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.

(*) Topics, a thorough coverage of which, go beyond the scope of the course.

**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**: (5-best/6) of them, one for each “mid-part;” total is for 15% of the final grade
- **Synchronous quizzes**: (5-best/6) of them, one for each “part;” total is for 20% of the final grade
- **Midterm**: 30% of the final grade
- **Final exam**: 35% of the final grade; covers all the material