1. The horizon paradox.

   (a) (2 pts.) Explain the horizon paradox in a few sentences.

   (b) (2 pts.) Compute the length of the horizon for sound waves at recombination. Use the actual values for the densities of matter and radiation as we did in the class of 28 Feb.

   (c) (2 pts.) In the class of 1 Mar, we found a different value for the length of the horizon. What effects did we not compute properly?

   (d) (2 pts.) By what minimum factor must the universe have inflated to solve the horizon problem?

   (e) (2 pts.) If inflation occurred at time $t_{\rm inf}$ after the Big Bang, what is the minimum duration for inflation to solve the horizon problem?

2. (6 pts.) Hartle 18-15.

3. Define $N_{\rm gal}(z)$ to be the number of galaxies *observed* to have a redshift $z' < z$ and to be within a solid angle $d\omega$ of a certain direction. Assume the number density of galaxies $n_{\rm gal}(a) = n_0 a^{-3}$, where a is the expansion parameter and n_0 is the present number density. Recall the redshift z and expansion parameter are related by $a = (1+z)^{-1}$. Assume the universe is flat and matter dominated.

   (a) (5 pts.) Find $N_{\rm gal}(z)$.

   (b) (2 pts.) Interpret the dependence on z of $N_{\rm gal}(z)$ for $z \ll 1$.

4. (5 pts.) Prove $g_{\mu\nu} g^{\nu\sigma} = \delta^\sigma_\mu$, where $g_{\mu\nu}$ is the metric for contravarient vectors, $g^{\mu\nu}$ is the metric for covarient vectors. $\delta^\sigma_\mu = 1$ if $\mu = \sigma$, and $\delta^\sigma_\mu = 0$ if $\mu \neq \sigma$. You must write the reasons for the steps in your proof.

5. (6 pts.) Consider spherical coordinates $(x^0, x^1, x^2, x^3) = (t, r, \theta, \phi)$ in flat space. Compute Γ^1_{22}, Γ^1_{33}, and Γ^3_{23}.

6. (5 pts.) Answer the questions posed in class on 13 March. Submit your answer on angel. The link is Lessons—Hwk5B. This and the next question are due by 2:40 on 20 Mar.

7. (5 pts.) Answer the questions posed in class on 15 March. Submit your answer on angel. The link is Lessons—Hwk5B.