Properties of Stars Exercises

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 with the command `update.packages("dslabs")`. You can also update all packages on your system by running `update.packages()` with no arguments, and you should consider doing this routinely.

Question 1

2/2 points (graded)

Load the `stars` data frame from **dslabs**. This contains the name, absolute magnitude, temperature 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 mean magnitude?

4.26 ✔ **Answer:** 4.26

4.26

Answer Code

```
mean(stars$magnitude)
```

What is the standard deviation of magnitude?

7.35 ✔ **Answer:** 7.35

7.35

Answer Code

```
sd(stars$magnitude)
```

Submit You have used 1 of 10 attempts

Answers are displayed within the problem

Question 2

1/1 point (graded)

Make a density plot of the magnitude.

How many peaks are there in the data?

- 1
- 2 ✔
- 3
- 4

Answer Code

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

Submit You have used 1 of 2 attempts

Answers are displayed within the problem

Question 3

1/1 point (graded)

Examine the distribution of star temperature.

Which of these statements best characterizes the temperature distribution?

- The majority of stars have a high temperature.
- The majority of stars have a low temperature. ✔
- The temperature distribution is normal.
- There are equal numbers of stars across the temperature range.

Answer Code

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

Submit You have used 1 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 y-axis 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.

Fill in the blank:

- decreasing linear
- increasing linear
- decreasing exponential ✔
- increasing exponential

Answer Code

```
stars %>%
    ggplot(aes(temp, magnitude)) +
    geom_point()
```

Submit You have used 1 of 2 attempts

Answers are displayed within the problem

Question 5

2/2 points (graded)

For various reasons, scientists do not always follow straight conventions when making plots, and astronomers usually transform values of star luminosity and temperature before plotting. Flip the y-axis so that lower values of magnitude are at the top of the axis (recall that **more luminous stars have lower magnitude**) using `scale_y_reverse`. Take the log base 10 of temperature and then also flip the x-axis.

Fill in the blanks in the statements below to describe the resulting plot:

The brighest, highest temperature stars are in the _____ corner of the plot.

- lower left
- lower right

- (●) upper left ✔
- ( ) upper right

Answer Code

```
stars %>%
    ggplot(aes(log10(temp), magnitude)) +
    geom_point() +
    scale_x_reverse() +
    scale_y_reverse()
```

For main sequence stars, hotter stars have _____ luminosity.

- (●) higher ✔
- ( ) lower

Answer Code

```
stars %>%
    ggplot(aes(log10(temp), magnitude)) +
    geom_point() +
    scale_x_reverse() +
    scale_y_reverse()
```

Submit You have used 2 of 3 attempts

ℹ Answers are displayed within the problem

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 (see question 4) we will call the main sequence stars. 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?

4 ✔ **Answer:** 4

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

Submit You have used 2 of 10 attempts

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

Explanation
Giants are in the upper right corner of the plot and generally have temperatures below 6000K.

Submit You have used 1 of 2 attempts

Answers are displayed within the problem

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
- Polaris
- van Maanen's Star ✔

Answer Code and Explanation
This is the white dwarf with the lowest luminosity (highest magnitude).

```
stars %>%
    ggplot(aes(log10(temp), magnitude)) +
    geom_point() +
    geom_text(aes(label = star)) +
    scale_x_reverse() +
    scale_y_reverse()
```

The two stars with lowest temperature and highest luminosity are known as supergiants. The two supergiants in this dataset are _____.

- Rigel and Deneb
- *SiriusB and van Maanen's Star
- Alnitak and Alnitam
- Betelgeuse and Antares ✔
- Wolf359 and G51-15

Answer Code and Explanation
These are the two stars in the upper right corner.

```
stars %>%
    ggplot(aes(log10(temp), magnitude)) +
    geom_point() +
    geom_text(aes(label = star)) +
    scale_x_reverse() +
    scale_y_reverse()
```

The Sun is a _____.

- ◉ main sequence star ✔
- ○ giant
- ○ white dwarf

Answer Code and Explanation
The Sun is on the main diagonal and is therefore a main sequence star.

```
stars %>%
    ggplot(aes(log10(temp), magnitude)) +
    geom_point() +
    geom_text(aes(label = star)) +
    scale_x_reverse() +
    scale_y_reverse()
```

Submit You have used 2 of 3 attempts

ℹ Answers are displayed within the problem

Question 9

3/3 points (graded)
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?

M ✔ **Answer:** M

Answer Code and Explanation
The coolest stars at the right of the plot are type M.

```
stars %>%
    ggplot(aes(log10(temp), magnitude, col = type)) +
    geom_point() +
    scale_x_reverse() +
    scale_y_reverse()
```

Which star type has the highest temperature?

O ✔ **Answer:** O

Answer Code and Explanation
The hottest star at the left of the plot is type O.

```
stars %>%
    ggplot(aes(log10(temp), magnitude, col = type)) +
    geom_point() +
    scale_x_reverse() +
    scale_y_reverse()
```

The Sun is classified as a G-type star. Is the most luminous G-type star in this dataset also the hottest?

No ✔ **Answer:** No

Answer Code and Explanation
The most luminous G-type star is a dwarf with a cooler temperature.

```
stars %>%
    ggplot(aes(log10(temp), magnitude, col = type)) +
    geom_point() +
    scale_x_reverse() +
    scale_y_reverse()
```

Submit You have used 1 of 3 attempts

Answers are displayed within the problem