Lab 1, Part 1: Class Norms and Social Identity Wheel

Welcome to the first lab! In this classroom activity, we will critically consider our social identities and how they shape and inform our lives. We all come from different backgrounds (science, math, and personal) and learning about the universe – especially with people you don't know – can be scary. As we begin the semester, we want to establish the foundation for a community where collaboration and support are the norms, where everyone can succeed by working together. In order to make this explicit, we will draft classroom norms together. What are norms? They "...are the informal rules that groups adopt to regulate and regularise group members' behaviour" (Feldman, 1984).

0.1 Post-Exercise Reflection

1. Why is it important to critically reflect on our identities, especially in a science lab?
2. What is the value of completing activities like this in our class?
3. What is one concern about you have about this class? How can I (or we, as a class) help alleviate it?

Lab 1, Part 2: Orders of Magnitude, Distances, and Scales in the Universe

Today, we'll explore some fundamental concepts used in astronomy. Astronomy is a field of extremes, and today we learn how to accurately quantify them. The goal of today's lab is to give you an understanding of how far away many astronomical objects are, and how the sizes of objects compare with the distance between them.

1 Scales of the Universe

1.1 Orders of Magnitude

Scientists use orders of magnitude to describe the sizes of various objects. In many cases, it is not necessary or practical to know an object's precise size. Its order of magnitude gives you an idea of how large it is. Strictly speaking, the order of magnitude of a value is the "power of ten" that is closest to the value. Although the Sun's radius is $695,000,000$ m, it's enough to know that its radius is *of order* 10^9 m.

I gave the Sun's radius with many zeros in the number, but we can write it in a more compact way by using scientific notation. To write a number in scientific notation, find the first non-zero digit in the highest place (the left-most place; in this case it's the 6), and put the decimal point after that digit. Then count how many places you moved the decimal place, which gives you the power of ten (in this case it's 8; convince yourself that this is true). If you move the decimal place left in order to change the format to scientific notation, the power of ten is positive. If you have to move the decimal place to the right for scientific notation (i.e. the number is less than 1), then the power of ten is negative. We can then say that the Sun's radius is 6.95×10^8.

While it's tempting to take the power of ten given in scientific notation as an object's order of magnitude, be careful. You need to round the number to the nearest power of ten, and in some cases, the nearest power of ten is the next one up. This is true for the Sun's radius - the power of ten used in scientific notation is 8, but since 6.95×10^8 rounds *up* to $10 \times 10^8 = 10^9$, the order of magnitude is actually 10^9.

For practice, find the order of magnitude of the following. Don't forget to include the unit!

1. **The Bohr Radius**, or the size of a hydrogen atom, 5.3×10^{-11} m
2. **The Empire State Building** 358 m
3. **The Universe** 4.32×10^{26} meters
4. **Two Years** 730.5 days
5. **The Hubble Space Telescope** 11,110 kg

1.2 Unit Conversions

Now look at some measurements that are *not* given in meters. To find their orders of magnitude, you'll first need to convert the value from the given units to meters.

Centimeters, inches, miles, and meters are examples of different units. When reporting a measurement it is very important to include the unit. Every number we will deal with in this lab represents something and requires a unit. Class is not 3 long - it is 3 *hours* long; the Brooklyn Bridge is not 1.13 long - it is 1.13 *miles* long.

To convert units, it's best to multiply the value by a fraction that is equal to one: 1 year/365 days, 12 inches/1 foot, etc. Sometimes, it may take several steps to reach the unit you want. For example, to convert 2.3 years to hours:

$$2.3\ years\left(\frac{365\ days}{1\ year}\right)\left(\frac{24\ hours}{1\ day}\right) = 20148\ hours \approx 10^4\ hours \tag{1}$$

In the following problems, convert the given values to meters, then give the order of magnitude. Use the table given below.

1. **Humans** Let's put it at 5'9", or use your own height if you wish.
2. **Distance from the Sun to the nearest star** 4.243 ly
3. **One Mile**
4. **The radius of the Earth** 6,371 km
5. **The Hubble Space Telescope (length)** 43.5 ft

1.3 Order of Magnitude Differences

Orders of magnitude are great for making (rough) comparisons. The Sun is about 10^6 times larger than the Earth, or six orders of magnitude larger. Saying "New York City has a population an order of magnitude greater than North Dakota" means "New York City's population is about 10^1 times the population of North Dakota".

To calculate the order of magnitude difference between thing A and thing B, you divide their orders of magnitude (OOM):

$$\frac{OOM(A)}{OOM(B)} \tag{2}$$

Remember that when you divide two of the same number with different exponents, you simply subtract the bottom exponent from the top exponent:

$$\frac{10^x}{10^y} = 10^{x-y} \tag{3}$$

1. The distance from Earth to the Sun is called an Astronomical Unit (AU). What's the order of magnitude difference between our distance from the Sun and the radius of the Earth?
2. What's the order of magnitude difference between Earth's distance from the Sun and the distance to the nearest star?

3. Estimate the order of magnitude difference between the length of the hallway and the thickness of a human hair. You can use a ruler to measure your hair, but you may not measure the hallway. Make reasonable assumptions in whichever units you wish, and convert those to meters. Show your work.

1 of these	**= this many of these**
1 inch ($''$)	2.54 centimeter (cm)
1 meter (m)	100 cm
1 kilometer (km)	1000 m
1 foot ($'$)	$12''$
1 mile	$6285'$
1 Astronomical Unit (AU*)	1.49×10^8 km
1 light-year (ly)	9.46×10^{12} km
1 light-year (ly)	63241 AU

*1 AU = the distance from Earth to the Sun

1.4 Powers of Ten

1. Why is it useful for scientists to use scientific notation and orders of magnitude when describing things in the universe?