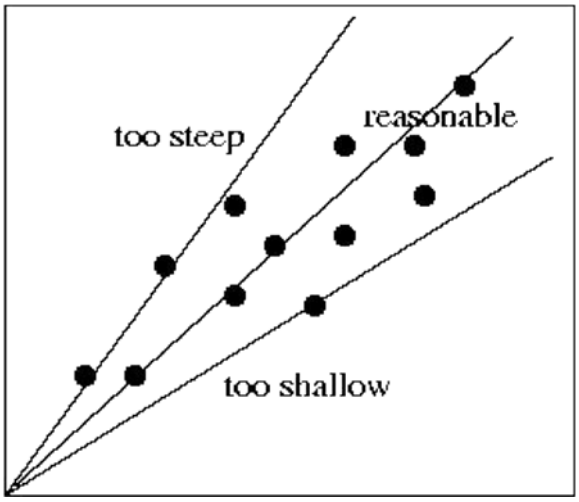
Step 5: Data Analysis

Determining the Hubble constant

1. Graph your data with **distance in megaparsecs (Mpc) on the x-axis**, and **velocity in kilometers per second (km/s) on the y-axis**. Draw a straight line that best fits the points on the graph; remember that this line **must pass through the origin** (the 0,0 point). Measure the slope of this line (rise/run), this is your value of the Hubble constant, in the units of *km/sec/Mpc*. Please show all calculations and record the slope (the Hubble constant) in the Table of Results (under Step 6).

Determining the uncertainty in the Hubble constant

2. Hubble's Law predicts that galaxies should lie on a straight line when plotted on a graph of distance vs. velocity. Your data probably do not make a perfectly straight line, and you most likely had to make a guess as to where to draw your line. One simple way to estimate the uncertainty in the value of H_o is to draw the steepest *reasonable* line *and* the shallowest *reasonable* line on the graph, and calculate their slopes. **Half of the difference** between these two slopes would be your uncertainty. Record in the table.



Determining the Age of the Universe:

3. Maximum age of the Universe: If the universe has been expanding since its beginning at a constant speed, the universe's age would simply be $1/H_o$.
   a. Find the inverse of your value of H_o.
   b. Multiply the inverse by 3.09×10^{19} km/Mpc to cancel the distance units.
   c. Since you now have the age of the Universe in seconds, divide this number by the number of seconds in a year: 3.16×10^{7} sec/yr. This age represents a very simple model for the expansion of the universe, and is the maximum age the universe can be. Record this number in the Table of Results.

EXAMPLE:	
Your Hubble constant is 75 km/sec/Mpc, then 1/75 = 0.0133 = 1.33×10^{-2} **$(1.33 \times 10^{-2}) \times (3.09 \times 10^{19}) = 4.12 \times 10^{17}$**	**(4.12×10^{17}) divided by $(3.16 \times 10^{7}) = 1.3 \times 10^{10}$** **This is 1.3×10^{10} years,** **or 13×10^{9} years,** **or 13 billion years.**

4. The age of the Universe with gravity: A better model would account for the deceleration caused by gravity. Models like this predict the age of the universe to be: $t = (2/3)*(1/H_o)$, or **2/3 of the maximum age** of the Universe. Re-calculate the age using this relation, and record in the Table. Remember to show all calculations.

Once you have the age of the Universe under both models, and the uncertainties attached to each model, you are ready to go onto Step 6: Questions.