Efficiency

A machine converts one type of energy into a different kind of energy.

For example: car: chemical → kinetic

No machine is 100% efficient, that is output < input (less than)

The "lost" energy is generally converted into heat.

Efficiency is a measure of what percentage of the input energy is transformed into the output or what percentage of the input power is transformed into output power.

$$Eff = \frac{W_{out}}{W_{in}} \times 100\%$$

$$Eff = \frac{P_{out}}{P_{in}} \times 100\%$$

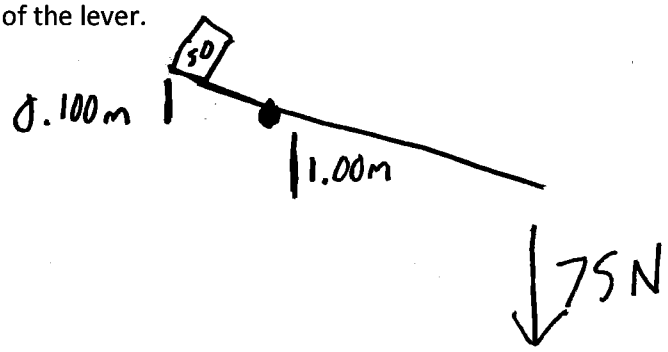
EXAMPLE: A 2600 W motor outputs 2300 W of power. What is the efficiency of the motor?

↑ Power in ↑ Power out

$$Eff = \frac{P_{out}}{P_{in}} = \frac{2300W}{2600W} \times 100\%$$

$$= 88\%$$

EXAMPLE: A lever is used to lift a 50.0 kg object 10.0 cm. To do this we must apply a force of 75 N to the end of the lever which displaces 1.00 m. Find the efficiency of the lever.



$$W_{in} = F\,d = 75N \times 1.00m$$
$$= 75\,J$$

$$W_{out} = \Delta E_p = mgh = 50 \times 9.8 \times 0.1$$
$$= 49\,J$$

$$Eff = \frac{49J}{75J} \times 100\%$$
$$= 65\%$$

EXAMPLE: How much work can a 22 kW electric car engine do in 60 seconds if it is 75 % efficient?

$22000\ W$

① What is P_{out}? $P_{in} \times Eff = 22000 \times 0.75 = 16500\ W$

② $P = \frac{work}{time} \rightarrow P \times time = Work$

$16500 \times 60 = 990000\ J$

$\approx 1\,000\,000\ J$

EXAMPLE: A 12 kW machine pulls a 680 kg block across a surface with $\mu = 0.44$ at 2.5m/s. What is the efficiency of the machine?

$P_{in} = 12000$ Watts

$P_{out} = F\bar{v}$

$F_{app} = F_{fric} = \mu F_N = \mu mg$

$= 2932.16\ N$

$P_{out} = 2932.16 \times 2.5$

$= 7330.4\ W$

$Eff = \frac{P_{out}}{P_{in}} = \frac{7330.4}{12000} = 61\%$