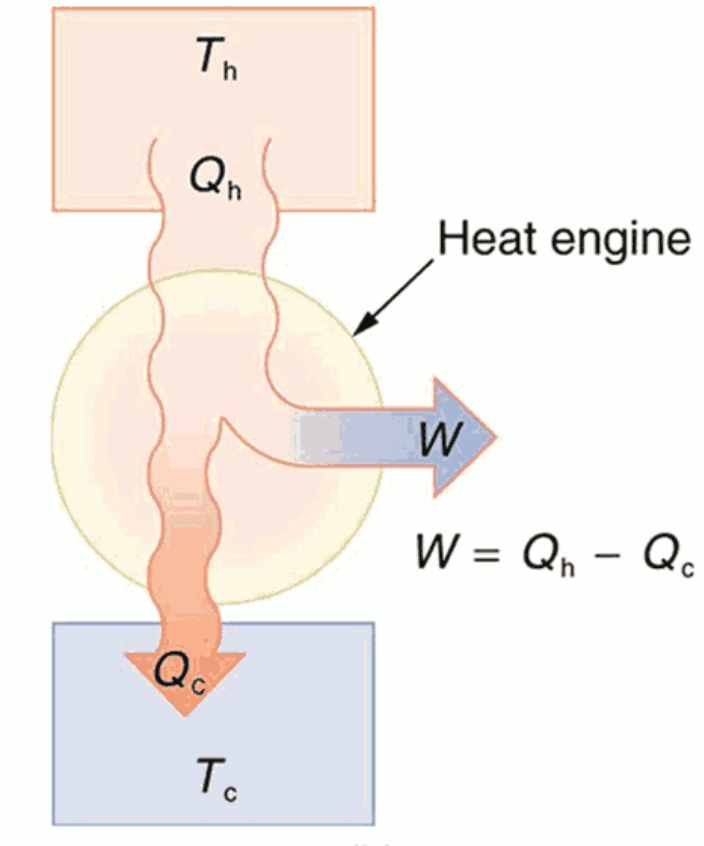
Thermodynamics - Applications

- Heat Engines
- Efficiency
- Thermoelectric Modules (Peltier / Seebeck)
- Heat Pumps
- Heat exchangers

Heat Engine

Heat Engine: A device that uses heat transfer to do work



1st Law of Thermodynamics

$$E_{final} = E_{initial} + Q + W$$

2nd Law of Thermodynamics
Heat travels from T_h to T_c

Image: OpenStax, College Physics. OpenStax CNX. 4. Nov. 2016
http://cnx.org/contents/Ax2o07Ul@9.39:_RSOYYkJ@4/Introduction-to-the-Second-Law

Heat Engine

Heat Engine Examples:

- Heated gas cylinder:

  Heating a gas causes the gas to expand and move the piston (Work = F*s)

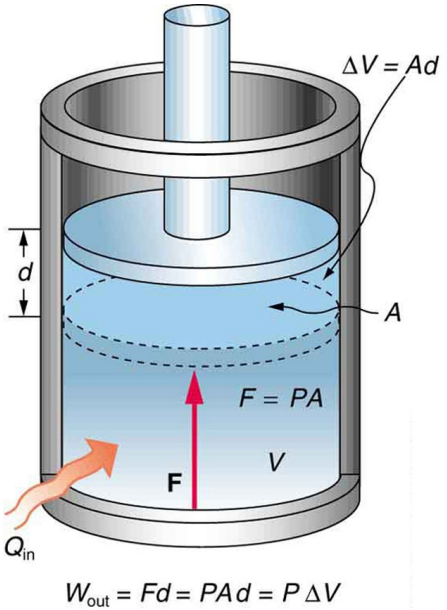


Image: OpenStax College, College Physics. OpenStax CNX. 2. Okt. 2018 http://cnx.org/contents/031da8d3-b525-429c-80cf-6c8ed997733a@14.2. Creative Commons 4.0 License http://creativecommons.org/licenses/by/4.0/

- Combustion engine

- Steam engine

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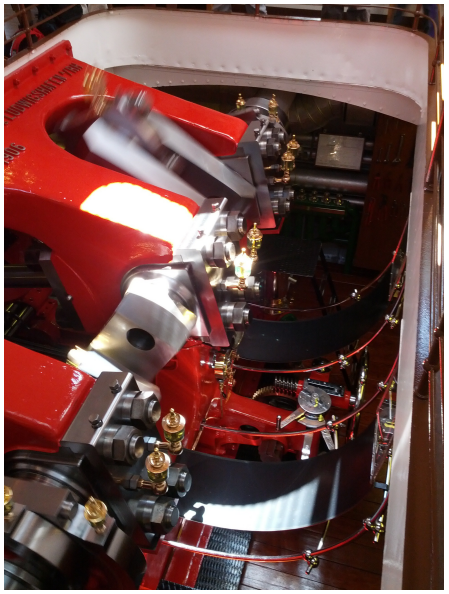
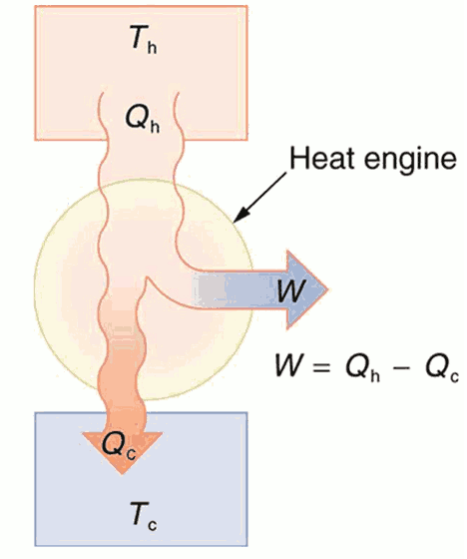


Video: Steam engine of the paddle-boat “Schiller” (Stefan Bracher) https://www.youtube.com/watch?v=hxkt8po0slE

Efficiency of a Heat Engine

$$Eff = \frac{W}{Q_h} = \frac{Q_h - Q_c}{Q_h}$$

W	Work done by the engine (work output)
Q_h	Heat transfer **to** the engine (energy input)
Q_c	Heat **leaving** the engine



2nd Law of Thermodynamics

- Heat travels from T_h to T_c
- The efficiency of a heat engine is always < 100%

Image: OpenStax, College Physics. OpenStax CNX. 4. Nov. 2016
http://cnx.org/contents/Ax2o07UI@9.39:_RSOYYkJ@4/Introduction-to-the-Second-Law

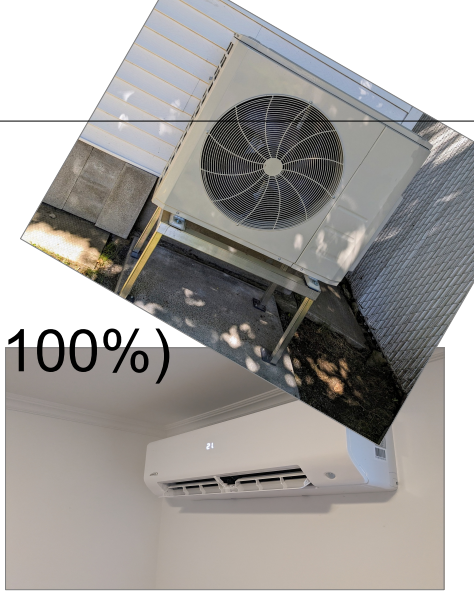
Efficiency in general

Efficiency

$$Eff = \frac{Useful\,Output}{Input}$$

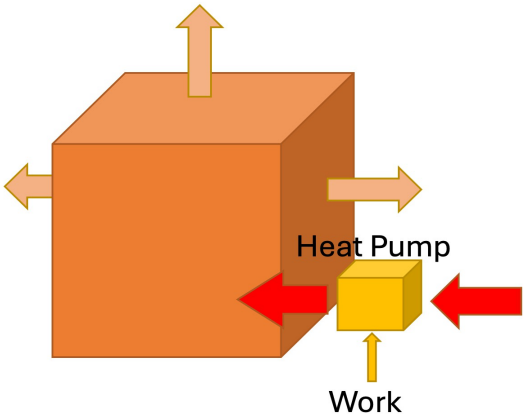
Useful Output	Work or desired energy change
Input	Energy going into the device

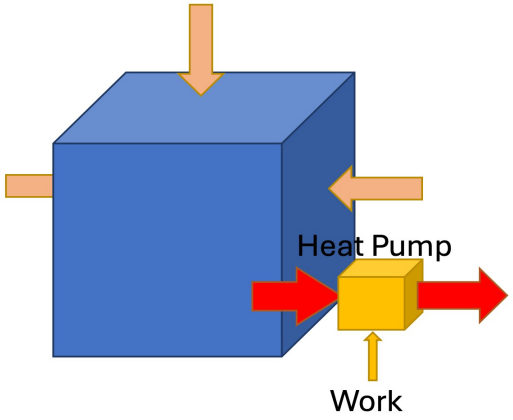
Heat Pumps



Heat Pumps: Use work to pump heat from cold to hot

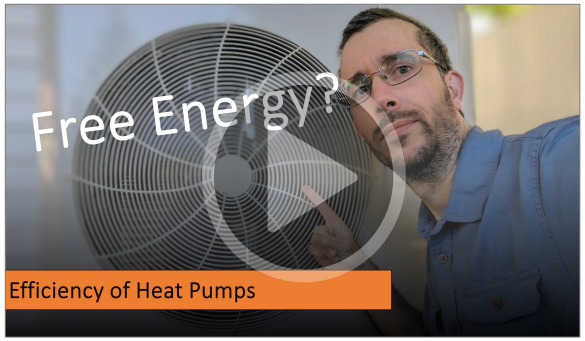
Heat pumped > work needed (Efficiency > 100%)





Efficiency

$$\frac{Useful\ Output}{Input}$$



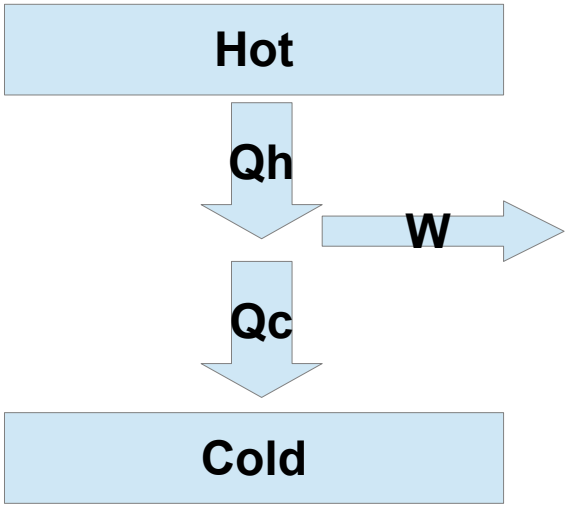
Stefan Bracher

Thermoelectric Modules (Peltier / Seebeck)

Thermoelectric Modules: Devices that convert between heat flow and electric work. (See heat engine) and

Peltier : Electric work creates heat flow

Seebeck: Heat flow creates electric work



1st Law of Thermodynamics

$$E_{final} = E_{initial} + Q + W$$

2nd Law of Thermodynamics
Heat travels from hot to cold

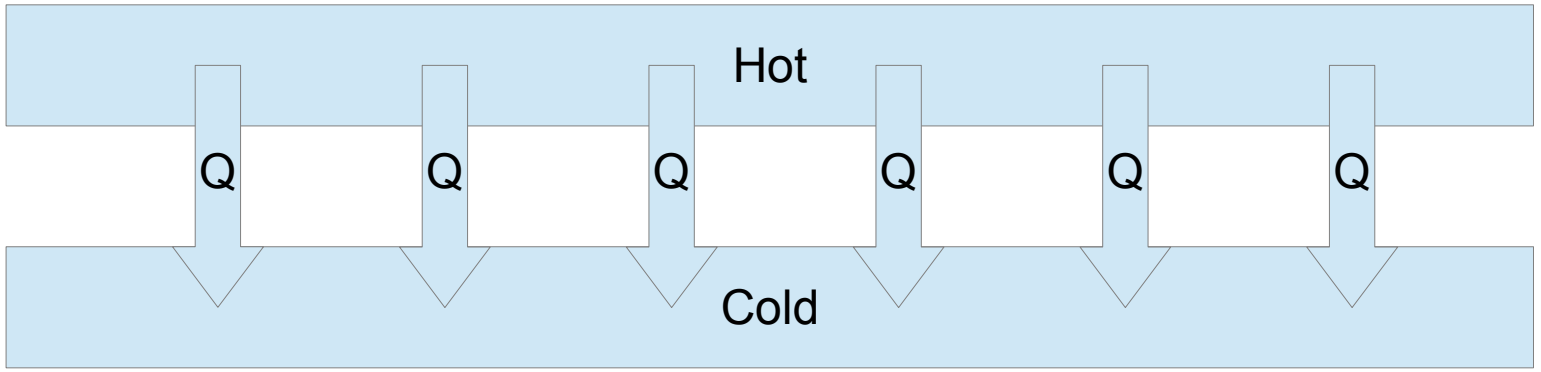
Compare

Heat engine/pump: Heat flow <-> Mechanical Work

Resistive heating: Electric Work -> Heat (one way)

Heat exchanger

Heat flows from one fluid (hot) to another one (cold)



2nd Law of Thermodynamics
Heat travels from hot to cold (until the temperatures are identical)

Additional Resources

- “The Ideal Gas Law” in “College Physics” Chapter 13.3

  https://cnx.org/contents/Ax2o07UI@14.2:j0ywdp9f@7/13-3-The-Ideal-Gas-Law

- “The First Law of Thermodynamics and Some Simple Processes” in “College Physics” Chapter 15

  https://cnx.org/contents/Ax2o07UI@14.2:xUMJ21t4@11/15-2-The-First-Law-of-Thermodynamics-and-Some-Simple-Processes

- “Introduction to the Second Law of Thermodynamics: Heat Engines and Their Efficiency” in “College Physics” Chapter 15

  https://cnx.org/contents/Ax2o07UI@14.2:_RSOYYkJ@6/15-3-Introduction-to-the-Second-Law-of-Thermodynamics-Heat-Engines-and-Their-Efficiency

- Conservation of Energy Videos and Exercises at CCDMD

  https://energydev.ccdmd.qc.ca/