PHYS 480/581
Cosmology

Worksheet #12
Monday 10/10/2022

Question 1.

(a) As we have just seen, the energy density for radiation (relativistic particles) in thermal equilibrium scales as $\rho_{\mathrm{rad}} \propto T^4$. Use your knowledge of how radiation dilutes in an expanding universe to determine how the temperature scales with the scale factor $a(t)$ of the universe.

(b) Given your answer from part (a), how does the number density n_{rad} of relativistic particles scale with $a(t)$? Does this answer make sense? Why?

(c) Does radiation need to be in thermal equilibrium to have an equation of state $w = P/\rho = 1/3$? Why or why not?