November 29, 2006 Name:________________________

Astronomy 102: Examination 4

Do not open the test until instructed to begin.

You must do this test on your own without consulting any outside notes. You may not discuss this test with anybody else either before or during your taking of the test. You are allowed a calculator for purposes of arithmetic, but you may not use any device that connects you to a network or allows you to communicate with any other people.

I confirm that I did not receive any help, nor did I reference any disallowed materials in doing this test.

Signature:____________________________

Instructions: Write your answers in the space provided. If you need additional space, continue on the back of each page, but indicate **clearly** that you have done so. No books, notes, or assistance from anyone is allowed. You are allowed to use, and will need, a calculator. Please **write legibly and be brief and to the point!** The exam has four questions; each question has equal weight.

(Equations and constants potentially useful for the test are on a separate sheet.)

1. For much of the 20th century, the value of t_H for our Universe was not known to better than a factor of two. Alan Sandage was one of the leading proponents of a "slow" Universal expansion, while Gerard de Vaucoulers as one of the leading proponents of a "fast" Universal expansion.

(a) Which scientist reported a *higher* value for t_H?

(b) Make the simplifying assumption that both scientists were reporting their value of t_H based on measurements of Type Ia supernovae in distant galaxies. Assume that both scientists measured the *same* redshift for each galaxy.

Which scientist was getting measurements that suggested that the distant supernovae were *brighter*?

(In reality, this situation was far more complicated than this; the purpose of this problem is for you to demonstrate that you understand how the brightness of a standard candle can lead to a measurement of the expansion rate. Draw a picture if you think it will help you reason this out.)

2. What are the three primary pieces of evidence discussed in class that lead us to accept the Big Bang Theory as a good description of the history of our Universe?

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3. The Quasar 3C273 is at a redshift z=0.158. For purposes of this problem, you may assume that the $z \ll 1$ condition is satisfied (that is, assume 0.158 is "a lot less than" 1, even though in reality this is pushing the boundary).

(a) How far away (in Mpc) was 3C273 at the time the light was emitted?

(b) By what factor has the size of the Universe expanded during the time the light from 3C273 was travelling to us?

(c) How long did the light from 3C273 take to reach us?

(d) Assume that the expansion rate of the Universe has not changed. Consider somebody living (somehow) in 3C273 *right now.* What value (in years) would that person measure for t_H?

(e) Assuming that the expansion rate of the Universe has not changed. Consider somebody who was living in 3C273 at the time when the light we've just observed was emitted. What value (in years) would that person have measured for t_H?

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4. (*Please read this problem carefully; it is **not** identical to a problem on the review test!*)

We have measured that our Universe is composed of about 70% Dark Energy, 25% Dark Matter, and 5% normal matter.

Consider another universe, just like ours, that has the same value of t_H as ours does. However, suppose that this Universe is composed of 95% Dark Energy and 5% normal matter, and has *no* Dark Matter.

(a) Is this other universe older than or younger than our Universe? Explain very briefly.

(b) Name at least *two* astronomical observations that would be different in this other universe from what is seen in ours as a result of the different constituents, and describe how they would be different.

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