Physics Education Laboratory
Lecture 09
Content Knowledge for Thermodynamics

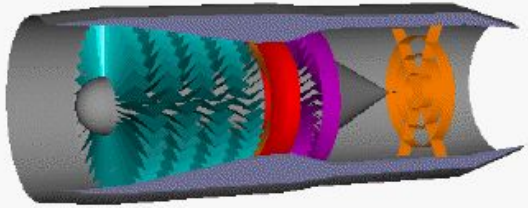
Francesco Longo - 30/10/23


BIG BOWL: TOO HOT. MEDIUM BOWL: TOO COLD. SMALL BOWL: JUST RIGHT. THIS GOES AGAINST ALL OF THE THERMODYNAMICS I EVER LEARNED!
©1993 Tom Swanson
TOM

Key concepts in thermodynamics

What is Thermodynamics?

Glenn Research Center



Thermodynamics is the study of the effects of work, heat, and energy on a system. Thermodynamics is only concerned with large scale observations.

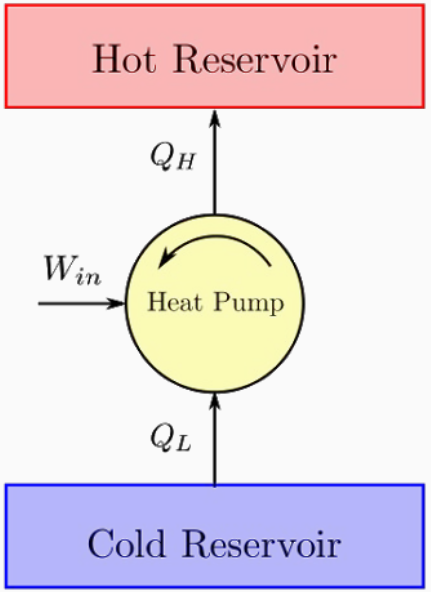
Zeroth Law: Thermodynamic Equilibrium and Temperature

First Law: Work, Heat, and Energy

Second Law: Entropy

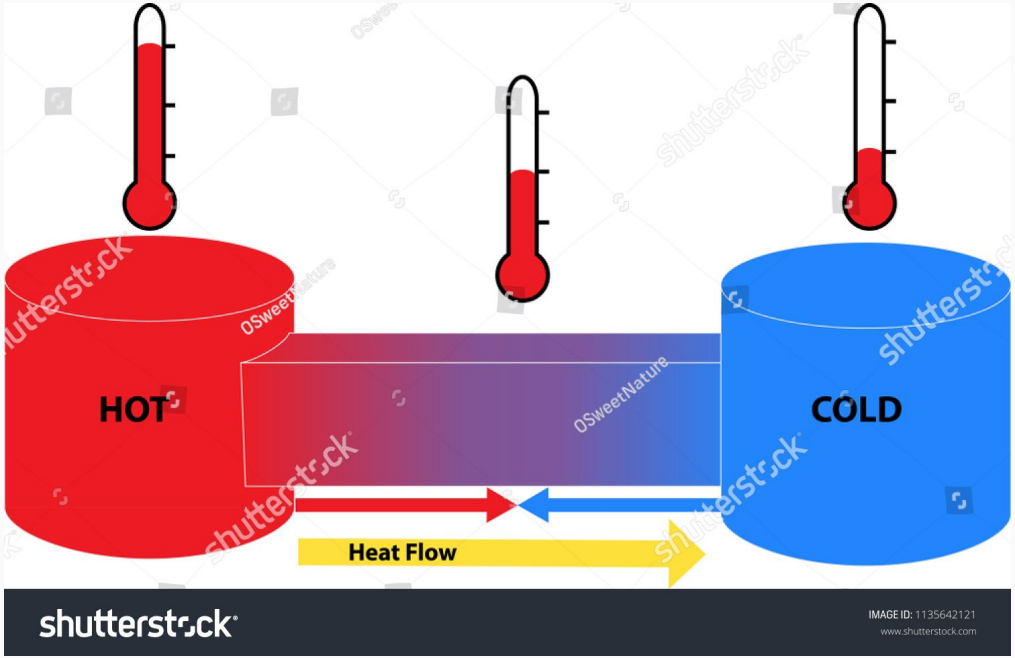
Key concepts in thermodynamics

- Temperature
- Thermodynamic state
- Thermodynamic Equilibrium
- State changes - Latent heat
- Heat - Heat exchange
- Work
- Internal energy
- Laws of gases - pV plane
- Reversibility / irreversibility
- Entropy



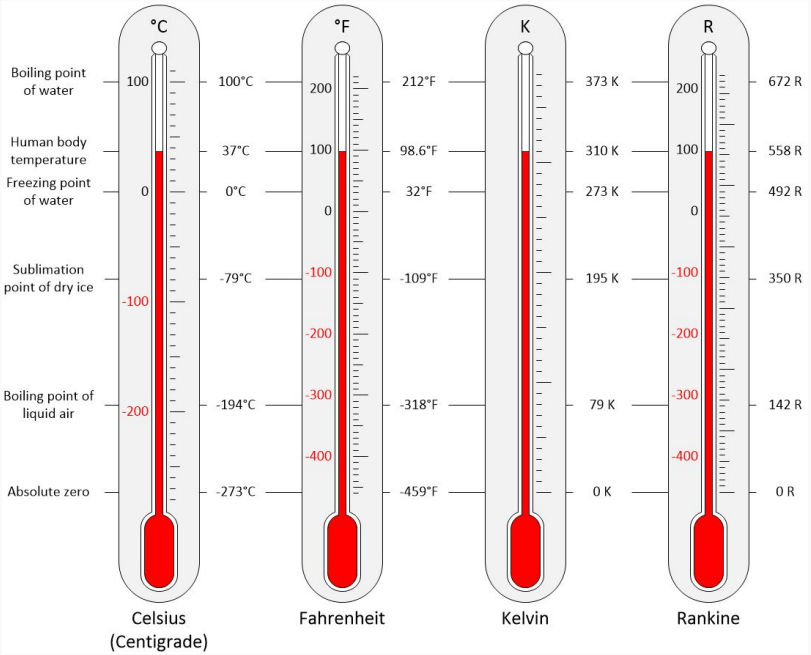
Key concepts in thermodynamics

- Temperature
- Hot vs Cold



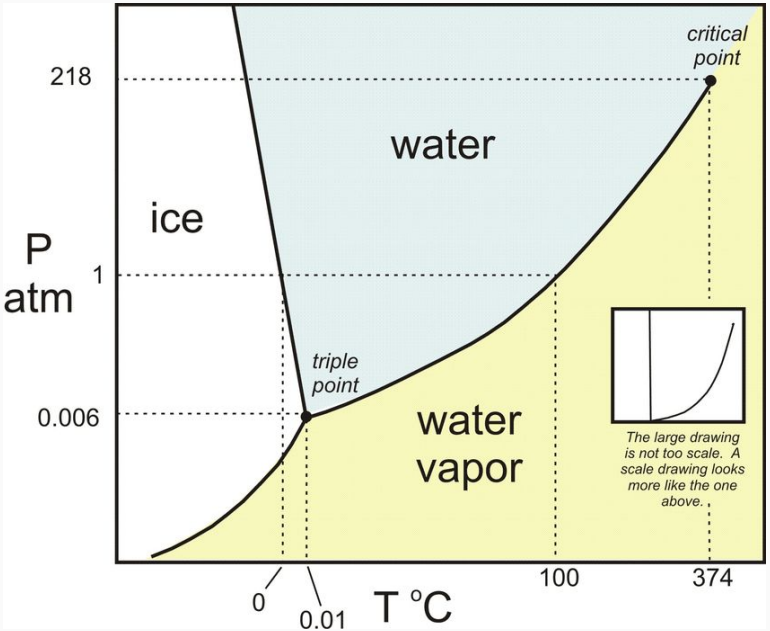
Key concepts in thermodynamics

- Temperature scales



Key concepts in thermodynamics

- State transitions
- Latent heat



Key concepts in thermodynamics

- Reversibility / irreversibility
- pV plane
- quasi-static phenomena

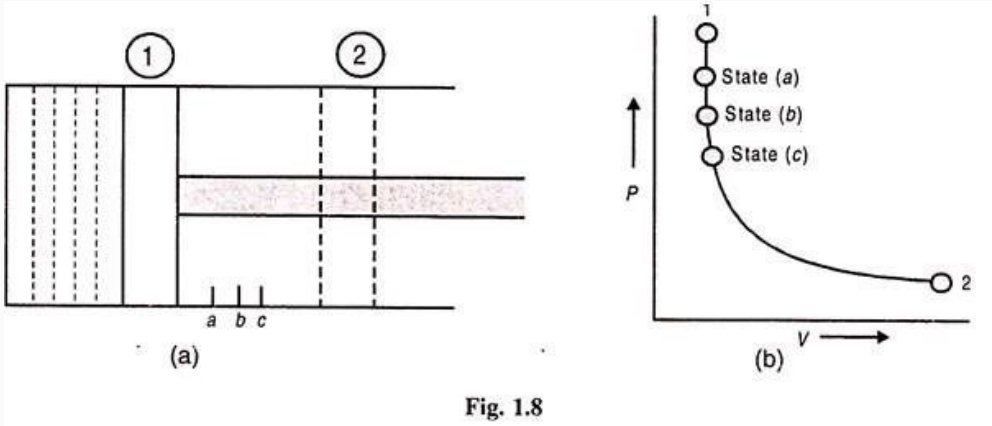
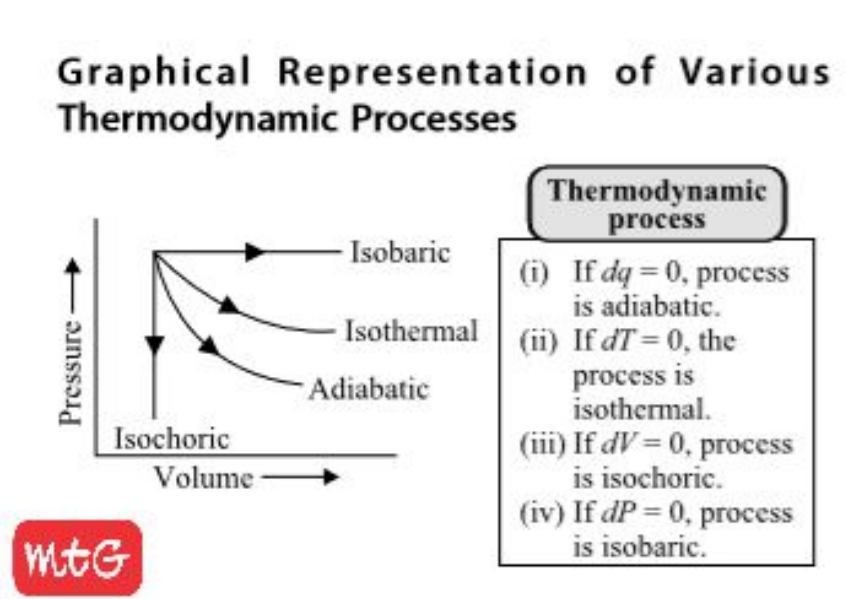


Fig. 1.8

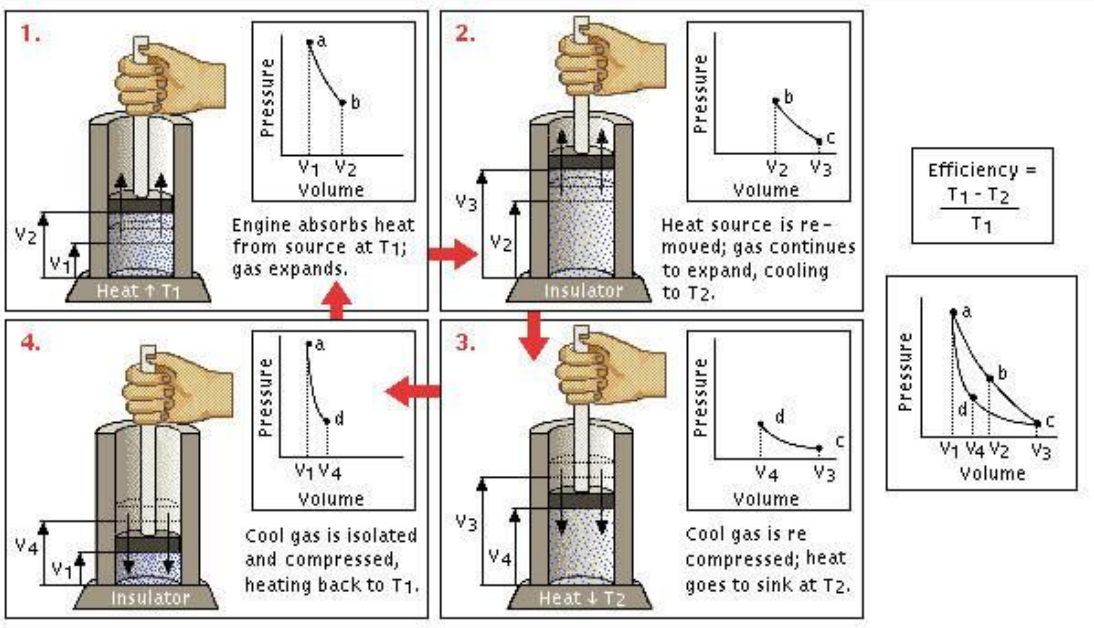
Key concepts in thermodynamics

- Processes in pV plane



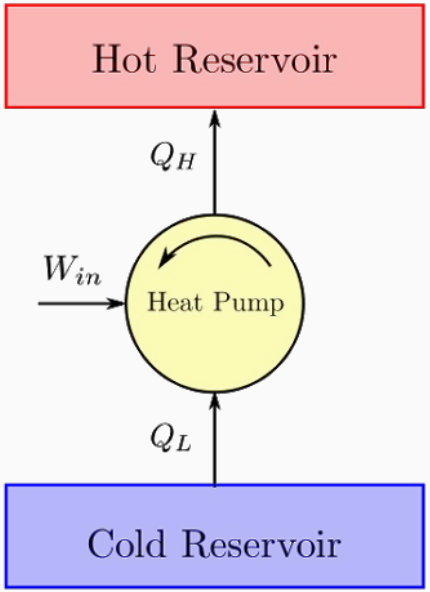
Key concepts in thermodynamics

- Thermodynamic cycles



Key concepts in thermodynamics

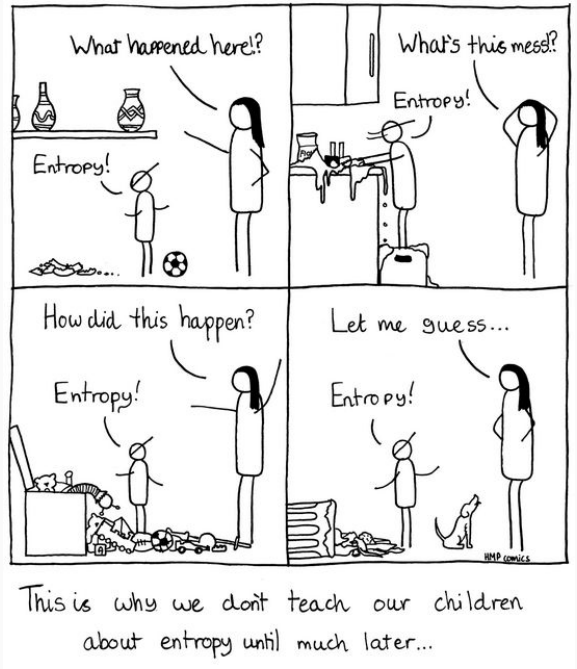
- Thermodynamics machines



Key concepts in thermodynamics

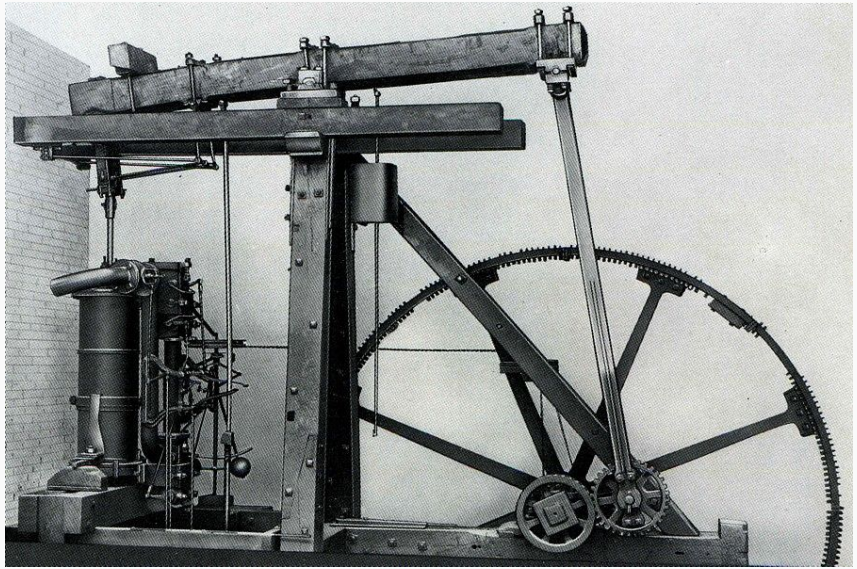
- Entropy as state variable
- Universe, System
- Closed or Open Systems
- Increase/Decrease of order

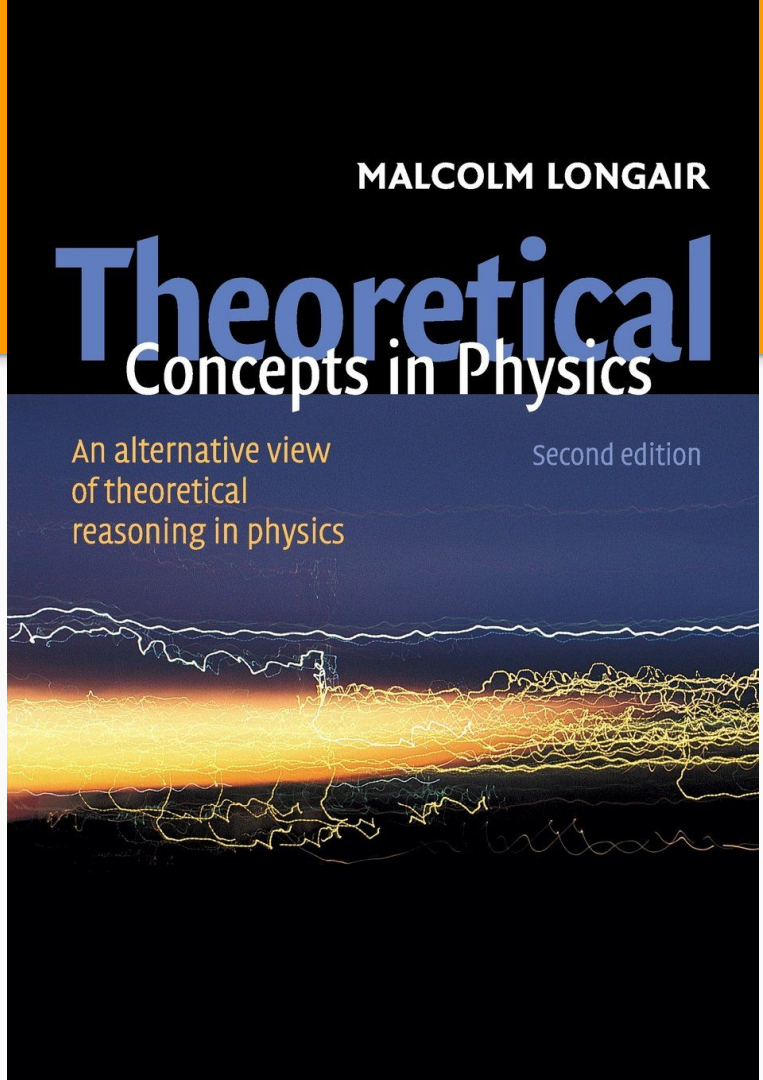
$$\Delta S = S_f - S_i = \int \frac{dq_{rev}}{T}$$



Knowledge of curricula

- Link to cultural needs …





Misconceptions

- Open vs. closed systems
- Evaluation of properties
- State concept
- Transient vs. steady state
- Realizing entropy is a thermodynamic property
- Reversibility
- Correct application of process equations vs. rate equations

(Karimi et al., 2014)

Misconception - example

Students often struggle to distinguish between isothermal and adiabatic processes. Students find it counter-intuitive that a system can absorb energy by a heat transfer, Q without a change in temperature during a process. In many cases the temperature increases with heating, but if the system undergoes a phase change at constant pressure the temperature remains constant. A classic example is boiling water trapped in a piston cylinder apparatus where the piston is free to rise in a gravitational field. In this example, the concept needs to be grasped is that temperature does not rise but the internal energy and volume will increase due to heating. Also the temperature and pressure in the two-phase region are not independent properties. **In a single-phase region, the student's intuition would lead to a correct evaluation that when there is a heat transfer into the system, the temperature of the system increases.**

(Karimi et al., 2014)

Traditional teaching

In the traditional approach to teaching and learning, the instructors are focused on what they will do to explain the material better, what experiments they will show, what problems they will assign and how they will grade student work. The students usually sit in a classroom with seats in rows facing the teacher and listen to the explanations taking notes. The students do not question the information that is supplied to them. The instructor grades them on how they understand this information and how they apply it to solve problems. The grades for student work are given once and those are recorded. The students do not have an opportunity to improve their work (in cases that they are allowed to do it, the second attempt receives a reduced grade for being second).

https://www.openaccessgovernment.org/investigative-science-learning-environment/74964/

Investigative Science Learning Environment

(ISLE approach)

OBSERVATIONAL EXPERIMENT

TESTING EXPERIMENT