MAT 501 Thermodynamics
Fall 2020

Moderator:
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Associates:
Course Data:
Hours: Mon 11.40-13.30/Thu 11.40-12.30 (A); 12-40-13.30 (B).
Office hours: TBA

Textbooks:

References:

Weeks Commencing/Topics:

Oct 5, 12 Part I
Thermodynamic systems
Piston-gas as a system
   Idealizations and assumptions about the piston, the gas, and the environment
Gases
   Ideal/perfect – what are the assumptions?
   Laws – observations/experiments
   Maxwell's "kinetic" theory
   Molecular interactions – radial distribution function*
States – a generalization: \( f(p, V, T, N) = 0 \) – how do we know that these variables suffice to describe a state?
Work done

Oct 19, 26 Part II
Internal energy
   Isolated systems – microcanonical formalism
Heat
   Interactions with the environment – Isothermal, adiabatic, and all else
   Canonical formalism – is there a pure mechanical correspondence? Ergodicity*
The first law
   Gases
   Expansions – what variables are fixed? Reversibility for each step or whole process?
   The maximum work theorem
      Expansion for different gases* Different piston constructs/shapes*

Nov 2, 9 Part III
The second law
I have not used “entropy.” Why not talk about entropy first?
Cycles
   Carnot – why Carnot? Are there other cycles? A general form of cycles*
      Microscopic/nanoscopic machines – what makes them different? Are they really different?
Finally, entropy
Szilard machine*
Can we relate the thermodynamic entropy to information (Shannon) and Kolmogorov entropy? Maxwell’s demon.

**Nov 16** Recapitulation and the **Midterm**

**Nov 23, 30** Part IV
Thermodynamic potentials
- Which variables do you want to keep constant?
- Are there any variables that are not “readily” measurable?
Helmholtz and Gibbs free energy
- Legendre transformations – that may give a helping hand for other potentials in your research
- The Maxwell relations
Extremum principles – Maupertius did it first! (A simple calculus of variations problem*)
The Nernst postulate and the Third Law

**Dec 7, 14** Part V
Stability of Thermodynamic Systems
Explain, why
- Addition of heat to a stable system must increase its temperature – volume Watson, how about volume?
- Isothermal expansion of a stable system must decrease its pressure
Revisit the original “intuitive” arguments about the cycles
Revisit the first and the second laws
Le Châtelier’s principle and Braun’s amendment

**Dec 21, 28** Part VI
Phase diagrams
- Stabilities of phases
- Phase boundaries and typical phase diagrams
Phase transitions
- First-order phase transitions in single component systems
- The discontinuity (of the volume – the lever rule; in the entropy – latent heat)
- Phase loci – The Clapeyron equation
- First order transitions in multicomponent simple systems – Gibbs’ phase rule
- Phase diagrams for binary systems
- Tisza’s and Ehrenfest’s theories of second-order phase transitions

**Jan 4**
Fluctuations and Critical phenomena*
- Work and heat fluctuations – (Jarzynsky and Crooks theorems)
- Order parameters and critical exponents. Scaling and universality.

**Class Policies**
Course will be online.
Hours to be **synchronized**: 1.5 hours/week (75 min/week) for whole class (all recorded)
- 1 hour*2/week (50min*2/week) for 2 times*20 (for each group, both recorded)
Hours to be **asynchronized**: 0.5 hours/week (25 min/week) for whole class (notes/viewgraphs/videos will be available)

**Grading**
- **Break-out room quizzes**: 6 of them, one for each “mid-part;” total is for 12% of the final grade
- **Synchronous quizzes**: 6 of them, one for each “part;” total is for 24% of the final grade
- **Midterm**: 28% of the final grade
- **Final exam**: 36% of the final grade; covers all the material