Name: _____

Date: _____

Section: _____

Astron 104 Laboratory #7
The H-R Diagram
Section 10.1, 10.5

Introduction

The **Hertzsprung-Russell diagram**, or H-R diagram for short, relates two fundamental properties of stars and helps reveal how stars work.

In an H-R diagram we plot the **luminosity** (how bright it is) of a star against its **surface temperature**. The majority of the stars lie on a narrow band which runs from the top left of the diagram (hot, bright stars) to the bottom right (cool, dim stars). This band is known as the **main sequence**, and highlights where stars spend the majority of their lives. A small number of stars near the ends of their lives do not lie on the main sequence, and these are classified as **red giants**, **red supergiants**, or **white dwarfs**, depending on their stage of evolution.

Experiment 1

This lab will utilize the color and luminosity of different stars, enabling you to construct a Hertzsprung-Russell diagram.

1. Click on *Virtual Astronomy* on the desktop

2. Click on *Start Virtual Astronomy Lab*

3. Click on *Unit 26: The Hertzsprung Russell Diagram*

4. Click on *Start Lab*

5. Click on *View the Stars*

   The view shows a portion of the sky containing a number of stars, with a range of surface temperatures. The stars are shown as colored, with the hottest stars being blue and the coolest stars red. By selecting "Number of stars" from the top menu, you may change the number of stars appearing in the window. Change this number to at least 40.

6. By positioning the cursor over any one of the stars, the display at the bottom of the window will show an identification number for that star, and its luminosity. Note these values.

7. Click on the star in order to view that star's emission as a function of wavelength. Measure the wavelength at which the peak light intensity occurs. To assist you in reading the plot, the display at the bottom of the screen shows the wavelength (in nm) at the position of the cursor. (Click anywhere in the window in order to be returned to the view of the stars.)

8. Use Wien's Law to calculate the surface temperature of the star:

$$\text{Surface Temperature} = \frac{2.898 \times 10^6 \, \text{K}}{\text{Peak Wavelength (nm)}}$$

9. Repeat the steps 8–10 for 20 stars and make a table of the values.

10. Plot the results on a graph of luminosity (on the vertical axis) vs. temperature (on the horizontal axis):

    (a) The temperature scale runs from hot on the left to cool on the right

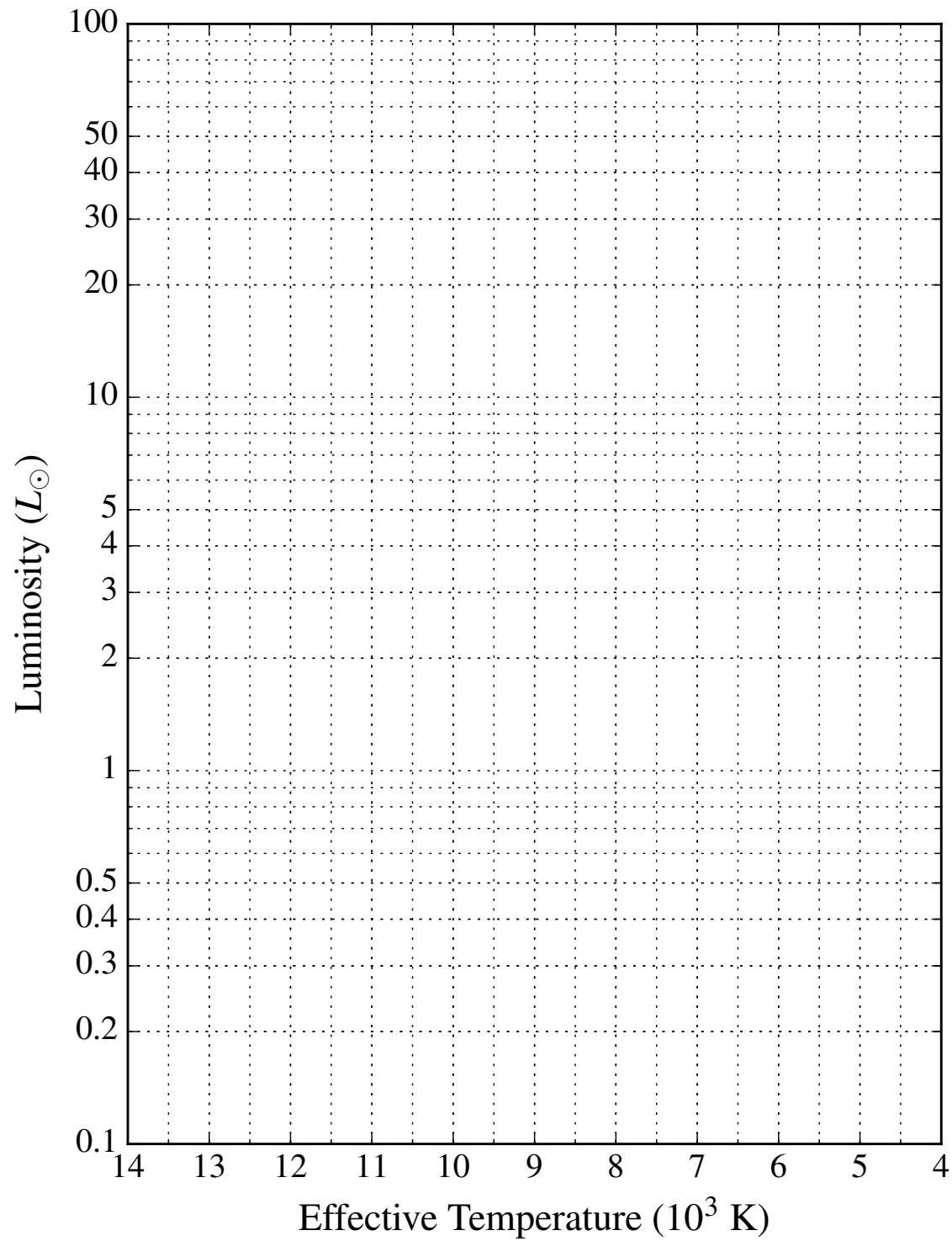   (b) The luminosity scale is logarithmic

    A template graph is supplied to help you with this plot.

11. Select "Check your results" from the overhead menu. The computer will generate an H-R plot for these stars, which you can use to compare with your own plot. *SHOW YOUR INSTRUCTOR!*

Star	Luminosity	Peak Wavelength	Surface Temperature

[25 pts.]

Calculations:

[25 pts.]

Experiment 2

In this exercise, we will be expressing the luminosity of a star in terms of its Absolute Visual Magnitude M_V. This is a scale based on how bright the star would appear if it were at a standard distance of 10 parsecs (about 32.6 light-years) from us. A difference of 1 magnitude is equivalent to a change of about $2.5\times$ in brightness. For historical reasons, the scale runs "backwards," with higher numbers indicating fainter stars. Since the scale is originally based on the apparent brightness of stars, extending it to the absolute brightnesses (luminosity) meant extending the scale into negative numbers for bright stars.

On the attached tables, both the Apparent Visual Magnitude (m_V) and the Absolute Visual Magnitude (M_V) are given. The Apparent Visual Magnitude is how bright the star appears in the sky. The human eye can usually only see stars that are brighter than about 6th magnitude. In the city, light pollution usually raises this limit to stars brighter than about 2nd magnitude.

On the blank H-R Diagram provided, plot the Absolute Magnitude of each star versus its spectral type for the two sets of stars in the Tables. To distinguish between the data sets, use a different color or symbol for each set. The distinction between the luminous and nearest stars will be important when we analyze the diagrams. [**25 pts**]

Notes:

- The diagram is plotted with the most luminous stars (most negative magnitudes) at the top and the hottest stars on the left. Each division of the magnitude scale is 0.5 magnitudes. Estimate the best position for each data point within that range.

- Each division of the spectral class scale (the letter) is 2 sub-classes (the numbers after each letter). Lower sub-classes are to the left (so B0 is to the left of B1, and B9 is to the left of A0). A star will therefore either be plotted on or halfway between the grid lines.

- Be sure to plot the **Absolute Magnitude** M_V for each star.

- You do not need to label the stars on the H-R diagram.

Questions [5 pts each]

1. Where on the HR diagram are most of the **nearby stars** located in terms of luminosity and temperature?

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2. Where on the HR diagram are most of the **apparently brightest** (i.e., **lowest apparent magnitude**) stars located in terms of luminosity and temperature?

3. Only 3 of the nearby stars are also on the brightest star list. (a) With respect to the Sun, where in space would you expect bright stars to be located (near or far)? (b) With respect to the Sun, where in space would you expect dim stars to be located (near or far)? Why?

4. (a) Which of the two groups of stars gives a more accurate picture of a true stellar population? (b) How would you make it more accurate?

5. What can we conclude about the number of cool stars in the Universe (types K and M)?

6. What can we conclude about the number of hot stars in the Universe (types O and B)?

The Brightest Stars			
Star	**Apparent magnitude** m_V	**Absolute magnitude** M_V	**Spectral Type**
Sirius	−1.4	1.5	A1
Canopus	−0.7	−5.6	F0
α Centauri	−0.3	4.1	G2
Arcturus	−0.1	−0.3	K2
Vega	0.0	0.6	A0
Capella	0.1	−0.5	G2
Rigel	0.1	−6.7	B8
Procyon	0.3	2.7	F5
Betelgeuse	0.4	−6.0	M2
Archernar	0.5	−2.7	B5
Hadar	0.6	−4.6	B1
Altair	0.8	2.3	A7
Acrux	0.8	−4.2	B1
Aldebaran	0.9	−0.6	K5
Antares	0.9	−5.2	M1
Spica	0.9	−3.5	B1
Pollux	1.1	1.1	K0
Fomalhaut	1.2	1.7	A3
Deneb	1.2	−7.1	A2
β Crucis	1.2	−3.9	B0
Regulus	1.4	−0.5	B7
Adhara	1.5	−4.1	B2
Castor	1.6	0.6	A1
Shaula	1.6	−5.0	B1
Bellatrix	1.6	−2.7	B2
Elnath	1.7	−1.3	B7
Miaplacidus	1.7	−1.0	A0
Alnilam	1.7	−6.3	B0

The Nearest Stars			
Star	**Apparent magnitude** m_V	**Absolute magnitude** M_V	**Spectral Type**
Sun	−26.8	4.8	G2
Proxima Centauri	11.1	15.5	M5
α Centauri A*	0.0	4.4	G2
α Centauri B	1.3	5.7	K5
Barnard's Star	9.5	13.2	M5
Wolf 359	13.4	16.6	M6
Lalande 21185	7.5	10.4	M2
Sirius A*	−1.5	1.4	A1
Sirius B	8.4	11.3	wd (B1)
Luyten 726-8A	12.5	15.4	M6
Luyten 726-8B	13.0	15.9	M6
Ross 154	10.4	13.3	M5
Ross 248	12.3	14.8	M6
ϵ Eridani	3.7	6.2	K2
Lacaille 9352	7.3	9.8	M2
Ross 128	11.1	13.5	M5
Luyten 789-6	13.3	15.6	M5
Procyon A*	0.4	2.7	F5
Procyon B	10.7	13.0	wd (A8)
61 Cygni A	5.2	7.5	K5
61 Cygni B	6.0	8.3	K7
Struve 2398	8.9	11.2	M3
Groombridge 34A	8.1	10.3	M1
Groombridge 34B	11.1	13.3	M4
ϵ Indi	4.7	6.9	K5
Cincinnati 2456A	8.9	11.2	M4
Cincinnati 2456B	9.7	12.0	M4
DX Cancri	14.8	17.0	M7
τ Ceti	3.5	5.7	G8
YZ Ceti	12.0	14.2	M5
Luyten's Star	9.8	12.0	M4
Kapteyn's Star	8.8	10.9	M2
Lacaille 8760	6.7	8.9	M1
Kruger 60A	9.7	11.8	M3
Kruger 60B	11.4	13.4	M4

O   B   A   F   G   K   M

ABSOLUTE VISUAL MAGNITUDE M$_V$

SPECTRAL CLASS