LAB – Exponential functions

Name_____

Atmospheric pressure decreases exponentially with altitude.

We are actually living near the bottom of an ocean of air.

At sea level, the weight of the air presses on us with a pressure of approximately 14.7 lbs/in^2.

At higher altitudes, less air means less weight and less pressure. Pressure and density of air decreases with increasing elevation.

Pressure varies smoothly from the earth's surface to the top of the mesosphere. This table compiled by NASA gives a rough idea of air pressure at various altitudes (as a fraction of one atmosphere).

fraction of 1 atm	average altitude	
	(m)	(ft)
1	0	0
1/2	5,486.3	18,000
1/3	8,375.8	27,480
1/10	16,131.9	52,926
1/100	30,900.9	101,381
1/1000	48,467.2	159,013
1/10000	69,463.6	227,899
1/100000	96,281.6	283,076

Determining atmospheric pressure:

$$p = p_0 e^{-\left(h/h_0\right)}$$

where:
p = atmospheric pressure (measured in bars)
h = height (altitude)
p_0 = pressure at height h=0 (surface pressure)
h_0 = scale height

This equation shows that the atmospheric pressure decays exponentially from its value at the surface of the body where the height *h* is equal to 0.

When $h_0 = h$, the pressure has decreased to a value of e^{-1} times its value at the surface.

The surface pressure on Earth is approximately 1 bar, and the scale height of the atmosphere is approximately 7 kilometers.

Earth: $p_0 = 1$ and $h_0 = 7$

Problems:

1. Estimate the pressure at an altitude of 3 kilometers in Earth's atmosphere.

Answer: $p = 1.0e^{-\left(3/7\right)} = 0.6514390575 \text{ bars}$

2. Estimate the pressure at an altitude equivalent to the height of Mount Everest (the highest point on Earth). The altitude of Mount Everest is 8,848 meters. (Change meters to kilometers.)

3. Estimate the pressure at an altitude equivalent to the height of Mount Kilimanjaro, 5,895 meters.

4. Estimate the pressure in the Earth's stratosphere at a height of 35 kilometers. This pressure will be approximately equivalent to the pressure on Mars.

5. Using your graphing calculator and the NASA table at the top, prepare a scatter plot of the altitude in kilometers (x-axis) and the air pressure (y-axis). Find an exponential model equation for this data.

6. Using your findings from questions 1, 2, 3 and 4, prepare a scatter plot of the altitude in kilometers and the air pressure. Find an exponential model equation for this data.

7. Compare the three equations you have obtained comparing altitude and air pressure. What are the similarities? What are the differences? Explain.