

Activity 9: Exploring the H-R diagram

Print Name:

Signature:

1.) _____

2.) _____

3.) _____

4.) _____

Activity:

Early this century, two researchers, Enjar Hertzsprung and Henry Norris Russell independently developed what has come to be known as the Hertzsprung-Russell (HR) diagram. The HR diagram is a plot of absolute magnitude/luminosity on the vertical axis versus spectral class/temperature/color on the horizontal axis. In this activity, you will create your own H-R diagram as well as explore its properties.

Part 1: Building the HR Diagram

In this portion of the activity, your group will create an HR diagram from the data in Tables I and II.

- 1) For each star, indicate its position on the graph below with a small "x." The Sun (G2, 4.8) has been plotted for you. Plot the bright stars (Table I) and near stars (Table II) in different colors by using, for instance, pencil for the bright ones and blue ink for the near ones. Each member of your group should plot about the same number of stars so that everyone gets some practice.

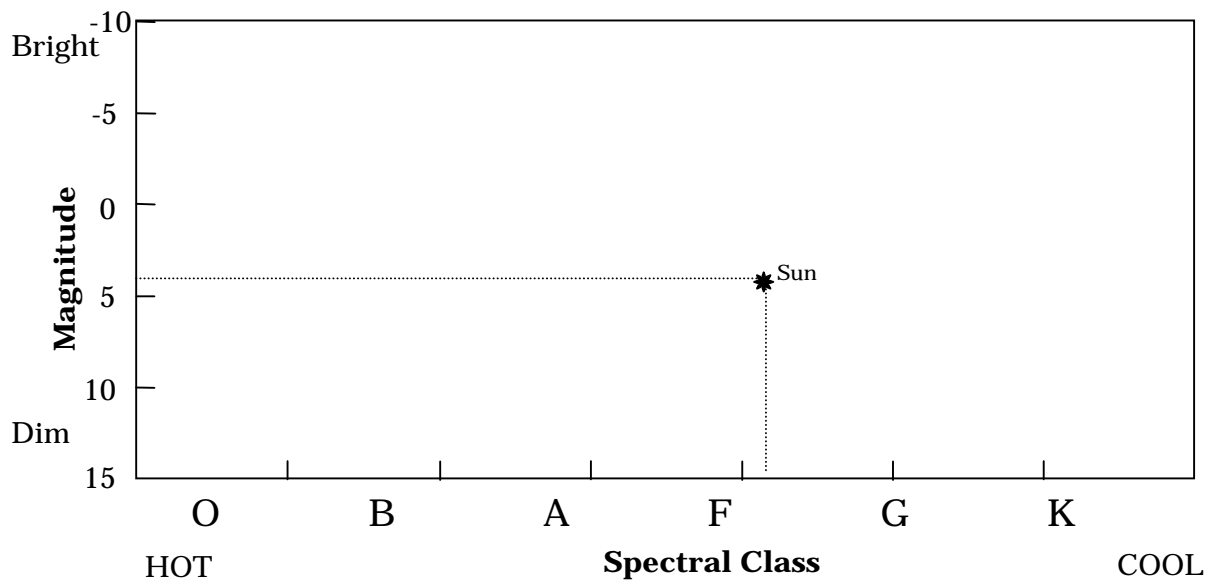


Table I: Bright Stars (as they appear from Earth)

Name	Spectral Class	Absolute Magnitude	Name	Spectral Class	Absolute Magnitude
Sirius B	B8	11.6	Betelgeuse	M2	-5.5
Canopus	F0	-3.1	Antares	M2	-4.5
Arcturus	K2	-0.3	Spica	B1	-3.6
Capella	G3	-0.7	Deneb	A2	-6.9
Rigel	B8	-6.8	Procyon A	F5	2.6

Table II: Near Stars

Name	Spectral Class	Absolute Magnitude	Name	Spectral Class	Absolute Magnitude
Sun	G2	4.8	Luyten 789-6 A	M6	14.6
Alpha Centauri A	G2	4.4	Ross 128	M5	13.5
Sirius A	A1	1.4	61 Cygnus A	K5	7.6
Ross 154	M5	13.3	61 Cygnus B	K7	8.4
Ross 248	M6	14.8	Procyon A	A0	13.0

- 2) In general (i.e., you may have to ignore some of the data points), is there a correlation between spectral class and absolute magnitude? What is it?

- 3) Can you make any generalizations about stars that are close to Earth?

- 4) Identify the Main Sequence, White Dwarfs and Red Giants on your H-R diagram.

Part 2: Stellar Sizes

Once we know a star's temperature and its total luminosity we can also deduce its size. The reason is that there is a connection between temperature and total energy output, which is described by the Stefan-Boltzmann law. There are two important aspects to remember:

- The total amount of light energy that a star emits—**called the luminosity and measured by the absolute magnitude**—increases with temperature. In fact,

it increases as the fourth power of the temperature so that a star the same size as our Sun but twice the temperature would emit 16 times the energy!

- The amount of energy that a star emits per area of surface depends only on the star's temperature. Therefore, the total luminosity of a star increases with the surface area. A star at the same temperature as our Sun but four times the surface area emits four times the energy.

To estimate the size of a star we first determine its temperature from either its color or spectral class. This tells us how much energy each area of the surface is emitting. The total luminosity is just a measure of the total energy, which allows the surface area to be determined, which is a measure of the star's size. Consider the stars in Table I to answer the following questions.

- 5) Does Sirius B have a higher, equal, or lower surface temperature than Rigel? Explain your reasoning. (*hint: compare their spectral classes*)
- 6) Which of these two stars has greater luminosity? Explain your reasoning.
- 7) Which is the larger of the two stars? Explain your reasoning.

Part 3: Classifications on the HR Diagram

- 8) How does the size of stars near the top left of the HR diagram compare with stars of the **same luminosity** near the top right of the HR diagram? Explain your reasoning.
- 9) How does the size of stars in the top left of the HR diagram compare with stars at the **same temperature** near the bottom left of the HR diagram? Explain your reasoning.

10) Classify the following newly discovered stars as main sequence, dwarfs, or giants.

- a. Hermanson A (G4 +5.2):
- b. α Slataurus (K8 -4.0):
- c. β Adamisus (A3 +10.4):
- d. Franciscus G (F2 +3.1):

Part 4: Estimating Relative Distances

Betelgeuse has an apparent magnitude of +0.4, which tells us how bright it appears at its true location. Betelgeuse has an absolute magnitude of -5.5, which tells us how bright it would appear if we could move it to a distance of 10 parsecs (about 33 light-years).

11) Where would Betelgeuse appear brighter, in its true location or if were at a distance of 10 parsecs? Explain your reasoning.

12) So, is its true location closer or farther than 10 parsecs? Explain your reasoning.

13) Below is a list of five stars and their apparent and absolute magnitudes. Your task is to classify each star as being located either closer or farther than 10 parsecs.

Star Name	Apparent Magnitude	Absolute Magnitude	Distance (Closer or farther)
Sirius	-1.5	+1.4	
Rigel	+0.14	-6.8	
Procyon	+0.37	+2.6	
Betelgeuse	+0.41	-5.5	
α Centauri	-0.01	+4.4	

Part 5: Spectroscopic Parallax

The table on the following page gives both the apparent magnitude and spectral class for five main sequence stars. For each star, do the following:

- 14) Using the HR diagram on the next page, estimate the absolute magnitude for each star.
- 15) Complete the table by classifying each star as being **less than, slightly more than, or much more than** 10 parsecs away.
- 16) Use the following equation to calculate the actual distance to the stars in parsecs.

$$d = 10^{(m-M+5)/5} \text{ pc}$$

Each group member should do at least one star.

Star	Apparent Magnitude	Spectral Class	Absolute Magnitude	Distance Estimate	Actual Distance
Rigel Kentaurus	0.0	G2			
Vega	+0.04	A0			
Rigel B	+6.6	B9			
Canopus	-0.72	F0			
Deneb	+1.26	A2			

