Name _____ **Class** _____

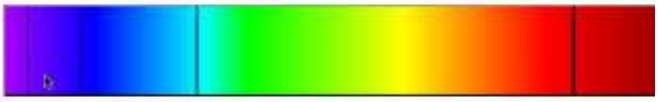
Investigation

Hubble's Law

What's the evidence that our Universe is expanding, contracting, or staying the same?

Materials

- Worksheet "Spectra of Fast-Moving Galaxies"
- Worksheet "Hubble's Law"



The line spectrum of hydrogen, the most common element in the Universe, has characteristic lines (wavelengths or frequencies) in the regions red, turquoise, blue, and violet. The boldest line in the hydrogen spectrum is in the red region. That is if the star or galaxy is not moving towards you or away from you. If it is moving towards you or away from you, each spectrum line will be shifted either toward the red or toward the violet end of the spectrum because of the Doppler effect.

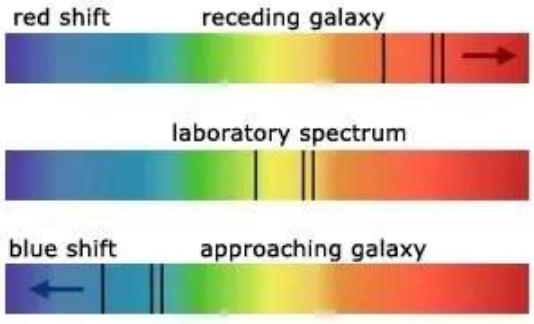
Review:

1. What is the Doppler Effect? (use your notes!)

   _____

2. If a star is coming toward us, which end of the spectrum will its spectral lines shift towards? Red or Blue? _____

3. If the star is moving away from us, which end of the spectrum will the spectral lines shift towards? Red or Blue? _____



Background:
*On the **Spectra of Fast Moving Galaxies** Sheet on the next page you see the Distance the Galaxies are away from ours (The Milky Way) and the Spectral Lines as they appear to us from that Galaxy. You will notice that compared to the Milky Way Galaxy Lines (which we are in, so they aren't moving compared to us)*

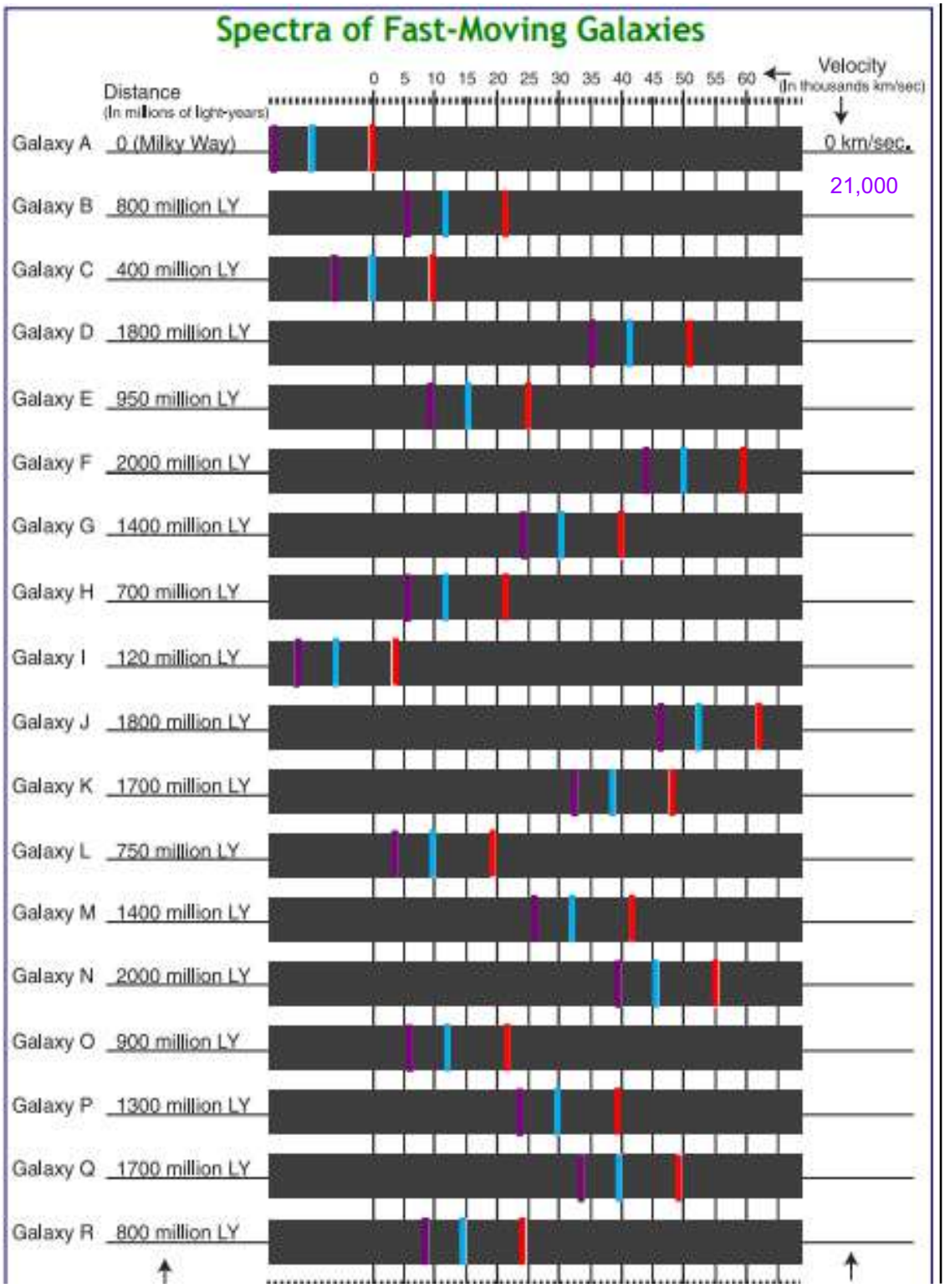
*The **bold red** colored line on each spectrum is the one that is normally in the **red** region. With extreme doppler shifts, that **bold red** line can appear in radically different parts of the spectrum. The scales at the top and bottom of the sheet relate Doppler shifts of the galaxies' spectra with the velocities of the galaxies. Positive velocity means the galaxy is moving away from us and negative velocity indicates the galaxy is moving toward us.*

Collecting and Analyzing Data of Galaxies

1. ***First, find out how fast each galaxy is moving on the** Spectra of Fast Moving Galaxies **section on the next page***

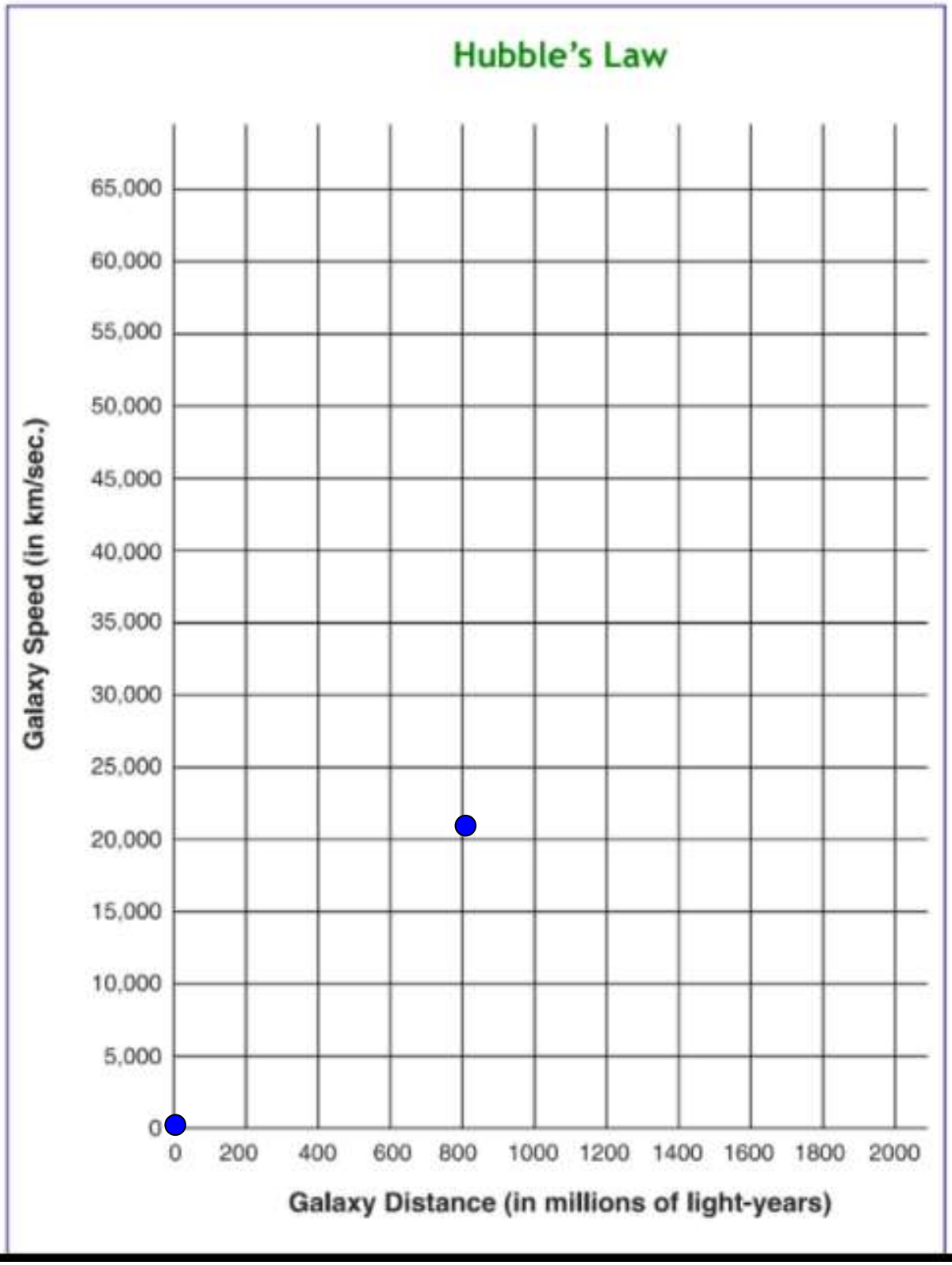
2. Understanding Check:
Notice all the galaxy's spectral lines are shifted toward the right which would be the red end of the spectrum. Does that mean the Galaxies are moving toward us or away from us? _____

Example: Galaxy B's red line seems to have shifted 21 spaces over. This means that Galaxy B is traveling at a Velocity of _____(look carefully at the units!)


Spectra of Fast-Moving Galaxies
Distance
(In millions of light-years)
0 5 10 15 20 25 30 35 40 45 50 55 60
Velocity
(In thousands km/sec)
0 km/sec.
21,000
Galaxy A 0 (Milky Way)
Galaxy B 800 million LY
Galaxy C 400 million LY
Galaxy D 1800 million LY
Galaxy E 950 million LY
Galaxy F 2000 million LY
Galaxy G 1400 million LY
Galaxy H 700 million LY
Galaxy I 120 million LY
Galaxy J 1800 million LY
Galaxy K 1700 million LY
Galaxy L 750 million LY
Galaxy M 1400 million LY
Galaxy N 2000 million LY
Galaxy O 900 million LY
Galaxy P 1300 million LY
Galaxy Q 1700 million LY
Galaxy R 800 million LY

Graphing Data to look for patterns

Use the Spectra of fast moving galaxies to make a scatterplot then use a ruler to draw a line of best fit through the data points.



Data Analysis

3. Using the graph, what is the relationship between the distance from the Galaxies and their Velocities?

*The relationship between galaxy distance and the velocity that you determined is called **Hubble's Law** because it was first discovered by astronomer Edwin Hubble.*

4.So what does this relationship (Hubble's Law) tell us the Universe is doing? Is it staying the same size, getting smaller or getting bigger? Is it happening at the same rate?

Measuring red shift turns out to be yet another powerful way to find the distance to the most far away galaxies. Assuming Hubble's Law applies for most galaxies, astronomers estimate distances to the most remote galaxies by measuring red-shifts, finding velocities, and calculating distances from Hubble's Law.

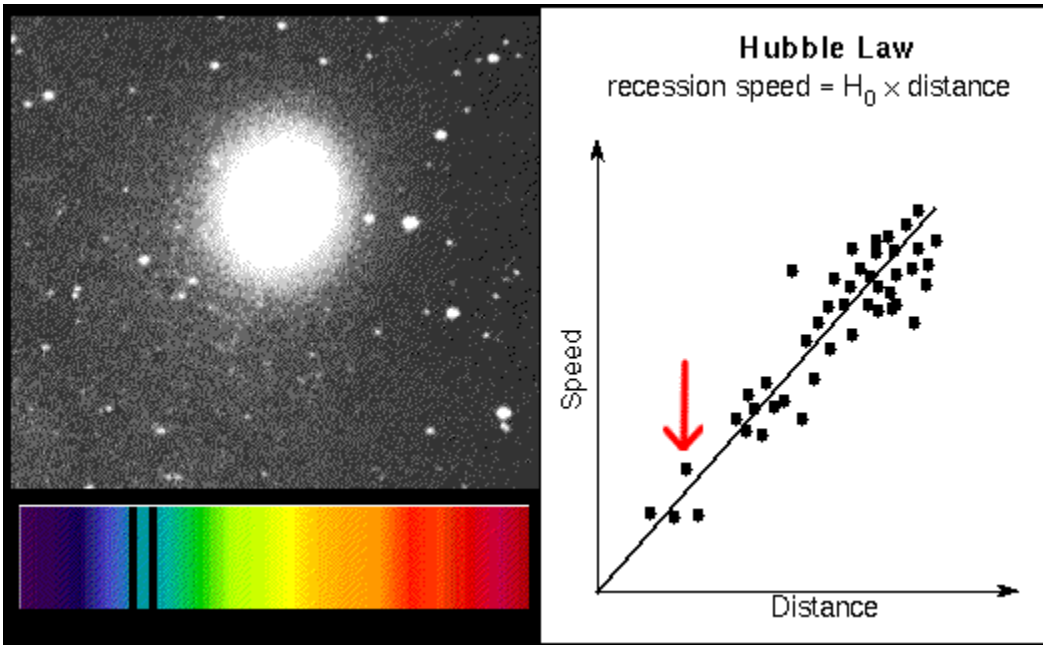
5. Look at the graph to make a prediction

If there was a Galaxy that was moving almost twice as fast as the ones on our graph (about 120,000 km/s) using the pattern you see, PREDICT how far away you think that Galaxy would probably be away in millions of light years.

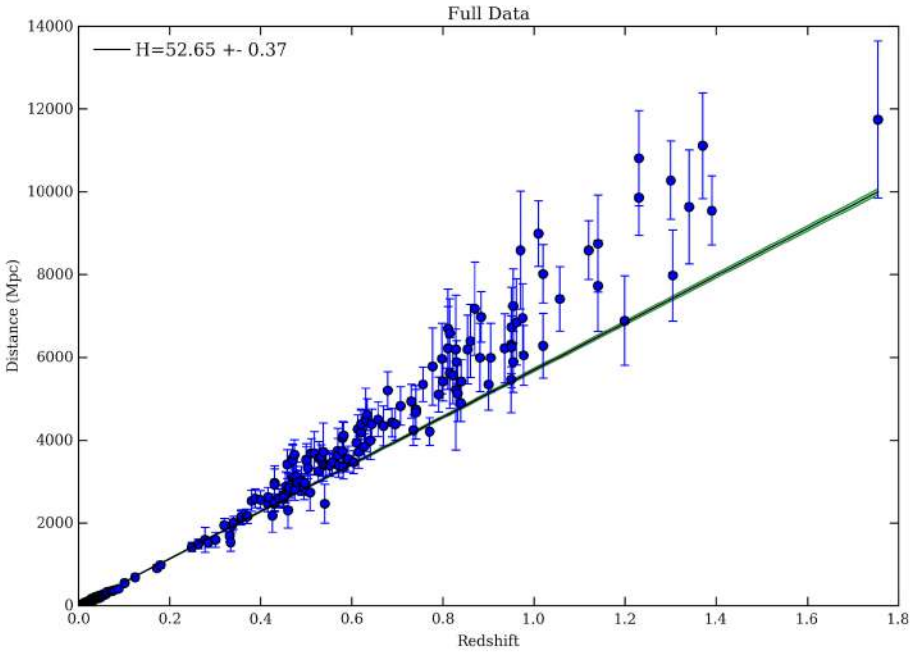
_____ mly

Here is a video about his discovery.

http://astro.wku.edu/astr106/Hubble_law_anim.gif



Here is real data about the velocity of the galaxies as determined by their redshifts.



* Real data https://depts.washington.edu/astroed/HubbleLaw/galaxies.html