

ASTRO190 HOMEWORK #2.

DUE Wed. 23 January.

All questions have the same weight for grading. Please submit your answer in pdf or text format to balick@uw.edu with subject line "HW1". 25% per day penalty for late submission.

1. Other than age, what are three intrinsic physical properties of people that are readily observable from 100 feet away? An "intrinsic property" is one like your age that everyone everywhere and everywhen in the Universe would measure for you. Careful: "weight" is not intrinsic but mass is.

2. Let's develop some sense of cosmic sizes. Fill in the blue entries with numbers to the nearest powers of ten. Your estimates must be in the units shown in blue.

Approx Size (m)	10 ⁰	10 ³	10 ⁶	10 ⁹	10 ¹²	10 ¹⁵	10 ¹⁸	10 ²¹	10 ²⁴	10 ²⁷
Object Name	You	Mt Rainier	Earth	Sun	Antares	Cat's Eye Nebula	Omega Centauri	Milky Way	Virgo Super-cluster	Observable Universe
Object Type	Human	Mtns	Planet	Sun-like star	Red giant	Nebula	Globular Cluster	Galaxy	Galaxy Cluster	Universe
Size in light-sec, day, month, year (10 ^x notation)	10 ⁻⁹ light secs	10 ⁻⁶ light secs	light secs	≈10 ¹ light secs	10 ² light secs	light days	light years	light years	light years	light years

These web pages will help.

See <http://www.eamesoffice.com/the-work/powers-of-ten/>
 If your web browser supports FLASH (not Safari or Firefox) then a very convenient source of this information is www.htwins.net/scale2. Otherwise see <https://www.youtube.com/watch?v=uaGEjrADGPA>, or other resources.

* "≈" and "≈" both mean approximately.

3. The most distant object ever observed, "GN-z11", was found in 2016 by very deep Hubble Space Telescope observations. The object seemingly lies at a distance from the Earth of around 13.4 billion light years. See the press release and Hubble image at

http://hubblesite.org/news_release/news/2016-07

- Why might the observers reasonably claim that the object is a distant galaxy when the object itself is barely detected and no details of its structure are visible in its image?
- About how old was the Universe when the light that we see now was emitted from the object?
- How can we determine what this distant object looks like at the present time?

The next two questions are tricky. Try both. The answer with the lowest grade will be dropped.

4. Using huge telescopes we can see very young galaxies like GN-z11 on opposite sides of the visible universe. However, they can't presently see one another. Explain.

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- 5 We believe that the Universe today is *infinite* and *uniform* (much the same everywhere as it is here—and thus endlessly boring). Nonetheless, what we observe as we peer into deep space with our very best telescope is described by the figure above. Be sure to note that it has an outer boundary. (Tip: review the class notes.)
- How can you reconcile the uniformity of today's universe with the figure?
 - Based on good (but limited) modern evidence we believe that the Universe is 13.8 billion years in age. How far is the edge of the observable universe in light years?
 - Generally speaking where would the first galaxies to form in the Universe lie in this figure?
 - Argue that the size of the observable universe increases by 1 light year per year.

Ponder on your own: what lies beyond the border of the figure?

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