = ma$$

$$= 1400\ kg\ 0.93\ m/s^2$$

$$= 1300\ N$$

$$\therefore F_p = 1300\,N + 700\,N = 2000\ N$$

$$P_I = 110\,hp \times \frac{746\,W}{hp} = 82060\ W$$

$$P_O = Fv = (2000\,N)(30.6\,m/s) = 61200\,N$$

$$Eff = \frac{P_O}{P_I} = \frac{6.12 \times 10^4\,W}{8.206 \times 10^4\,W} = 0.75$$

Automobiles do work to overcome frictional forces, climb hills, and to accelerate → this is when they need power.