Classifying Stars by Temperature and Brightness

Introduction:
If you were to plot a graph of height vs. mass for a random selection of people, what might you expect to see? Because most people weigh more the taller they are, we expect to see a correlation. While there may be some exceptions to this relation, for the most part it is true.

Amazingly enough, when you plot the brightness of a star vs. its temperature, another type of correlation becomes apparent. In this activity, we will determine that correlation by creating a Hertzsprung-Russell diagram.

Properties of Stars:

Magnitude:

There are two ways of measuring the brightness of a star, by apparent magnitude and by absolute magnitude. Apparent magnitude is the brightness of the star based on how we perceive it from the Earth. Absolute magnitude is based on the intrinsic brightness of the star. Because we are identifying the star by its brightness, we will use absolute magnitude.

Brighter stars have a lower value of magnitude – so a star with a negative magnitude is actually brighter than a star with a positive magnitude.

Temperature:

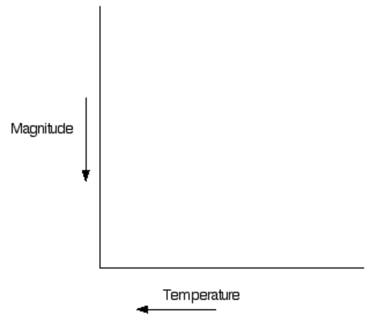
The temperature of stars is often measured in Kelvin (not degrees Celcius). Kelvin is very similar to Celcius, but whereas 0 degrees Celcius is the freezing point of water, 0 Kelvin is absolute zero…the freezing point of everything! At this temperature everything freezes and stops moving, even electrons around the nucleus of an atom!

Hertzsprung and Russell:
Ejnar Hertzsprung and Henry Russell independently discovered this correlation in the early 1910s. The diagram has since been used to infer properties of stars based on their temperature, brightness and composition.

Ejnar Hertzsprung

Henry Russell

Analysis:
Using the graph paper provided, draw a set of axes similar to the ones below:



Note that the direction of the axes are flipped! They go from large to small – this is the conventional way of drawing this graph, and the only reason we can't do it in Excel!

Now plot the following stars on your graph. They are a list of the 25 closest stars to the Earth, and the 25 brightest stars in the sky. Plot the 25 closest stars in one colour, and the 25 brightest stars in another colour.

Table 1: 25 Bright Stars - (stars which appear very bright from Earth)

Star	Absolute Magnitude	Temperature (K)
Sirius A	1.4	9620
Regulus	-0.8	13260
Canopus	-3.1	7400
Centaurus A	4.3	5840
Bellatrix	-4.3	23000
Arcturus	-0.4	4590
Vega	0.5	9900
Capella	-0.6	5150
Deneb	-7.2	9340
Castor	1.2	9620
Rigel A	-7.2	12140
Adhara	-5.2	23000
Procyon A	2.6	6580
Dubhe	0.2	4900
Achemar	-2.4	20500
Beta Centauri	-5.1	25500
Betelgeuse	-5.7	3200
Altair	2.2	8060
Aldebaran A	-0.8	4130
Polaris	-4.6	6100
Crucis A	-3.3	20500
Crucis B	-4.7	28000
Antares A	-5.2	3340
Fomalhaut	2.0	9060
Spica	-3.4	25500

Table 2: 25 Nearby Stars (stars which are close to the Earth)

Star	Absolute Magnitude	Temperature (K)
Struve 2398	11.9	2940
Struve 23948	11.9	2940
HD 93735	10.5	3200
YZ Ceti	14.1	2670
Ross 154	13.1	2800
Ross 248	14.8	2670
Epsilon Eridani	6.1	4590
L 789-6	14.5	2670
Ross 128	13.5	2800
61 Cygnus A	7.6	4130
Wolf 424A	15.0	2670
Epsilon Indi	7.0	4130
Proxima Centauri	15.5	2670
Struve 2398A	11.2	3070
Lacaille 9352	9.6	3340
Tau Ceti	5.7	5150
BD +5 1668	11.9	2800
Lacaille 8760	8.7	3340
Kapteyn's Star	10.9	3480
Krueger 60 A	11.9	2940
Krueger 60 B	13.3	2670
Ross 614	13.1	2800
BD – 12 4523	12.1	2940
Barnard's Star	13.2	2800
Wolf 359	16.7	2670

Discussion:

After plotting your data, answer the following questions in complete sentences here on the sheet.

1. What general trends do you see in the data? Are there generalizations you can make about bright stars? How are they different than stars which are close to the Earth?

2. Our star, the Sun, has a magnitude of 4.8 and a temperature of 5840K. How does it compare to the bright stars? How does it compare to the nearby stars? Which is it most like?

3. Most of the stars seem to be along a line from the upper left corner to the lower right corner of the HR Diagram. Stars which fall in to this category are called main sequence stars. This represents the hydrogen-burning phase of a star's life. Does our Sun fit in to this category? Explain why or why not.

4. Main sequence stars which are very bright, are fusing hydrogen into helium atoms at an enormous rate. How long will these stars shine compared to the dimmer main sequence stars?

5. What happens when a star runs out of hydrogen? Would this change its location on the HR diagram? Where would a star which is about to go supernova be located?

6. White dwarfs, the end result when a small star "dies," are hot, but dim. Where would they be on your HR Diagram? Circle the appropriate area and label.

7. Would black holes fit in somewhere on the diagram? If so, where?