FOR | WEDNESDAY | 4/22/2020

A Derivation – Distance from Magnitude

Starting Points

$$\frac{I_1}{I_2} = 100^{(m_1 - m_2)/5}$$

$$I_1 = L_1 / 4\pi R_1^2 \qquad I_2 = L_2 / 4\pi R_2^2$$

Nasty derivation

$$\frac{L_1 / \cancel{4\pi} R_1^2}{L_2 / \cancel{4\pi} R_2^2} = 100^{(m_1 - m_2)/5}$$

Same star at different distances $\Rightarrow L_1 = L_2$

$$\frac{1/R_1^2}{1/R_2^2} = 100^{(m_1 - m_2)/5}$$

Make R_1 the "standard" distance

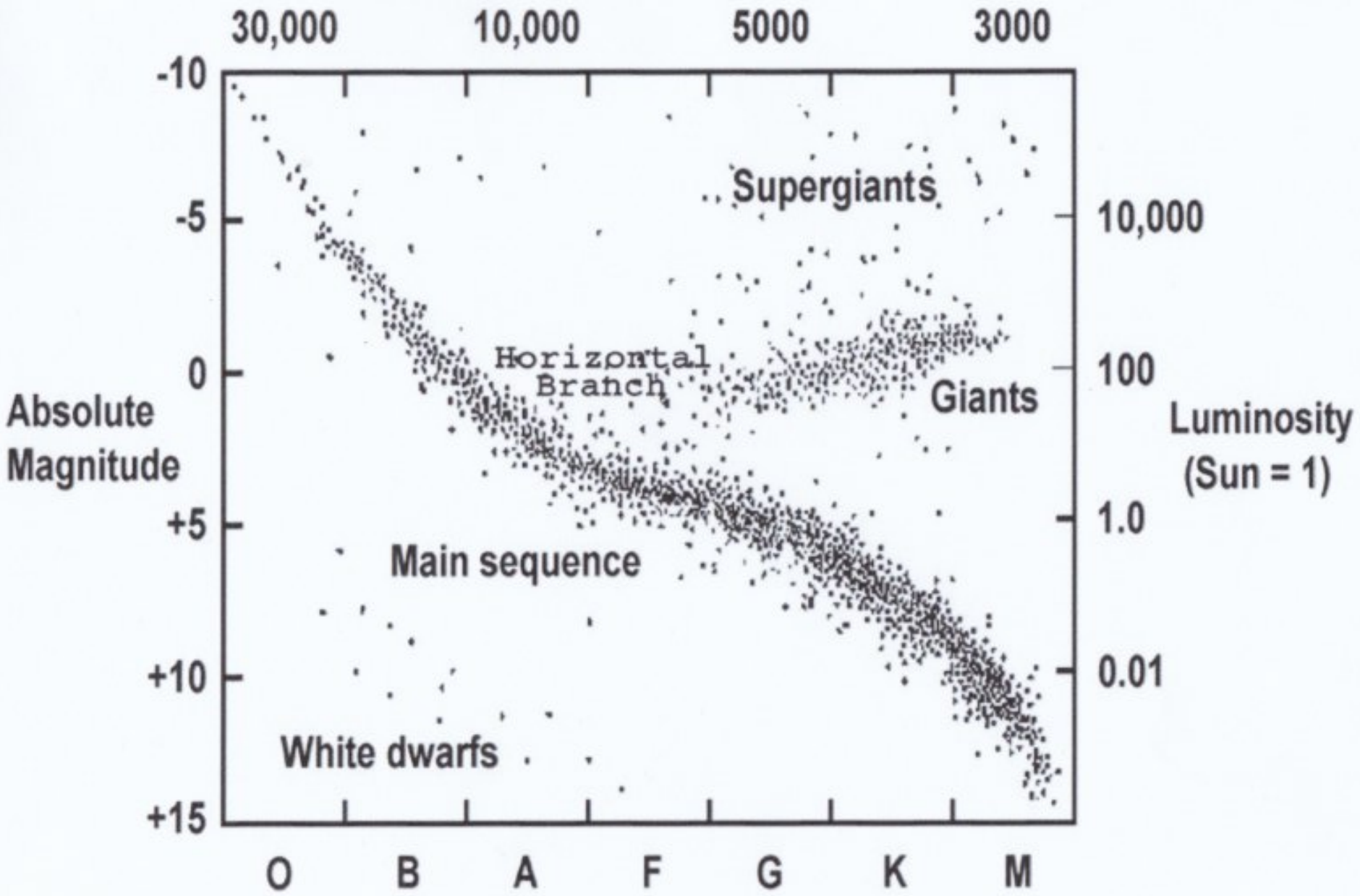
$$R^2 / (10\ \text{parsec})^2 = 100^{(m - M)/5}$$

Take $\sqrt{\ }$ of both sides to solve for R

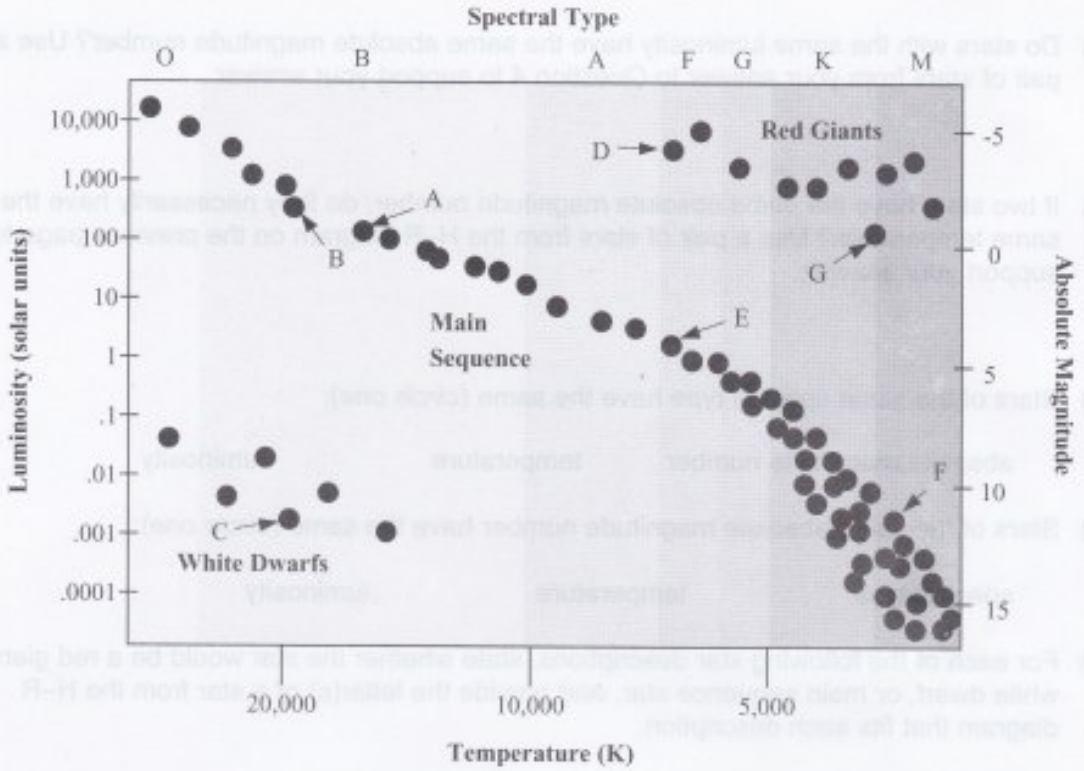
RESULT

$$R = 10\ \text{parsec} \cdot 10^{(m - M)/5}$$

- R: Actual distance
- 10 parsec: standard distance
- m: apparent magnitude
- M: absolute magnitude


30,000
10,000
5000
3000
-10
-5
0
+5
+10
+15
Absolute Magnitude
Supergiants
Horizontal Branch
Giants
Main sequence
White dwarfs
10,000
100
1.0
0.01
Luminosity (Sun = 1)
O
B
A
F
G
K
M

Use the H–R diagram below to answer questions throughout this activity.



1) What are the spectral type, temperature, absolute magnitude number, and luminosity of Star A?

   a) Spectral type:

   b) Temperature:

   c) Absolute magnitude:

   d) Luminosity:

2) Which two pairs of labeled stars (A–G) in the diagram have the same temperature?

3) Do stars of the same temperature have the same spectral type? Use a pair of stars from your answer to Question 2 to support your answer.

4) Which two pairs of labeled stars have the same luminosity?

5) Do stars with the same luminosity have the same absolute magnitude number? Use a pair of stars from your answer to Question 4 to support your answer.

6) If two stars have the same absolute magnitude number, do they necessarily have the same temperature? Use a pair of stars from the H–R diagram on the previous page to support your answer.

7) Stars of the same spectral type have the same (*circle one*):

absolute magnitude number temperature luminosity

8) Stars of the same absolute magnitude number have the same (*circle one*):

spectral type temperature luminosity

9) For each of the following star descriptions, state whether the star would be a red giant, white dwarf, or main sequence star, and provide the letter(s) of a star from the H–R diagram that fits each description.

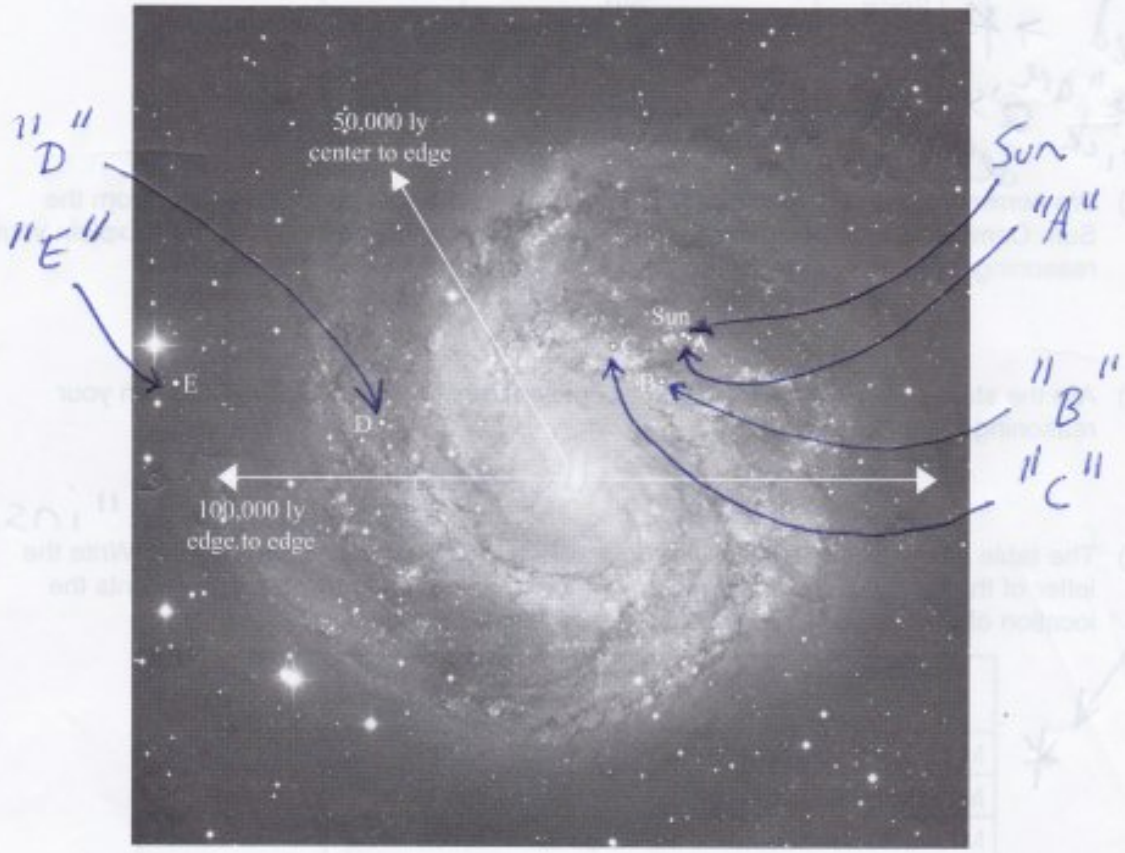
a) very bright (high luminosity) and very hot (high temperature)

b) very dim and cool

c) very dim and very hot

d) very bright and cool

This tutorial will give you a better understanding of the size of the Milky Way Galaxy by investigating the distances and sizes of objects within the Milky Way Galaxy and outside the Milky Way Galaxy elsewhere in the universe. Below is a picture of a spiral galaxy similar to the Milky Way. Because we are located within the Milky Way, we are unable to take a picture of our entire galaxy from the outside. Let's assume that this picture represents our Milky Way Galaxy and has the dimensions labeled below. **Note that in this picture, 1 centimeter (cm) represents 10,000 light-years (ly); equivalently, you can use 1 millimeter (mm) to represent 1,000 light-years (ly).**



1) The Sun's position in the Milky Way is shown in the picture above. What is the approximate distance from the Sun to the center of the Milky Way? Recall that 1 cm represents 10,000 ly.

2) The table below lists five bright stars in the night sky. Write the letter of the dot (A–E) from the picture on the previous page that best represents the location of each star. You can use letters more than once. Recall that 1 mm represents 1,000 ly.

Star	Distance from Sun (in light-years)	Letter
Sirius	9	
Vega	26	
Spica	260	
Rigel	810	
Deneb	1,400	

The four marked "*" are trick Q's designed to make a point.

3) We normally consider Deneb to be a bright but distant star at 1,400 ly away from the Sun. Compared to the size of our Milky Way Galaxy, is Deneb truly distant? Explain your reasoning.

4) Are the stars from Question 2 inside or outside the Milky Way Galaxy? Explain your reasoning.

This is a silly question. The answer is obviously "inside."

5) The table below lists three Messier objects and their distances from the Sun. Write the letter of the dot (A–E) from the picture on the previous page that best represents the location of each object. You can use letters more than once.

Messier Object	Distance from Sun (in light-years)	Letter
M45 Open Cluster (Pleiades)	380	
M1 (Crab Nebula)	6,300	
M71 Globular Cluster	12,700	

6) Are these Messier objects part of the Milky Way Galaxy? Explain your reasoning.

7) The Crab Nebula has a width of about 11 light-years. If you wanted to accurately draw the Crab Nebula on your diagram, would you use a small blob or a tiny dot at the location you indicated in Question 5? Explain your reasoning. Note: The dots marking the locations on the picture are about 1 mm across. To answer this question well, state how much of a mm at our scale would 10 light-years be? ____ mm (PS: 10 of 11; I rounded.)