ASTRONOMY 121 - Fall 2025
Homework Assignment #2
DUE by Tuesday, October 14, 2025
400 points

NOTE: Be sure to show all calculations clearly, and box/circle/highlight the final result.

Problem 1. [50 points]

Using $n(E) = \frac{g(E)}{e^{E/KT}-1}$ and $p_\nu = h\nu/c$, derive $u(\nu)d\nu = E(\nu)n(\nu)d\nu$, i.e., the energy density of photons of frequency ν in the range $d\nu$ in thermal equilibrium. Calculate the same, but expressed in terms of wavelength rather than frequency.

Problem 2. [30 points]

From Problem 1, calculate the total energy density of the photon field in thermodynamic equilibrium, and comment on the Stefan-Boltzmann's law. NOTE: $\int x^3 dx/(e^x - 1) = \frac{\pi^4}{15}$

Problem 3. [30 points]

The radius of the Sun is 16 arcmin of arc as seen from the Earth. The radiant flux at the top of the Earth's atmosphere is 1.338×10^6 erg s^{-1} cm^{-2} (a.k.a., the solar constant). Calculate the effective temperature of the Sun using only the data given. NOTE: from the solar constant and the distance of the Sun, the solar luminosity is calculated.

Problem 4. [50 points]

Calculate the position of the maximum of the blackbody spectrum in the form $\lambda_{max}T = constant$. The wavelength of maximum intensity in the solar spectrum is 5000Å. Assuming the Sun radiates as a blackbody, compute its surface temperature.

Problem 5. [50 points]

The mass of the Hydrogen atom is equal to 1.007825 amu, and the mass of the Helium atom is 4.002603 amu. Calculate the energy released by nuclear binding when four Hydrogen atoms combine to form one Helium atom. How much energy is liberated when 1 g of Hydrogen is converted to 1 g of Helium? Assume 1 amu = 1.66053886×10^{-24} g.

Problem 6. [30 points]

If an O5 star were at 35,000 K blackbody, where would the peak in the continuous spectrum be (express the peak wavelength in nm, and mention in what part of the electromagnetic spectrum it is)?

Problem 7. [50 points]

Calculate the radii of B0, A5, and M0 main-sequence stars, given their absolute bolometric magnitudes M_{bol} = -6.7, 1.7, and 7.6, respectively, and effective surface temperatures of T_{eff} = 21000, 8100, and 3300 K, respectively. Compare to the solar radius, i.e., express the radii in units of solar radius.

Problem 8. [30 points]

Calculate the radius (in units of Earth radius) of a white dwarf having a luminosity $L=10^{-2}$ $L_\odot$ and an effective temperature T_{eff}=10000 K.

Problem 9. [30 points]

If the apparent magnitude of the M_V=0 RR Lyrae variables in a given cluster is m_V=15, what is the distance to the cluster?

Problem 10. [50 points]

Estimate the approximate main-sequence lifetime of a star with absolute visual magnitude M_{Bol}=0 (A0 star), M_{Bol}=-10.6 (O5 star), and M_{Bol}=7.6 (M0 star). Plot the estimated main-sequence lifetime of a star as a function of its mass (from 0.1 $M_\odot$ to 100 $M_\odot$) (make a log-log plot).