PHYS 1001:
Thermal Physics

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Module Outline

- Lectures
- Lab + tutorials + assignments
- “University Physics”, Young & Freedman
  - Ch. 17: Temperature and heat
  - Ch. 18: Thermal properties of matter
  - Ch. 19: The first law of thermodynamics
  - Ch. 20: The second law of thermodynamics

Module Outline

1. Temperature and heat
2. Thermal expansion
3. Heat capacity and latent heat
4. Methods of heat transfer
5. Ideal gases and the kinetic theory model

6, 7. The first law of thermodynamics

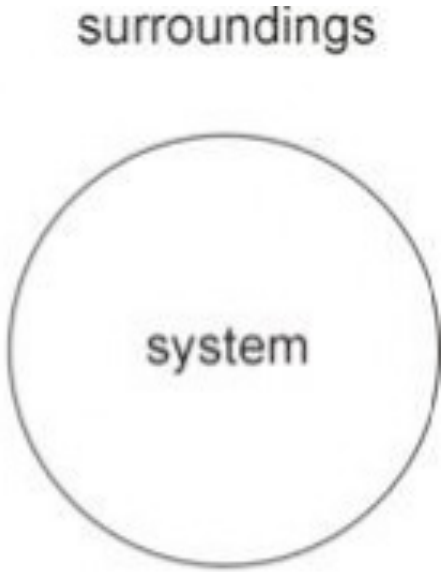
8, 9. 2nd Law of Thermodynamics and entropy

10. Heat engines, and Review

What is temperature?

- “Hotness” and “coldness”
- How do we measure it?

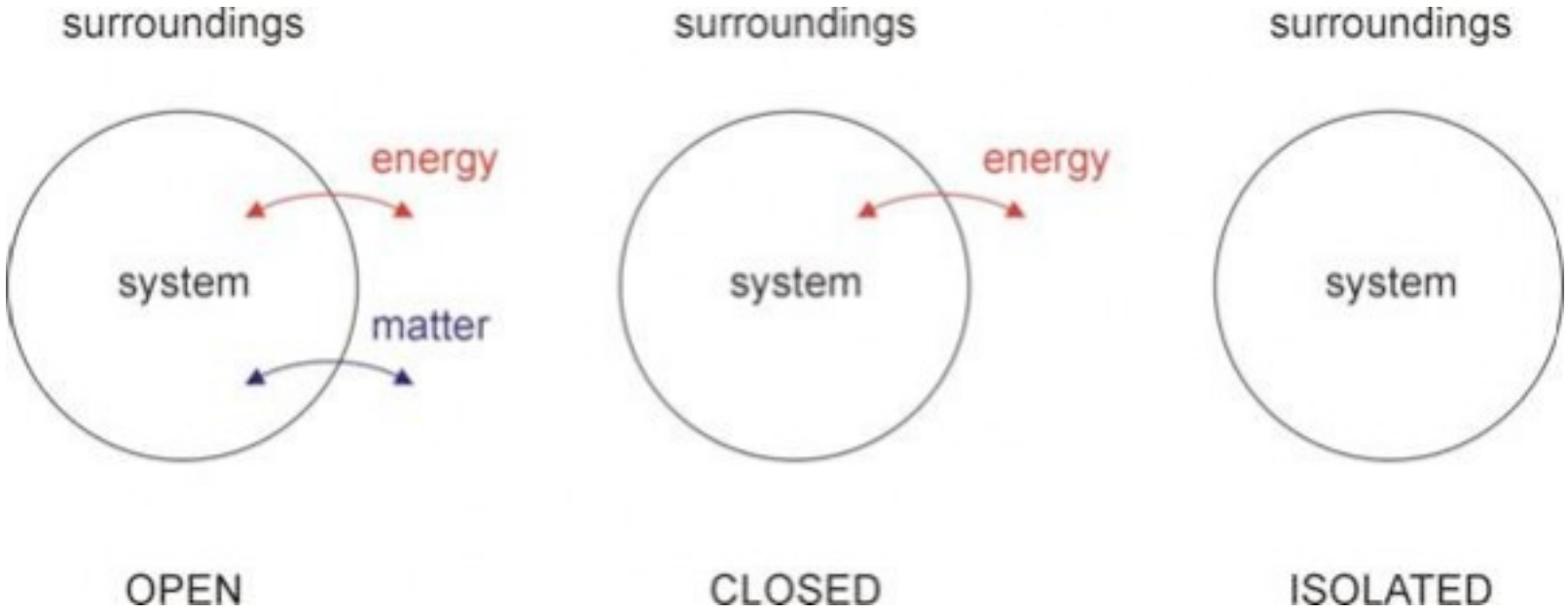
Thermodynamic systems



State variables (macroscopic):
T, p, V, M, ρ etc.

A *thermodynamic system* is a quantity of matter of fixed identity, with surroundings and a boundary.

Thermodynamic systems

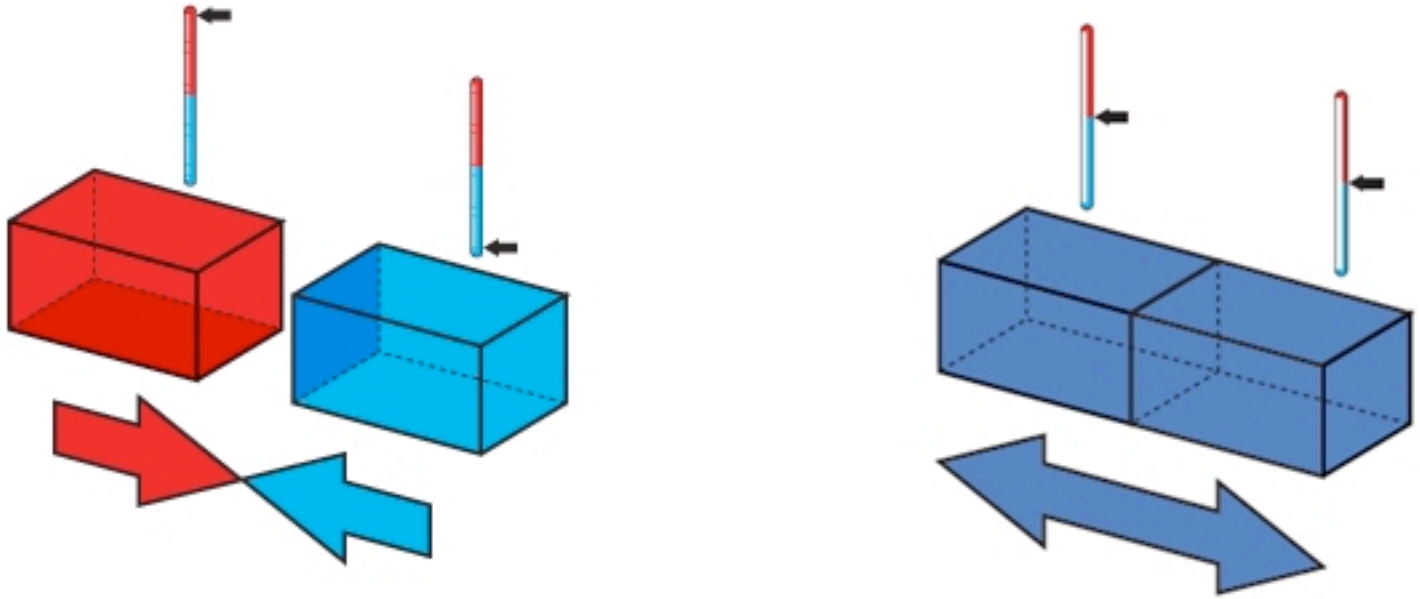


Systems can be

- open – mass and energy can flow through boundary
- closed – only energy can flow through boundary
- isolated – nothing gets through boundary

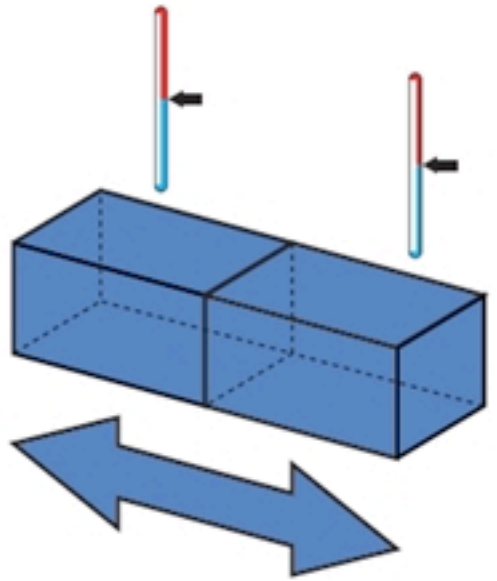
Thermal equilibrium

- If two objects are in thermal contact, the hotter object cools and the cooler object warms until no further changes take place ➔ the objects are in *thermal equilibrium*.



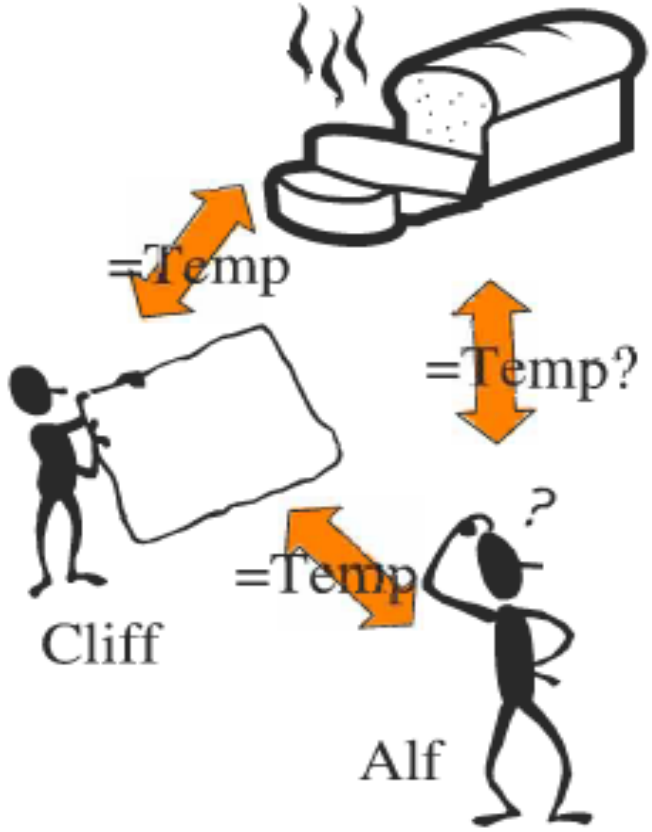
What is temperature?

Temperature is the value of the property that is same for two objects, after they've been in contact long enough and are in thermal equilibrium.



Zeroth law of thermodynamics

If A and B are each in thermal equilibrium with C, then A and B are in thermal equilibrium with each other.



Consequence: Two systems are in thermal equilibrium if and only if they have the same temperature.

How do we measure temperature?

- We measure temperature with a *thermometer*, which
  - comes into thermal equilibrium with the system to be measured
  - has a property which changes with temperature

Thermometers

- liquid thermometer – change in dimensions
- gas thermometer – change in pressure
- thermistor – change in resistance
- Galilean thermometer – change in buoyancy
- EM radiation – artery thermometer

Is human skin a thermometer?

- Can you tell the temperature of an object by touching it?

Thermometers

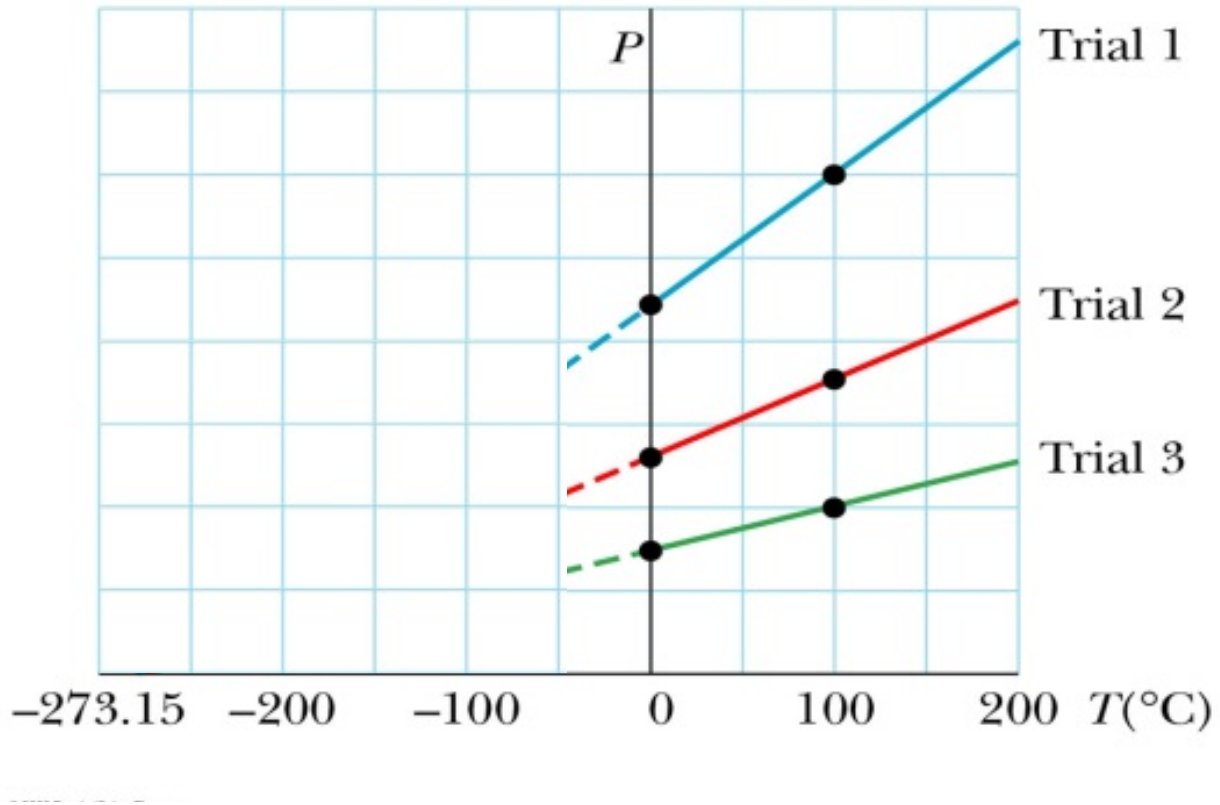
Any property X that changes with temperature can be used to construct a thermometer, and hence construct a temperature scale:

$$T(X) = aX$$

Does the value we obtain for temperature of a system depend on the choice of thermometer?

Absolute zero

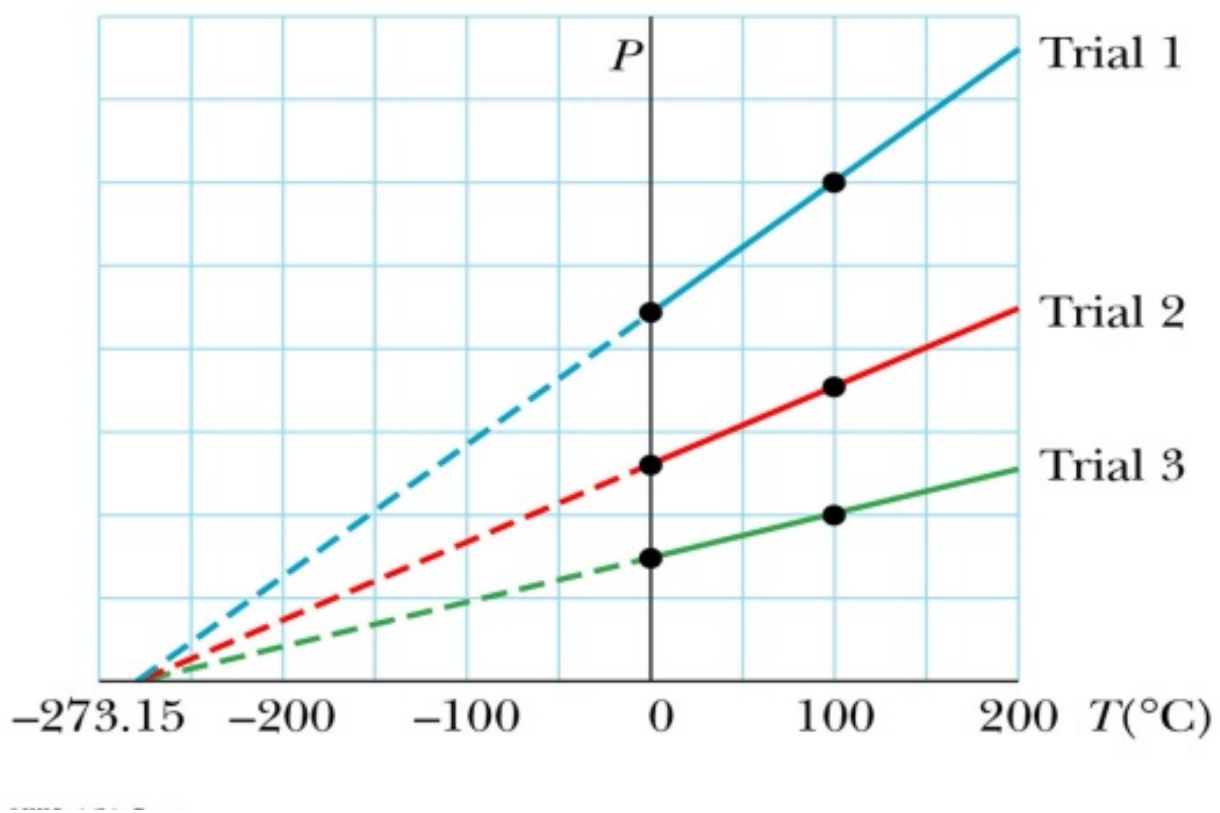
The pressure of a gas at constant volume increases with temperature.



YF §17.3

Regardless of the gas used, the curves extrapolate to the *same* temperature at zero pressure.

The temperature at which $p = 0$ is called **absolute zero**.



Regardless of the gas used, the curves extrapolate to the *same* temperature at zero pressure.

The temperature at which $p = 0$ is called **absolute zero**.

The absolute-zero reference point forms basis of **Kelvin temperature scale** (absolute temperature).

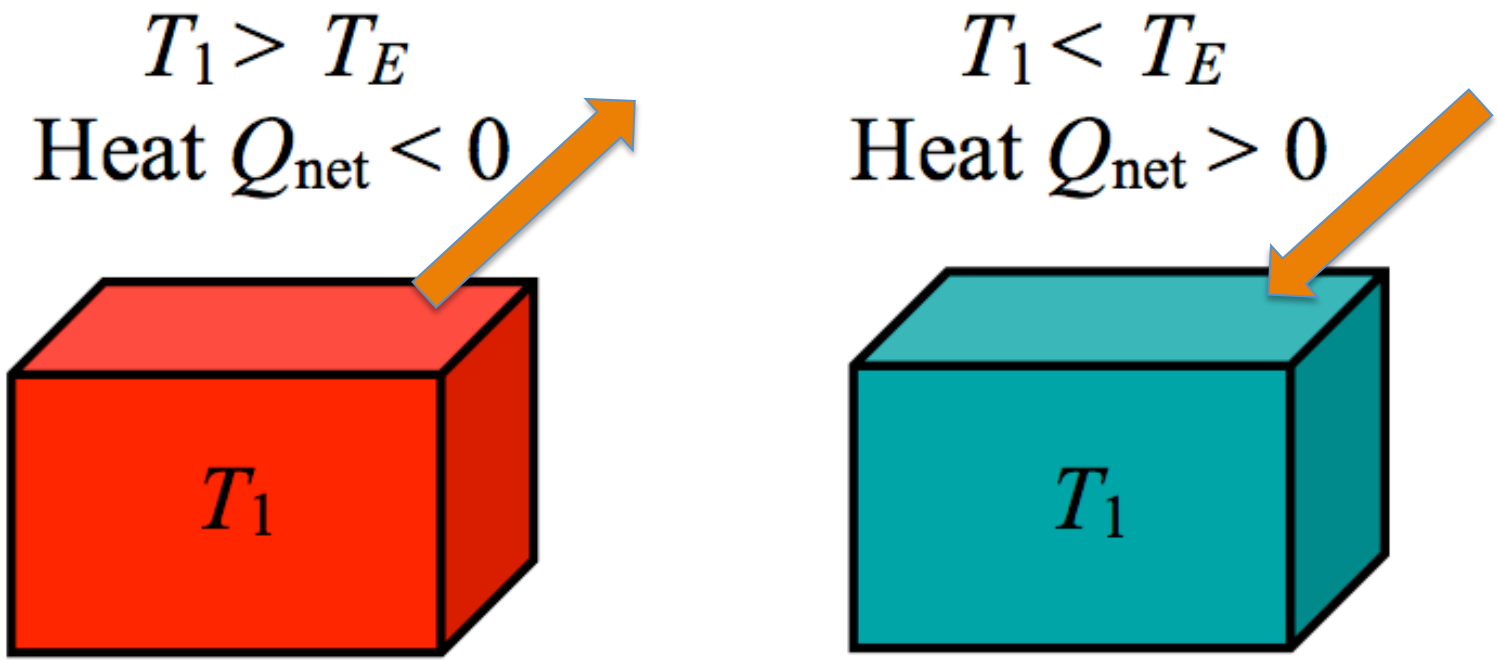
$$0\ \text{K} = -273.15\ ^\circ\text{C}$$

so

$$T_k = T_C + 273.15$$

Heat

Heat – energy transfer due to a temperature difference.



Symbol Q, units: J

YF §17.5

Heat

- The temperature *difference* determines the direction of heat transfer.

- Bodies don't "contain" heat; heat always refers to energy in transit from one body to another.

- We can change the *temperature* of a body by adding heat to it.

Typical exam question

Consider a hot cup of coffee sitting on a table as the system. Using this system as an illustration, give a scientific interpretation of the terms: **temperature**, **heat**, **thermal equilibrium**.

YF §17.3

Next lecture

Thermal expansion

Read: YF §17.4