

Heat Engines

Physics

Why no engine can be 100% efficient, and what sets the limit.

The maximum possible efficiency of a heat engine depends only on the hot and cold reservoir temperatures.

$$\eta_{\text{max}} = 1 - T_c/T_h \text{ (kelvin)}$$

$T_h = 600 \text{ K}$, $T_c = 300 \text{ K}$

50% maximum

Real engines

Friction, turbulence, finite time.

Well below Carnot

To improve

Raise T_h or lower T_c

THE COMMON MISTAKE

× **Using Celsius**

✓ **Kelvin only**

The ratio T_c/T_h is meaningless unless both are absolute temperatures.

This is the second law in practical form: waste heat is not an engineering failure, it is thermodynamically required.