# Efficiency

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There are no perfect machines or objects that do work in the universe. There is always a loss of energy when trying to do work.

→ Friction is our primary cause, it changes "useful" work energy into "useless" heat energy.

efficiency → eff ← I use this one
efficiency → e

Units: no → as a percentage

Remember: when calculating turn eff % into a decimal

$$eff = \frac{P_{out}}{P_{in}}$$

← Power output: the resulting power

eg: how high a mass is lifted / time $\Delta PE/t$

eg: Temperature change over time $\Delta Q/t$

eg: Change in velocity over time $\Delta KE/t$

↑ Power input: Power put into the system

eg: The energy/power of a motor

eg: a person pushing / pulling over time

eg: a hot plate or heater over time

eg: Gravity can be an input

$$eff = \frac{W_{out}}{W_{in}}$$

Sanity check your problems:

efficiency can never be higher

than 100%! $W_{out} < W_{in}$

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A 4000W crane lifts a 20kg crate up 100m in 50s. How efficient is the crane?

$eff = \frac{P_{out}}{P_{in}}$

$P_{out} = \frac{W}{t} = \frac{mgh}{t} = \frac{20(9.8)(100)}{50} = 392\,W$

↗ crate being lifted

$P_{in} = 4000W$

$eff = \frac{392W}{4000W} = 0.098 = \boxed{9.8\%}$

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A 74% efficient hot plate has a rating of 300W. How long will it take to heat 250g of water up 5°C?

$P_{out} = \frac{Q}{t} = \frac{mc\Delta T}{t} = \frac{0.25(4180)(5)}{t}$

$P_{in} = 300W$

$eff = \frac{P_{out}}{P_{in}} \Rightarrow P_{in} \times eff = P_{out}$

$P_{in} \times eff = \frac{mc\Delta T}{t}$

$t = \frac{mc\Delta T}{P_{in} \cdot eff}$

$t = \frac{0.25(4180)5}{300 \times 0.74} = \boxed{23.5\,s}$

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$P_{out}$ → calculate based on results

$P_{in}$ → calculate (sometimes) → ramp