Final information

- 4-6 pm, Thursday, 20 March, 55 Roessler
- Closed book, two 3”x5” note cards
- Bring a law blue book.
- A calculator will probably be needed.
- Coverage:
  - Most of the final will be on Unit T. If you know the stuff in it, you will do well. (Do not worry about other topics ‘till you have it wired.)
  - You can be sure that there will be a conceptual/writing question about entropy and the Second Law or an application thereof.
  - The chapters *Overviews* give an excellent outline of what you should know. I will make just a couple of comments to modify that information:
    - You should be familiar with the concepts involved in the Einstein solid and their relation to the basics of statistical mechanics. However you do not need to know the details like the formula for g(U,N).
    - An additional fact about entropy that we discussed in lecture is

      $$\left.\frac{\partial S}{\partial V}\right|_U = \frac{P}{T}$$

  - For other versions of summaries, check out the documents *First law stuff, Foundations,* and *Stat. mech. and thermo. main points* on our website.
  - More advanced topics of lower priority:
    - The black body radiation spectrum:
      - The thing to know if you’re only knowing one: the total energy density $u_0 = \frac{4\sigma}{c}T^4$.
      - To know a little more, add the expressions for the entropy density s, and the pressure P.
      - Note: The k’s that appear on page 2 of the blackbody document are wavenumber. The other time k means wavenumber is in the first line after the heading “Temperature of the universe” on page 3. The other k’s in the document are k_B. In particular, the k in the definition of the Stefan-Boltzmann constant is k_B.
    - Cosmology:
      - (Be smart in using your study time; there will be at most one small cosmology problem.)
      - The cosmic microwave background radiation is black body radiation with present temperature about 2.7K, and its temperature is inversely proportional to the scale factor R.

- **The interpretation of the scale factor R(t).**
- **The definition of the Hubble parameter H in terms of R and its relation to the Hubble expansion:**

  $H \equiv \dot{R} / R$ and $v \approx H_0 d$ when v and d are not too big.

- **The the energy density ρ, the critical energy density ρ_c , and Ω. What Ω and the contribution to it from a cosmological constant say about the fate of the universe.**

- **Some limited knowledge of relativity may be needed in other problems. In particular, you should know the energy/momentum relations for massive and massless particles:**

  $E^2 = |\vec{p}|^2 + m^2$ and $E = |\vec{p}|$ (in units with $c = 1$.),

  and that photons with angular frequency ω behave like massless particles with energy $E=\hbar\omega$. It might also be useful to remember the relativistic Doppler shift for light and its relation to the redshift z as discussed in Appendix B to Unit R:

  $$\frac{\lambda_R}{\lambda_E} = \sqrt{\frac{1 + v_x}{1 - v_x}} \quad \text{and} \quad z \equiv \frac{\lambda_R}{\lambda_E} - 1$$