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# **Properties of Stars Exercises**

This comprehensive assessment is available to verified learners only.

### **Background**

Astronomy is one of the oldest data-driven sciences. In the late 1800s, the director of the Harvard College Observatory hired women to analyze astronomical data, which at the time was done using photographic glass plates. These women became known as the "Harvard Computers". They computed the position and luminosity of various astronomical objects such as stars and galaxies. (If you are interested, you can learn more about the Harvard Computers). Today, astronomy is even more of a data-driven science, with an inordinate amount of data being produced by modern instruments every day.

In the following exercises we will analyze some actual astronomical data to inspect properties of stars, their absolute magnitude (which relates to a star's **luminosity**, or brightness), temperature and type (spectral class).

### **Libraries and Options**

```
library(tidyverse)
library(dslabs)
data(stars)
options(digits = 3) # report 3 significant digits
```

*IMPORTANT*: These exercises use **dslabs** datasets that were added in a July 2019 update. Make sure your package is up to date by reinstalling the package with the command install.packages("dslabs").

## Question 1

2/2 points (graded)

Load the stars data frame from **dslabs**. This contains the name, absolute magnitude, temnerature in degrees Kelvin, and spectral class of selected stars. Absolute magnitude (shortened in these problems to simply "magnitude") is a function of star luminosity, where **negative** values of magnitude have higher luminosity.

| What is the mea     | n magnitude?                 |
|---------------------|------------------------------|
| 4.26                | ✓                            |
| 4.26                |                              |
| What is the stand   | dard deviation of magnitude? |
|                     |                              |
| 7.35                |                              |
| 7.35                |                              |
| Submit Yo           | u have used 1 of 10 attempts |
|                     |                              |
| ✓ Correct (2/2      | 2 points)                    |
| Question 2          |                              |
| 1/1 point (graded)  |                              |
| Make a density p    | olot of the magnitude.       |
| How many peaks      | s are there in the data?     |
| <u> </u>            |                              |
| <ul><li>2</li></ul> |                              |
|                     |                              |
| 3                   |                              |
| <u>4</u>            |                              |
| ✓                   |                              |
| Submit Yo           | u have used 1 of 2 attempts  |
|                     |                              |
| ✓ Correct (1/       | l point)                     |
|                     |                              |
|                     |                              |

## Question 3

0/1 point (graded)

Examine the distribution of star temperature.

Which of these statements best characterizes the temperature distribution?

| The | no o i o ritu | of store | h a    | a biab | +        |      |
|-----|---------------|----------|--------|--------|----------|------|
| me  | majority      | or stars | nave a | a mgn  | temperat | ure. |

| The main ritu | of store | h a a  | 10,4,40,000 | ratius 🗚  |
|---------------|----------|--------|-------------|-----------|
| The majority  | OI Stars | nave a | low tempe   | rature. 🔻 |

| The temperature | distribution is   | normal. |
|-----------------|-------------------|---------|
| me temperatare  | alsti isatioii is |         |

|   | <del>-</del> |     |       |         | · ·      |        | . 1 |             |        |
|---|--------------|-----|-------|---------|----------|--------|-----|-------------|--------|
| ( | There        | are | eguai | numbers | of stars | across | tne | temperature | range. |
|   |              |     |       |         |          |        |     |             |        |



#### **Answer**

Incorrect:

Try again. Make a density plot of temperature with <code>geom\_density</code> - the distribution has a different pattern.

#### **Answer Code**

```
stars %>%
    ggplot(aes(temp)) +
    geom_density()
```

Submit

You have used 2 of 2 attempts

Answers are displayed within the problem

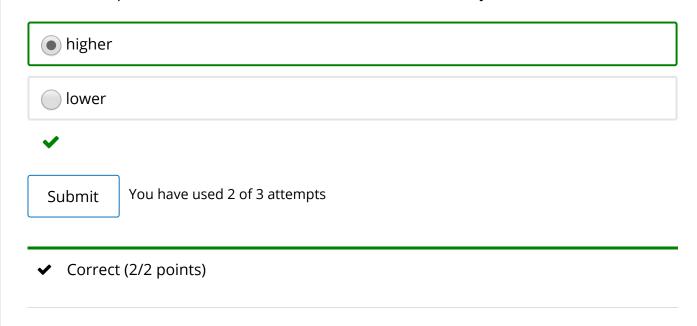
## Question 4

1/1 point (graded)

Make a scatter plot of the data with temperature on the x-axis and magnitude on the yaxis and examine the relationship between the variables. Recall that lower magnitude means a more luminous (brighter) star.

Most stars follow a \_\_\_\_\_\_ trend. These are called main sequence stars.

|   | asing linear  |
|---|---|
| increa  | sing linear   |
| • decre   | asing exponential   |
| increa  | sing exponential  |
| <b>~</b>  |   |
| Submit  | You have used 1 of 2 attempts   |
| <b>✓</b> Corre  | ct (1/1 point)  |
| 2/2 points (gr<br>For various<br>plots, and a   | aded)<br>reasons, scientists do not always follow straight conventions when making<br>stronomers usually transform values of star luminosity and temperature  |
| olots, and a<br>pefore plot<br>recall that<br>Take the lo   | aded)<br>reasons, scientists do not always follow straight conventions when making  |
| 2/2 points (gr<br>For various<br>plots, and a<br>pefore plot<br>recall that<br>Take the log   | reasons, scientists do not always follow straight conventions when making stronomers usually transform values of star luminosity and temperature ling. Flip the y-axis so that lower values of magnitude are at the top of the axis more luminous stars have lower magnitude) using scale_y_reverse(). It because 10 of temperature and then also flip the x-axis.  |
| 2/2 points (gr<br>For various<br>plots, and a<br>pefore plot<br>recall that<br>Take the log   | reasons, scientists do not always follow straight conventions when making stronomers usually transform values of star luminosity and temperature sing. Flip the y-axis so that lower values of magnitude are at the top of the axis more luminous stars have lower magnitude) using <code>scale_y_reverse()</code> . It is base 10 of temperature and then also flip the x-axis.  The statements below to describe the resulting plot:  The thing is the statements below to describe the resulting plot:  The thing is the statements below to describe the resulting plot:  |
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| 2/2 points (gr<br>For various<br>plots, and a<br>pefore plot<br>recall that<br>Take the log<br>Fill in the bl   | reasons, scientists do not always follow straight conventions when making stronomers usually transform values of star luminosity and temperature ing. Flip the y-axis so that lower values of magnitude are at the top of the axis more luminous stars have lower magnitude) using scale_y_reverse(). It is base 10 of temperature and then also flip the x-axis.  The statements below to describe the resulting plot:   |
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### Question 6

1/1 point (graded)

The trends you see allow scientists to learn about the evolution and lifetime of stars. The primary group of stars to which most stars belong we will call the main sequence stars (discussed in question 4). Most stars belong to this main sequence, however some of the more rare stars are classified as "old" and "evolved" stars. These stars tend to be **hotter** stars, but also have **low luminosity**, and are known as white dwarfs.

How many white dwarfs are there in our sample?



#### **Explanation**

These stars are in the lower left of the plot from question 5. There are 4 stars in this region.

You have used 1 of 10 attempts Submit

**1** Answers are displayed within the problem

## Question 7

1/1 point (graded)

Consider stars which are not part of the Main Group but are not old/evolved (white dwarf) stars. These stars must also be unique in certain ways and are known as giants. Use the plot from Question 5 to estimate the average temperature of a giant.

Which of these temperatures is closest to the average temperature of a giant?:

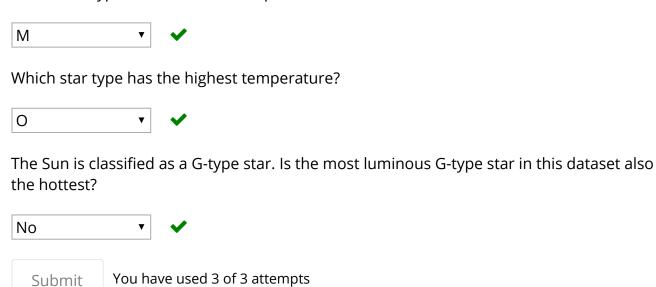
| ● 5000K   |
|---|
| 10000K  |
| 15000K  |
| 20000K  |
| <b>✓</b>  |
| Submit You have used 2 of 2 attempts  |
| ✓ Correct (1/1 point)   |
| Question 8  |
| 3/3 points (graded) We can now identify whether specific stars are main sequence stars, red giants or white dwarfs. Add text labels to the plot to answer these questions. You may wish to plot only a selection of the labels, repel the labels, or zoom in on the plot in RStudio so you can locate specific stars. |
| Fill in the blanks in the statements below:   |
| The least lumninous star in the sample with a surface temperature over 5000K is   |
| Antares   |
| Castor  |
| Mirfak  |

| _  | anen's Star   |
|--|---|
| <b>~</b>   |   |
|  | s with lowest temperature and highest luminosity are known as supergiants. ergiants in this dataset are |
| Rigel a  | nd Deneb  |
| *Sirius  | 3 and van Maanen's Star   |
| Alnitak  | and Alnitam   |
| Betelge  | euse and Antares  |
| Wolf35   | 9 and G51-I5  |
| <b>~</b>   |   |
| he Sun is a  |   |
|  | ·   |
|  | equence star  |
|  |   |
| • main s   | equence star  |
| main se  | equence star  |
| main so  | equence star  |
| ● main some giant  ■ giant  ■ white contact the some some some some some some some som | equence star  warf  |

Remove the text labels and color the points by star type. This classification describes the properties of the star's spectrum, the amount of light produced at various wavelengths.

Which star type has the lowest temperature?

✓ Correct (3/3 points)



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