

PHYS 301
Thermodynamics and Statistical Mechanics

Worksheet #11
Thursday March 26 2026

Question 1.

Temperature of the Earth: The “solar constant” is the amount of energy per unit area per unit time that the Earth receives from the Sun. Here, we will model the Sun as a sphere of radius $R_{\odot} = 6.96 \times 10^8$ m with a surface temperature of $T = 5772$ K.

- (a) Using the Stefan-Boltzmann law, determine the total luminosity L_{\odot} of the Sun in Watts.
- (b) Assuming that the distance Sun-Earth is 1.496×10^{11} m, compute the solar constant in W/m^2 .
- (c) Assume that the Earth is a perfect blackbody. Its Sun-facing side (area πR_{\oplus}^2) is thus absorbing all incoming solar radiation, and then re-radiating it over its entire surface area ($4\pi R_{\oplus}^2$). Use this to estimate the surface temperature of the Earth. The radius of the Earth is $R_{\oplus} = 6.371 \times 10^6$ m.

Question 2.

Non-relativistic boson gas: Consider a gas of non-relativistic bosons made of particles of mass m at temperature T (with $mc^2 \gg k_{\text{B}}T$), chemical potential μ , in a box of volume V . Each particle has total energy $E = mc^2 + p^2/2m$, where p is the momentum and c is the speed of light. Show that the number density of bosons in the box is

$$n(T, \mu) = \frac{\langle N \rangle}{V} = \frac{1}{h^3} (2\pi m k_{\text{B}} T)^{3/2} e^{-(mc^2 - \mu)/k_{\text{B}} T}. \quad (1)$$