Chapter 04 — 2nd Law of thermo

- Homework solutions are posted to class web site
- Some topics on HW are not covered in class (by design)
- Supplemental lecture videos available via Kahn Academy (see our website)

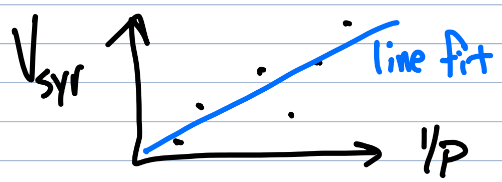
Hw problem #69:

$P = V^{-\gamma}\,\text{constant} \Rightarrow \ln P = -\gamma \ln V + \ln \text{constant}$ and so can infer γ from the slope

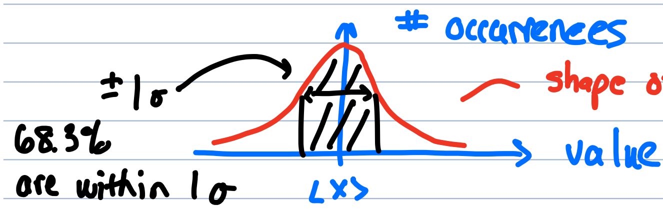
This is similar to the graphing ideas for Lab #2

One *could* just take 2 pressure and $V_{syringe}$ measurements and solve $P_1 V_1 = P_2 V_2 \Rightarrow P_1 (V_{flask} + V_{syr_1}) = P_2 (V_{flask} + V_{syr_2})$

But we took multiple measurements and plotted V_{syr} vs $\frac{1}{P}$



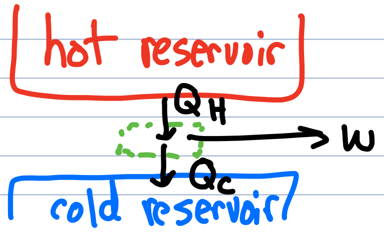
What's up with "uncertainty" via standard deviation $\div \sqrt{N_{trials}}$?



shape of a Gaussian $e^{-\frac{(x-\langle x\rangle)^2}{2\sigma^2}}$

95.4% with 2σ of average

<u>Heat engines</u> convert (a portion of input) heat to work or mechanical energy



If an engine is carried through a cyclic process, then the initial and final energies are equal → $U_2 = U_1 \Rightarrow \Delta U = Q - W = 0$
→ $Q = W$

$$W = Q_{total} = Q_H + Q_c = |Q_H| - |Q_c|$$

thermal efficiency is the ratio of output work to heat input

$$\rightarrow e = \frac{W}{Q_H} = \frac{|Q_H| - |Q_c|}{Q_H} = 1 - \left|\frac{Q_c}{Q_H}\right|$$

ch011s1.html slide → ActivPhysics Sim # 8.14

Q_1 A → 2nd colum
B → 3rd
C → 1st
D → 4th

Q_2 $$P = \frac{nRT}{V} = \frac{1.0 \; 8.3145 \cdot 500\,K}{10\,dm^3}\left(\frac{10\,dm}{1\,m}\right)^3 = 416\;kPa$$

Q_3 A: $\Delta U = 0$ $\quad Q = W = \int p\,dV = nRT \ln V_f/V_0 = 2.67\,kJ$

B: $Q = 0$ $\quad W = -\Delta U = -\frac{3}{2} nR\Delta T = 2.49\,kJ$

C: $\Delta U = 0$ $\quad Q = W = nRT \ln V_f/V_0 = -1.61\,kJ$

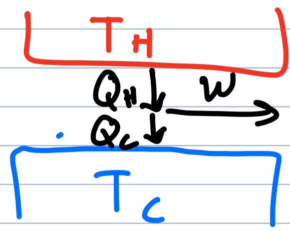
D: $Q = 0$ $\quad W = -\Delta U = -\frac{3}{2} nR\Delta T = -2.49\,kJ$

Q_4 $$e = \frac{W}{Q_H} = \frac{2.67\,kJ + 2.49\,kJ - 1.61\,kJ - 2.49\,kJ}{2.67\,kJ}$$

Q_5 $$e = 1 - \frac{T_c}{T_H} = 1 - \frac{300}{500} = 0.4$$

Concept Q s1.html

engine

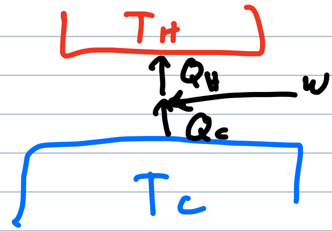


$W = Q_H + Q_C$

$= |Q_H| - |Q_C|$

efficiency $= \frac{\text{output work}}{\text{input heat}} = \frac{W}{Q_H}$

refrigerator



$W = Q_H + Q_c$

$|W| = |Q_H| - |Q_c|$

performance $= \frac{\text{heat removed}}{\text{work needed}} = \frac{|Q_c|}{|W|}$