The Hertzsprung-Russell Diagram and Stellar Evolution

Names: _____

The H-R Diagram and Stellar Properties Activity

1. In which corner of the diagram (upper right, upper left, lower right, or lower left) would stars with radii 1000 times larger than that of the Sun be plotted?

In which corner would stars with radii 1000 times smaller than that of the Sun appear?

Star	Luminosity (solar units)	Radius (solar units)	Surface Temperature (K)
Sun	1.00	1.00	5800
Star a		0.10	5800
Star b		2.00	5800
Star c		1.00	11600 (or 12000)
Star d		1.00	2900
Star e		100.00	2900
Star f		0.01	11600 (or 12000)

3. (a) Considering the measurement uncertainty inherent in the data, do most of the points lie on (or near to) the Main Sequence line (within the Main Sequence strip)?

(b) Region A:
Region B:
Region C:
Region D:

What object's position is marked by the X?

What two lines intersect at this spot?

(c) The "Dwarfs (V)" label for the Main Sequence strip is unfortunate because the most luminous stars at the upper end of this strip have radii roughly _____ times that of the Sun.

(d) Of the hundred nearest stars, only _____ are obviously intrinsically brighter than the Sun.

(e) Move the cursor to the middle of the nearest star sample, where many of them are concentrated. This region is labeled _____ on the diagram. The luminosities for these typical stars are _____ that of the Sun's, their radii are _____ that of the Sun's, and their surface temperatures are _____ K.

(f) The nearest star sample shown is technically incomplete; at least five nearby white dwarfs were omitted. The most famous is the companion to the bright, nearby star Sirius A; Sirius B has a luminosity of 0.027 L_{Sun} and a surface temperature of 25,000 K. Moving the cursor to where this star would be plotted, its radius is _____ that of the Sun's.

(g) Of these 150 brightest stars, only _____ is/are intrinsically fainter than the Sun. While all the nearest stars were predominantly Main Sequence (V) stars, the brightest stars sample also includes many objects of luminosity classes _____ and _____

(h) Move the cursor to the most luminous star in this sample.
Its luminosity is _____ L_{Sun},
its radius is _____ R_{Sun},
its surface temperature is _____ K,
and its B-V color is _____ .
The region where the cursor is now located is labeled _____ .

(i) Move the cursor to the largest star in this sample.
Its luminosity is _____ L_{Sun},
its radius is _____ R_{Sun},
its surface temperature is _____ K,
and its B-V color is _____ .
The region where the cursor is now located is labeled _____ .

(j) There are _____ stars that are members of BOTH samples (both nearest and brightest stars).

Fill in the blanks with either NEAREST or BRIGHTEST:

(k) In summary, the _____ star sample is more representative of a typical volume of stars in our Galaxy, whereas the _____ star sample is a specially selected sample, heavily weighted towards relatively rare, highly luminous objects.

The H-R Diagram for the Pleiades, a Young Star Cluster

Circle the correct answers:

1. If the Sun were to be viewed from larger and larger distances, it would appear brighter / fainter / unchanged.

Its apparent magnitude would increase / decrease / remain unchanged.

Its absolute magnitude would increase / decrease / remain unchanged.

2. (a) Identify the seven brightest Pleiades stars from their apparent V magnitudes:

(b) The brightest cluster star is #_____ , with an apparent V magnitude of _____ .

If this star also has an apparent B magnitude of 2.78, and a B-V color index of –0.09, explain how the color index was computed.

(c) Star #1 is roughly _____ times brighter than star #4.

(d) Star #_____ is almost 100 times brighter than star #15.

Circle the correct answers:

3. If the stars in the Pleiades cluster lay only ten parsecs from Earth, they would appear brighter / fainter / unchanged, though their absolute magnitudes would be brighter / fainter / unchanged.

Solar-type star #16 would have an apparent V magnitude of _____ and would just be visible to the unaided eye as a faint star. Star #16 is actually much farther away than ten parsecs (it lies around _____ parsecs away) so it appears much fainter: its actual apparent V magnitude is _____.

Circle the correct answers:

4. (a) As a star cluster ages, its Main Sequence turn-off point steadily becomes brighter / fainter and bluer / redder. The masses of the stars around the turn-off point decrease / increase.

(b) The difference between absolute and apparent magnitude is the same for all members of the Pleiades cluster, because it is purely a function of the cluster distance from Earth. Use the absolute magnitude of the Sun and the apparent magnitude of solar-type star #16 to estimate this difference, and then determine the absolute magnitude of star #1, Alcyone (the brightest star in the Pleiades). Show your work, as well as stating your final answer.

The brightest, bluest star still remaining on the Main Sequence is sometimes used to define a cluster's turn-off point. The term "turn-off" comes from recognizing that this star will be the next one to leave (or turn off) the Main Sequence, and become a red giant. For the Pleiades, this turn-off point is currently at absolute magnitude _____ and B-V color _____

(c) Locate star #14 (resembling Sirius) in Figure 6.4. There are only _____ stars on the diagram that are brighter and bluer than it.

An H-R Diagram for M67, an Older Star Cluster

3. **ATTACH A PRINTOUT OF YOUR FIRST FIGURE WITH A COPY OF YOUR LIST OF 12 STARS. INCLUDE A FIGURE CAPTION STATING WHICH STAR IS THE SOLAR-TYPE STAR, AND WHICH STARS FALL INTO EACH OF THE OTHER FOUR CATEGORIES.**

6. (a) What happens if an aperture is too small? Where will the associated star appear on the H-R diagram, relative to its correct position?

(b) What happens if an aperture is too large? Does it matter whether the extra space is dark sky, or contains a neighboring object?

(c) What happens if the aperture is offset from the center of the star?

(d) What happens if you place an aperture directly between two stars?

7. Discuss your results (your age estimate) for M67 below, explaining how you came to your conclusion. Note the particular features on the H-R diagram which were most important to your decision-making process.

8. Compare your results for M67 with those for the Pleiades, with respect to the following five factors:

(a) Cluster turn-off point:

(b) Presence of red giants:

(c) Presence of red dwarfs:

(d) Presence of massive blue Main Sequence stars:

(e) Age of cluster:

ATTACH A PRINTOUT OF YOUR SECOND FIGURE SHOWING THE FINAL H-R DIAGRAM. BE SURE TO INCLUDE A FIGURE CAPTION EXPLAINING IT.

Final Questions

1. How does the Sun compare to the other members of the nearest star sample? If one assumes this sample is representative of typical stars found throughout the universe, to what extent is the Sun a typical star?

2. Consider the brightest stars in the sky, and why they appear so bright. Three students debate this issue. Student A: "These stars must be very close to us. That would make them appear brighter to us in the sky." Student B: "These stars are intrinsically very luminous, so they emit a tremendous amount of energy.'' Student C: "I think it's because these stars are very close and very luminous.'' Use what you've learned in this lab to support the views of one of the three students and answer the question "Why do the stars which appear the brightest in the night sky seem so bright?''

3. Are these apparently bright stars very common (do stars like them make up a large percentage of all stars)? Explain your reasoning.

4. Consider how the H-R diagram of the Pleiades would look far in the future.

(a) Suppose all of the Main Sequence stars above solar-type star #16 had run out of fuel and left the Main Sequence. What other regions in the diagram (besides the Main Sequence) would now be populated?

(b) How old would this cluster be? Explain.

5. The best explanation for why the H-R diagram for M67 does not include any white dwarf stars is (a) this cluster is not old enough for any of its stars to have evolved to this stage, or (b) the data this H-R diagram is based on only includes stars brighter than an apparent V magnitude of 16, and we expect any white dwarfs in M67 to be fainter than this. Explain your choice of answer.

6. When measuring apparent magnitudes for stars in M67, if two equal-mass stars were tightly clustered in a binary system and could not be separated (they appeared as one star), where would their combined properties place them on the H-R diagram (versus where they would be placed if they were separable)?

7. The constellation of Cancer contains the star cluster M44, which, like the Pleiades, is visible to the unaided eye on a clear night.

(a) Using its H-R diagram in Figure 6.5, compare this cluster's age with that of of the Pleiades and M67 clusters. Explain how you arrived at your conclusion.

(b) Is M44 closer to or farther away from us than the Pleiades, and closer to or farther away from us than M67? Explain your answer.