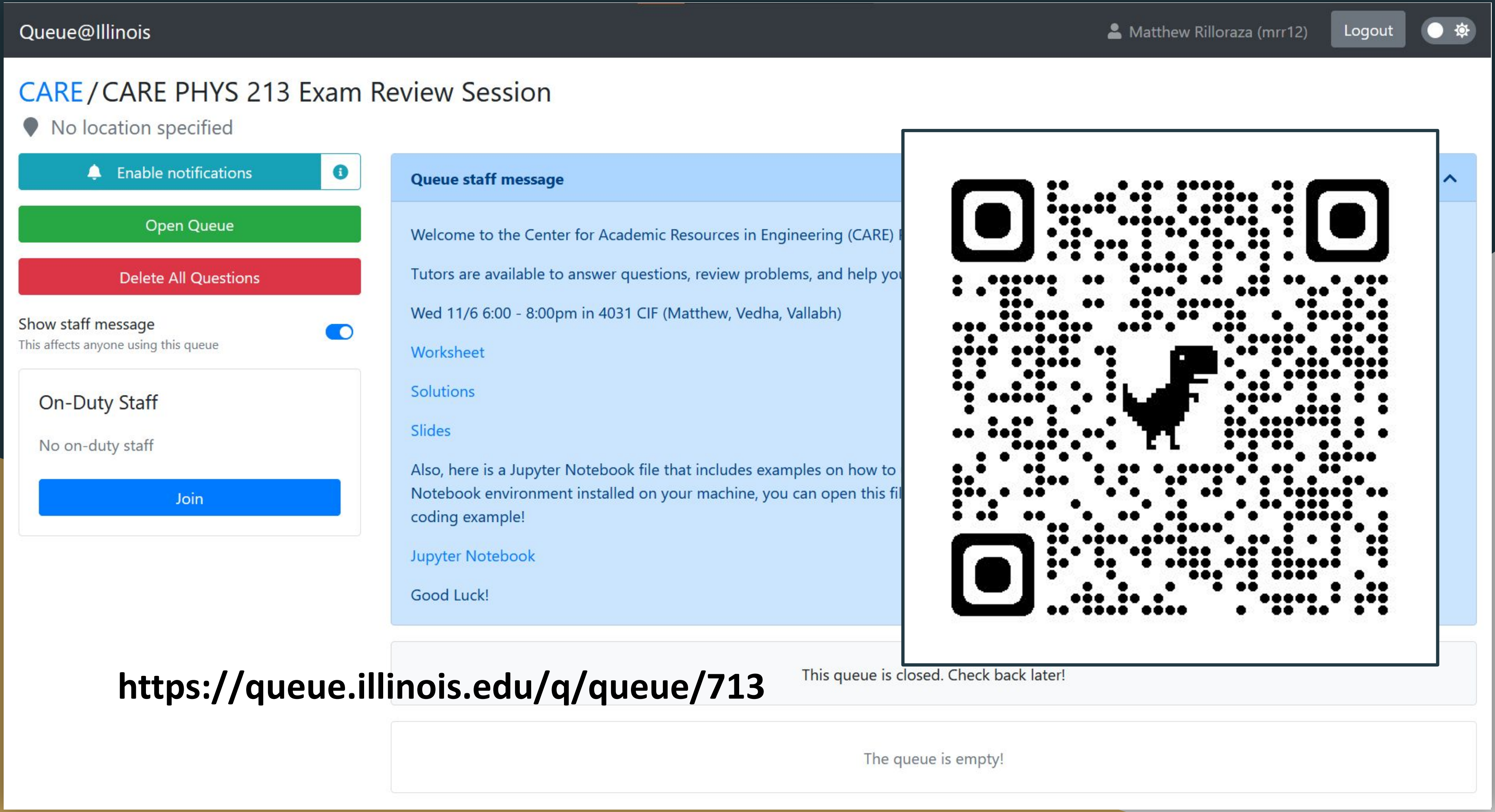
CARE PHYS 213 Review Session - Quiz 2

Please add yourself to the queue!



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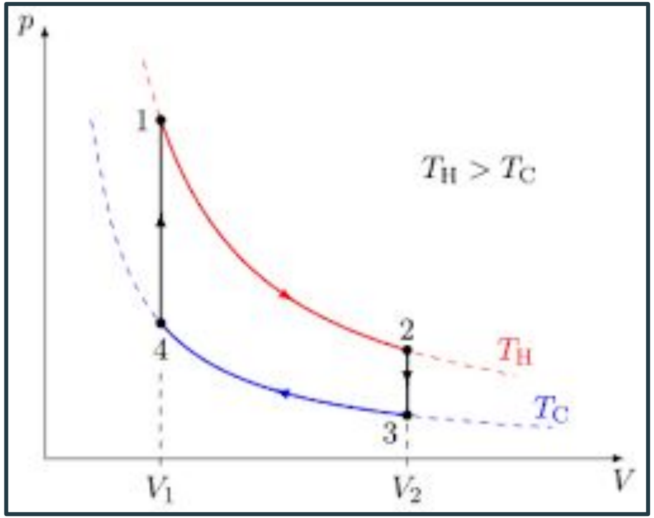
Topic breakdown for the Exam 2

- Ideal Gases, rms velocity
- Thermodynamic Processes, Reversible Processes
- Heat Engines
- Gibbs Free Energy



Ideal gas and Equipartition

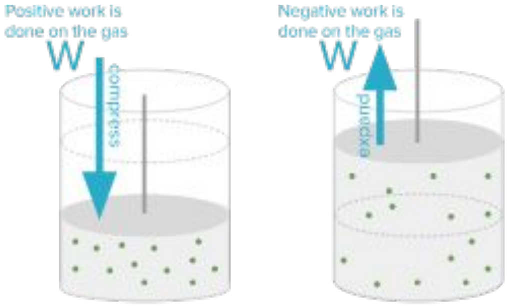
- Ideal Gas: Approximation of particles as points with no interactions:
  - Follows ideal gas law:

$$pV = NkT = nRT$$

- Equipartition: each degree of freedom contributes ½ kT of energy
  - Internal energy in each particle:
    - $U = (N_{\mathrm{DOF}}/2)kT$
  - Molar heat capacity:
    - $c_{\mathrm{M}} = (N_{\mathrm{DOF}}/2)kN_{\mathrm{A}}$

Heat Capacity in Different Scenarios

- **Work done by a gas is equal to the negative work done on the gas**
  - Gas is “winning” ⟶ work by is positive
  - Gas is “losing” ⟶ work by is negative
- Heat capacity at constant pressure is always larger than heat capacity at constant volume
  - The gas “does work” and wastes some of the input heat



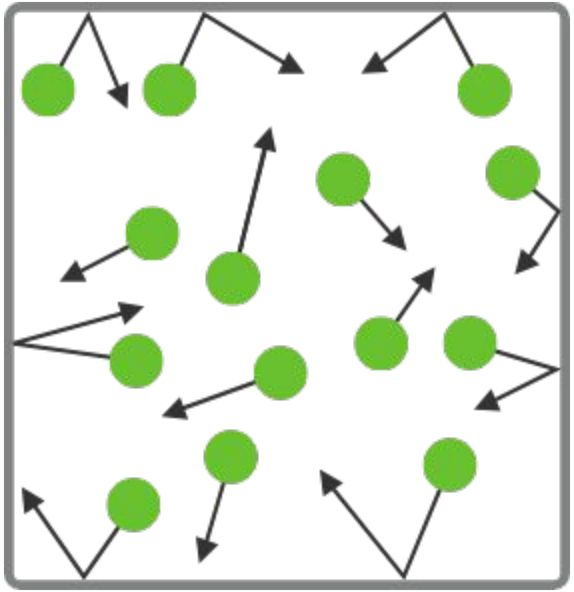
dW_{on}	Work on $-pdV$	Constant volume	$C_V = \frac{dU}{dT}$
dW_{by}	Work by pdV	Constant pressure	$C_p = \frac{dU}{dT} + p\frac{dV}{dT}$

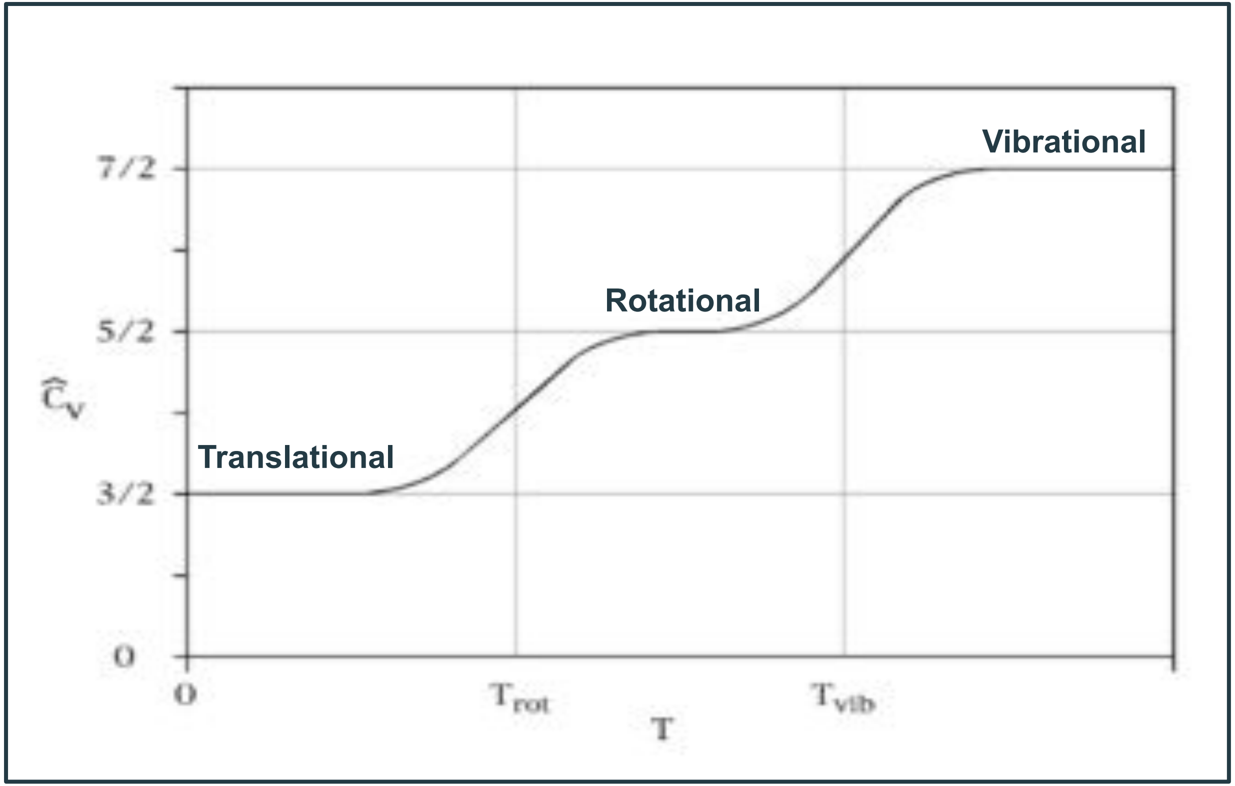
Root-Mean-Square Velocity

- v_{rms} : the average (translational) velocity of gas particles
- Translational kinetic energy : KE = $\frac{1}{2}m(v_{rms})^2$
- Relationship to temperature:

$$\frac{1}{2}mv_{rms}^2 = \frac{3}{2}kT$$

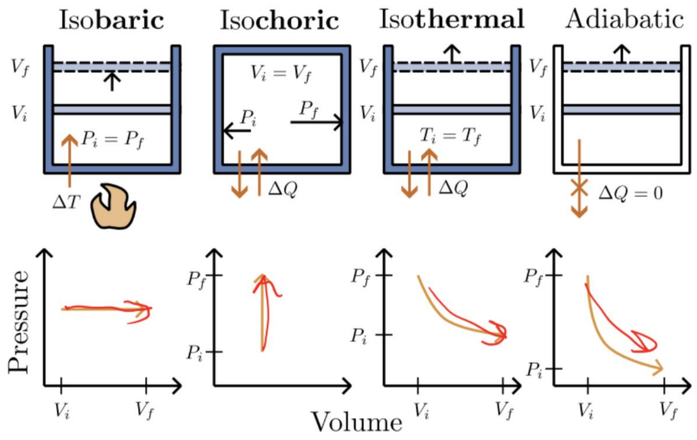
- Notice: this does not depend on the number of DOFs; it is always $(3/2)kT$
  - This is because translational KE only depends on the translational modes of motion (and there are always only 3 translational modes)





Vibrational
Rotational
Translational
7/2
5/2
3/2
0
$\hat{C}_V$
0
T_{rot}
T_{vib}
T

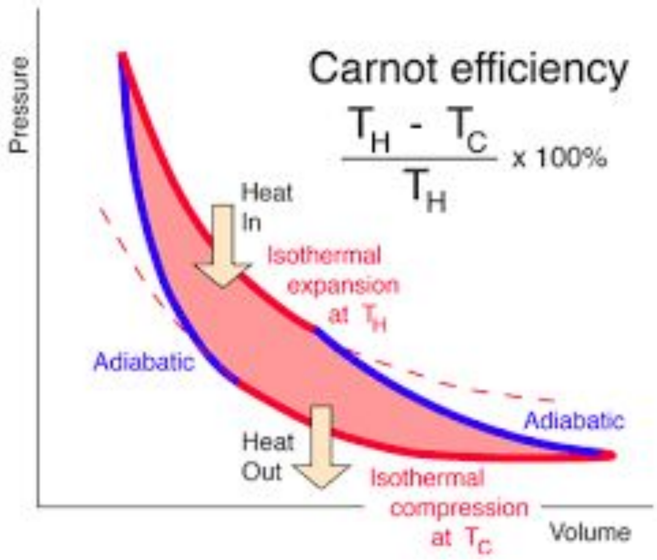
Thermodynamic Processes



- Isochoric or Isovolumetric
  - Constant Volume, Irreversible
- Isobaric
  - Constant Pressure, Irreversible
- Isothermal
  - Constant Temperature, Reversible ($\Delta S_{total} = 0$, $\Delta U = 0$)
- Adiabatic
  - Constant Heat (dQ = 0), Reversible ($\Delta S_{total} = 0$, $\Delta Q = 0$)

Reversible Processes

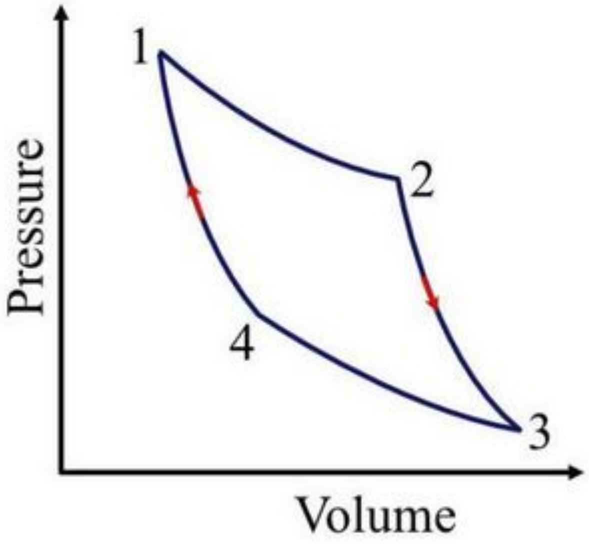
- **Isothermal + adiabatic processes** are reversible
  - $\Delta S_{total} = 0$ (no change in entropy)
  - For isothermal processes:
    - $PV = \text{constant}$
  - For adiabatic processes:
    - $PV^{\gamma} = \text{constant}$



p-V Diagram

$$W_{\text{by}} = \int_{V_i}^{V_f} p \, \mathrm{d}V$$

- Used to visualize thermodynamic cycles
- **Area enclosed in the curve is equal to the work per cycle**
  - **Clockwise direction: work is positive** (engine did work)
  - **Counterclockwise direction: work is negative** (work done on engine)



Heat Engines

- Cycles of Thermodynamic processes are used to make engines, heat pumps, and refrigerators
- Efficiency of engines:

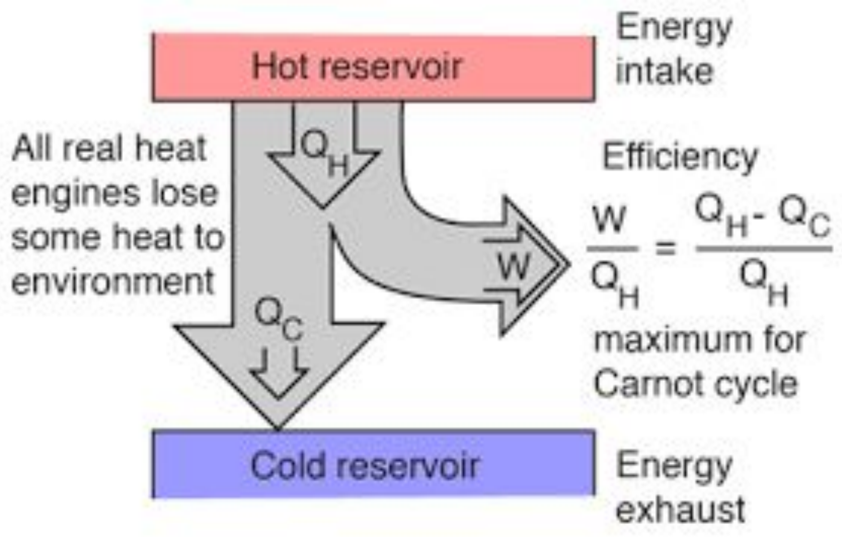
$$\epsilon = \frac{W_{by}}{Q_H} \leq 1 - \frac{T_C}{T_H}.$$

- COP of pumps and refrigerators:

Heat pump: $COP = \frac{Q_H}{W_{on}} \leq \frac{1}{1-\frac{T_C}{T_H}}$

Refrigerator: $COP = \frac{Q_C}{W_{on}} \leq \frac{1}{\frac{T_H}{T_C}-1}$

Efficiency/COP can be thought of as "what you get out" divided by "what you put in."



Gibbs Free Energy

- Useful when temperature and pressure is constant

$$G = U - T_{\text{env}} S + pV$$

- Minimizing Gibbs of a system will maximize total entropy
  - So as a system approaches equilibrium, free energy will decrease to a minimum
- Fundamental Thermodynamic Relation in Equilibrium:
  - $T\mathrm{d}S = \mathrm{d}U + p\mathrm{d}V - \mu\mathrm{d}N$
  - $\mu = (\mathrm{d}G/\mathrm{d}N) \rightarrow \mu N = G$ at constant pressure and temperature
  - Equilibrium favors lowest μ

Good Luck!

Feel free to ask any questions you may have!

You got this!!!

“Queue”-R Code

The team’s drop-in hours:
(held on Grainger 4th floor, west wing)

Matthew: Wed 12-2pm
Zaahi: Wed 2-4pm
Vedha: Sun 12-2pm, Wed 1-3pm and 5-6pm, Thursday 8-10pm
Wesley: Fri 1-3pm, Sat 2-4pm
David: Fri 3-5pm
Aparna: Mon 4-6pm, Wed 5-7pm

Check CARE website for more information!