All three of these equations are equivalent to each other, and all are just cleverly-disguised versions of the inverse-square law, $b = L / (4\pi d^2)$. In all of these expressions, *m* is the apparent magnitude, *M* is the absolute magnitude, and *D* is the distance ***in parsecs***.

For purposes of this lab, weíll make the (not terribly realistic) assumption that all of the galaxies you observed have the same absolute magnitude (in other words, they all have the same intrinsic luminosity): *M* = ñ22. (Note the minus sign: the absolute value is a negative number in this case.) When you observed each galaxy, you recorded its apparent magnitude *m*, so you have enough information to find the distance to each galaxy.

Youíll need to determine the speed of each galaxy in addition to its distance. Remember the Doppler Effect formula, which can be written

(B) $$\mathbf{v = c\ \frac{\Delta\lambda}{\lambda_0}}$$

Hereís how to use your data to get a value for the Hubble parameter. You can either do steps 1-4 on paper or by entering your data into an Excel worksheet. Either way, once you get to step 5 (plotting a graph), youíll want to use Excel.

1. Use your measured magnitudes and the assumed absolute magnitude for each galaxy and derive the distance, D, to each galaxy using equation **(**A). Express your answer in both parsecs and mega parsecs in the appropriate places on your data table. Note that equation **(**A) tells you how to find the log of the distance.

2. Use your measured wavelengths to calculate the redshifts for each line, $\Delta\lambda_H$ and $\Delta\lambda_K$. Record each on your data table.

3. Use the Doppler shift formula, to determine the velocities as determined by both the H and K lines. There is a place on the data table for each of these figures:

4. Calculate and record the velocity of the galaxy. It is the average of the velocities determined from the H and K lines.

5. Now plot a Hubble diagram by graphing the velocity of a galaxy in km/sec (y-axis) vs. the distance in megaparsecs (x-axis). Draw a straight line through the origin (a *trendline* in Excel) that best fits all the data points. The slope of the line is the Hubble Parameter (H). To calculate the slope of the line, measure a value of **D** and **v** from a point near the **upper right** end of the trendline. Determine H using the following equation:

(C) $$\mathbf{H = \frac{v}{D}}$$

where H is the Hubble Parameter in km/sec/Mpc
v is the velocity measured from your line
D is the distance measured from your line

Record your value for the Hubble Parameter on your data table on the line called the **Average Value of H.**