Phy 4C 1/18

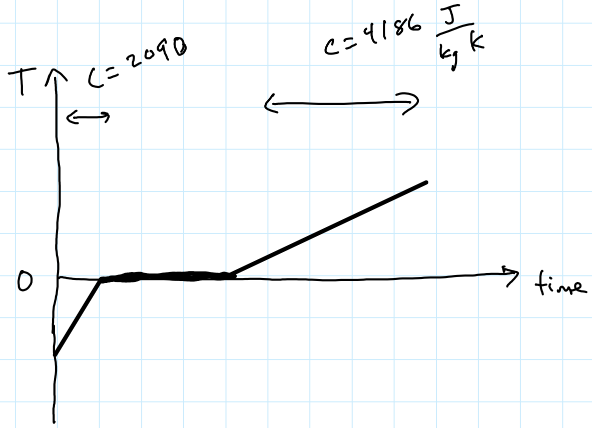
Wednesday, January 18, 2017 10:52 AM

Goals for the Lecture:

1) Conceptually understand heat transfer processes: conduction, convection, and radiation
2) Be able to solve problems involving conduction
3) Be able to solve problems involving radiation

worksheet p. 260

Top:



bottom: A takes longer

p. 261 Top: A is less

bottom: tape gets longer, so measured distance is shorter and actual distance is longer

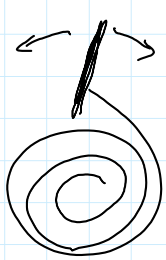
Application of the day: Thermal Expansion

Liquids:

1) Engine coolant is typically filled when cool. When heated it expands. Most car radiators have overflow reservoirs that catch the liquid and return it to the radiator when needed.

Solids:

1) Tight metal lid on a glass jar in the kitchen. Run it under hot water, the metal expands more than the glass and it becomes easy to remove.
2) Bridges have expansion joints
3) Thermostats are often made with bi-metallic strips or coiled metal that changes shape as it heats and cools.



Gases:

1) Hot air balloons heat the air inside the balloon. The hot air expands and spills out of the balloon. Less air in the balloon means it weighs less and experiences a buoyant force and floats in the more dense colder air surrounding the balloon.

Heat Transfer

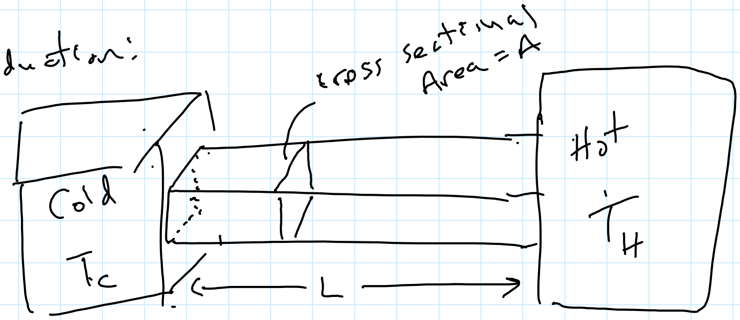
Heat Transfer

- Conduction
  - energy transfer by collisions
  - primary mechanism for solids
  - good electrical conductors are good thermal conductors

- Convection
  - primary mechanism for fluids (gas or liquid)
  - motion of the fluid itself

- Radiation
  - transmission of energy by electromagnetic waves

Conduction:



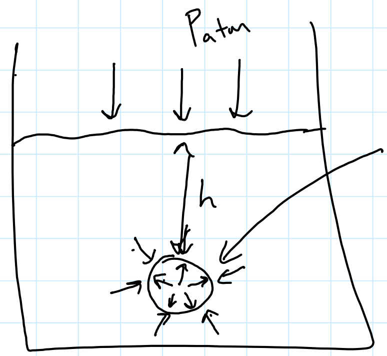
$$Q \propto \begin{cases} K & \text{material conductivity} \\ \frac{1}{L} & \text{length of material} \\ A & \text{cross sectional Area} \\ \Delta T & \text{temp difference} \\ t & \text{time} \end{cases}$$

conduction:

$$Q = \frac{K A \Delta T \, t}{L}$$

units for K: $\frac{J}{m \cdot {}^\circ C \, s}$

Boiling:



gas pressure inside bubble must be greater than pressure trying to crush the bubble

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Radiation:

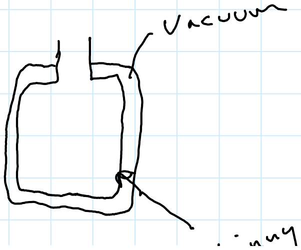
$Q \propto$
- T^4 temp
- e emissivity
- A surface area
- t time
- σ Stefan-Boltzmann Constant 5.67×10^{-8}

$$Q = e \sigma T^4 A t$$

max e is 1

e = 1 is a perfect emitter

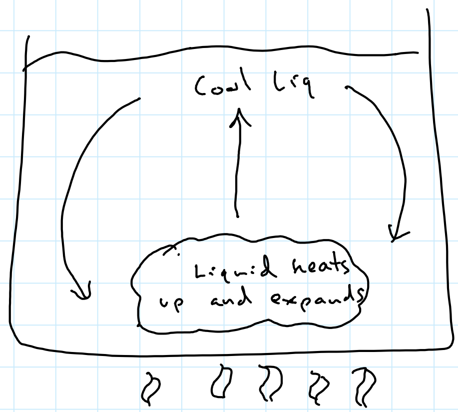
good thermos of travel mug



reduce heat transfer by all 3

redu-
heat transfe
by all 3
methods

Convection:



- add heat at bottom
- fluid heats and expands
- less dense fluid rises
- Cool liquid sinks
- "Convection currents" form

↑ Quiz ↑

Ideal Gas Law:

$$PV = nRT \quad \text{or} \quad PV = NKT$$

$$R = \begin{cases} 0.0821 \ \frac{L\ atm}{mol\ K} \\ 8.31 \ \frac{J}{mol\ K} \end{cases}$$

$$K = 1.38 \times 10^{-23} \ \frac{J}{K}$$

Pressure: $1 \ Pa = \frac{N}{m^2}$

Work: PV units J

$P \leftarrow Pa$, $V \leftarrow m^3$

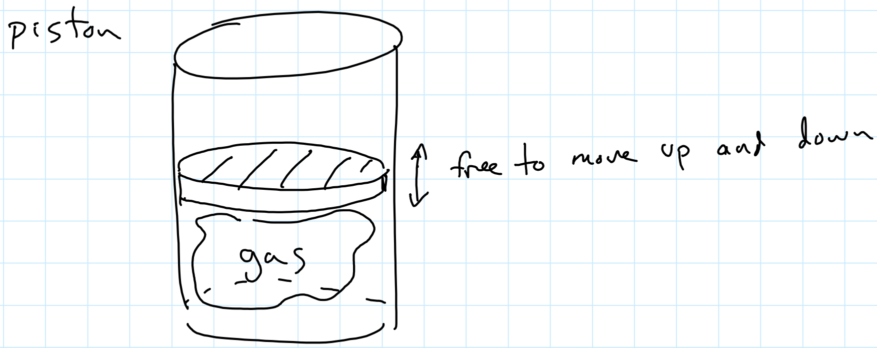
$$(Pa)(m^3) = J$$

OR

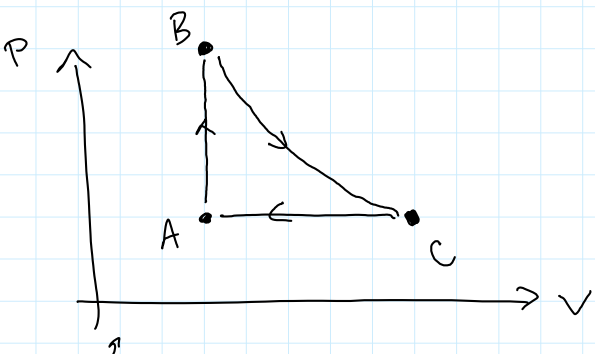
$(kPa)(L) = J$

$1\ m^3 = 1000\ L$

$1\ atm = 101{,}325\ Pa$



P-V Diagram



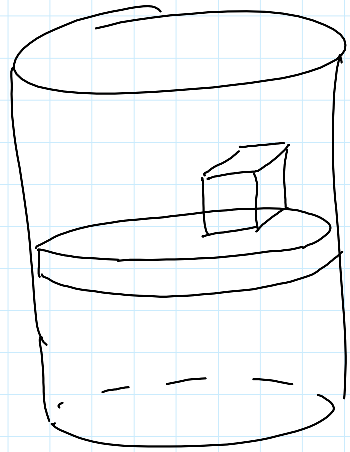
start at A

A → B add energy, heat gas, but lock piston (so volume is same)

B → C remove heat source, allow piston to expand until pressure is back to starting pressure

C → A hold P constant and reduce volume (by reducing temp)

To maintain Constant Pressure



Worksheet p. 263

Top: $PV = NkT$

$$T \propto \frac{PV}{N}$$

$$T_A \propto \frac{(2)(2)}{1}$$

$$T_B \propto \frac{(2)(2)}{2}$$

$$T_C \propto \frac{(1)(2)}{1}$$

$$T_D \propto \frac{(1)(1)}{1}$$

$$T_A > T_B = T_C > T_D$$

bottom: Because cross-sectional area is same for each:

$P \propto W$ (piston + weight)

$$W_A = 10\ N + 2\ N = 12\ N$$

$$W_B = 12\ N$$

$$W_C = 4\ N$$

$$W_D = 20\ N$$

$$P_D > P_A = P_B > P_C$$

p. 264 Top: $PV = nRT$

$$n \propto \frac{PV}{T}$$

since T = constant

$n \propto PV$

since $P \propto W$ (W = weight + piston)

$n \propto W V$

$n_A \propto (12)(5)$

$n_B \propto (12)(3)$

$n_c \propto (4)(5)$

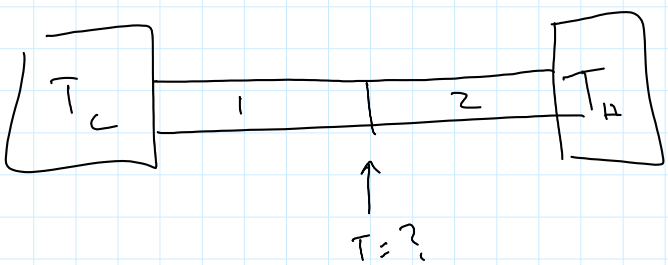
$n_D \propto (20)(3)$

$n_A = n_D > n_B > n_c$

bottom: Free to move

so, $P_{left} = P_{right}$

Conduction Prob



$$\left(\frac{Q}{t}\right)_1 = \left(\frac{Q}{t}\right)_2$$

Solve for T (temp at interface)