

**Fall 2005 ASTR 1120-001 General Astronomy: Stars & Galaxies.
Problem Set 1. Due Th 1 Sep**

Your name:

Your ID:

Please show your working on this sheet, and write your answers on this sheet. Attach extra sheets if you need them. Express your answers in scientific notation. By the way, if you can't do any particular question, then *guess* a reasonable answer (and say you guessed), and use your guess for subsequent answers. The grader will not penalize you for getting a wrong answer because you miscalculated in a previous question — (s)he'll compensate. Mind you, if you make a ridiculous guess, (s)he might penalise you for that.

In each case the question asks you to decide whether to figure the answer exactly, or just to estimate it. Don't forget to explain why! Please note that *you will get marked down if you give too many significant figures when only a rough estimate is justified*. You might estimate an answer as, for example, 3×10^{11} , or just 10^{11} ; anything more accurate would be unjustified.

Here are some cool exact numbers:

Speed of light = 299,792,458 m/s (meters per second, not miles per second!)

1 year = 31,556,930 seconds

1 AU (Astronomical Unit) = 149,597,870 km

1 pc (parsec) = $648,000/\pi$ AU

1. Lightyears in a parsec

How many meters are there in a parsec? How many meters are there in a lightyear? Therefore, how many lightyears are there in a parsec? Are these numbers you can figure out exactly, or should you just estimate them? Why?

1 parsec = _____ meters.

1 lightyear = _____ meters.

1 parsec = _____ lightyears.

2. Radius of Observable Universe

From measurements of the rate of expansion of the Universe (the “Hubble constant”), we estimate that the age of the Universe is about 14 gigayears ($1 \text{ Gyr} = 10^9 \text{ yr} = \text{a billion years}$). Light can travel only a finite distance during the age of the Universe, so the observable radius of the Universe is approximately the age of the Universe times the speed of light (not exactly, because the Universe may have decelerated or accelerated a bit). What is the radius of the Universe, first in lightyears, then in megaparsecs ($1 \text{ Mpc} = 10^6 \text{ pc}$). Are these numbers you can figure out exactly, or should you just estimate them? Why?

The radius of the observable Universe is about _____lightyears.

The radius of the observable Universe is about _____Mpc.

3. Number of Galaxies in Universe

From question 2, what is the volume of the observable Universe, in Mpc^3 ? As a rough average, the distance between galaxies is around 1 Mpc, so that there is about 1 galaxy per cubic Megaparsec in the Universe. What is the number of galaxies in the observable Universe? Are these numbers you can figure out exactly, or should you just estimate them? Why? [Hint: Even though the observable Universe is really spherical, approximate it as a cubical box (why not?). You want to fill this cubical Universe with little cubes called galaxies. How many galaxies wide is the Universe? It's a box, so you have to cube that to get the number of little boxes in the big box, don't you?]

The volume of the observable Universe is about _____ Mpc^3 .

The number of galaxies in the observable Universe is about _____.

4. Number of Stars in the Galaxy

The typical distance between stars is about 1 parsec. Our Galaxy, the Milky Way, is a disk of stars about 3×10^4 parsecs in diameter, and about 300 parsecs thick. How many stars there are in the Galaxy? Is this a number you can figure out exactly, or should you just estimate it? Why? [Hint: This is a bit like the previous problem, except the box — the Galaxy — looks more like a briefcase than a cubical box.]

The number of stars in our Galaxy is about _____.

5. Atoms in the Universe

Each star contains roughly 10^{57} atoms. How many atoms are there in the observable Universe? Is this a number you can figure out exactly, or should you just estimate it? Why?

The number of atoms in the observable Universe is about _____.

6. Distance between atoms in the Universe

Suppose all the atoms in the observable Universe were uniformly spread out through it. From the volume of the Universe in question 3, and the number of atoms in the Universe from question 5, what would be the volume occupied by each atom? Express your answer in cubic meters. Therefore, what would be the average distance between atoms, in meters? Are these numbers you can figure out exactly, or should you just estimate them? Why?

The average volume occupied by each atom would be about _____ m^3 .

The average distance between atoms would be about _____ meters.