Name _____ Date _____ Class _____

Characteristics of Stars

This section explains how astronomers measure distances to stars. It also describes how stars are classified.

Use Target Reading Skills

As you read about stars, stop and write what you know about that topic. As you read the section, write what you learn. An example is done for you.

What You Know
1. Stars are bright and hot.
2.
3.

What You Learned
1.
2.
3.

Introduction

1. Imaginary patterns of stars are called _____.

Classifying Stars

2. What are five characteristics used to classify stars?

a. _____ **b.** _____

c. _____ **d.** _____

e. _____

3. What reveals a star's temperature?

_____

_____

4. Circle the letter of what is revealed by the red color of the supergiant star called Betelgeuse.

a. It is an extremely hot star.
b. It is in a constellation.
c. It is far away.
d. It is a fairly cool star.

5. Stars that are much larger than the sun are called _____.

6. Is the following sentence true or false? Each element has a unique set of lines on a spectrum. _____

7. How can astronomers infer which elements are found in a star?

_____

_____

_____

_____

8. What does a spectrograph do?

_____

_____

_____

9. What is the chemical composition of most stars?

_____

_____

Brightness of Stars

10. The amount of light a star gives off is called its _____.

11. Why does Rigel shine as brightly as Betelgeuse, even though Rigel is much smaller than Betelgeuse?

_____

_____

_____

_____

Characteristics of Stars *(continued)*

12. What two factors determine how bright a star looks from Earth?

a. _____

b. _____

13. Complete the table about the measurement of a star's brightness.

Brightness of Stars	
Measurement of Brightness	**Definition**
Apparent brightness	**a.**
Absolute brightness	**b.**

Star X is closer to Earth than Star Y. Star X appears brighter than Star Y. Use the table to answer the following questions.

c. Compare Star X with Star Y using the term *apparent brightness*.

_____

_____

_____

d. Can you compare the absolute brightness of Star X with Star Y? Why or why not?

_____

_____

_____

_____

_____

14. Is the following sentence true or false? The closer a star is to Earth, the brighter it appears. _____

Characteristics of Stars *(continued)*

15. What two things must an astronomer find out in order to calculate a star's absolute brightness?

a. _____

b. _____

Measuring Distances to Stars

16. Is the following sentence true or false? In space, light travels at a speed of 300,000 kilometers per year. _____

17. What is a light-year?

_____

_____

_____

18. A light-year equals about _____ kilometers.

19. Is the following sentence true or false? The light-year is a unit of time.

_____

20. What is parallax?

_____

_____

_____

21. Astronomers use parallax to measure the distance to which of the following objects?

a. distant stars
b. the sun
c. the planets
d. nearby stars

22. To measure parallax shift, astronomers look at the same star at two different times of the year, when Earth is on different sides of the _____.

The Hertzsprung-Russell Diagram

23. The diagram that shows the relationship between the surface temperatures of stars and their absolute brightness is called the _____.

24. Look at the Hertzsprung-Russell diagram in your textbook. Write what is measured on each of the two axes of the diagram.

a. *x*-axis (horizontal axis): _____

b. *y*-axis (vertical axis): _____

Characteristics of Stars *(continued)*

25. An area on the Hertzsprung-Russell diagram that runs from the upper left to the lower right and includes more than 90 percent of all stars is called the _____.

26. Circle the letter of each sentence that is true based on the Hertzsprung-Russell diagram in your textbook.

a. The sun is a main-sequence star.
b. White dwarfs are brighter than supergiants.
c. Rigel is hotter than Betelgeuse.
d. Polaris is brighter than the sun.

Name _____ Date _____ Class _____

Characteristics of Stars

Key Concepts

- How are stars classified?
- How do astronomers measure distances to the stars?
- What is an H-R diagram and how do astronomers use it?

When ancient observers around the world looked up at the night sky, they imagined that groups of stars formed pictures of people or animals. Today, we call these imaginary patterns of stars **constellations.**

Astronomers classify stars according to their physical characteristics. **Characteristics used to classify stars include color, temperature, size, composition, and brightness.** Stars vary in their chemical composition. Astronomers use spectrographs to determine the elements found in stars. A **spectrograph** is a device that breaks light into colors and produces an image of the resulting spectrum.

The brightness of a star depends upon both its size and its temperature. How bright a star looks from Earth depends on both its distance from Earth and how bright the star actually is. The brightness of a star can be described in two different ways: apparent brightness and absolute brightness. A star's **apparent brightness** is its brightness as seen from Earth. Astronomers can measure apparent brightness fairly easily using electronic devices. A star's **absolute brightness** is the brightness the star would have if it were at a standard distance from Earth.

Distances on Earth's surface are often measured in kilometers. However, distances to the stars are so large that kilometers are not very practical units. **Astronomers use a unit called the light-year to measure distances between the stars.** A **light-year** is the distance that light travels in one year, about 9.5 million million kilometers.

Standing on Earth looking up at the sky, it may seem as if there is no way to tell how far away the stars are. However, astronomers have found ways to measure those distances. **Astronomers often use parallax to measure distances to nearby stars. Parallax** is the apparent change in position of an object when you look at it from different places.

Two important characteristics of stars are temperature and absolute brightness. Ejnar Hertzsprung and Henry Norris-Russell made a graph to find out whether these characteristics are related. The graph they made is called the **Hertzsprung-Russell diagram,** or H-R diagram. **Astronomers use the H-R diagram to classify stars and to understand how stars change over time.** Most of the stars in the H-R diagram form a diagonal line called the **main sequence.** More than 90 percent of all stars, including the sun, are main-sequence stars. In the main sequence, surface temperature increases as brightness increases.

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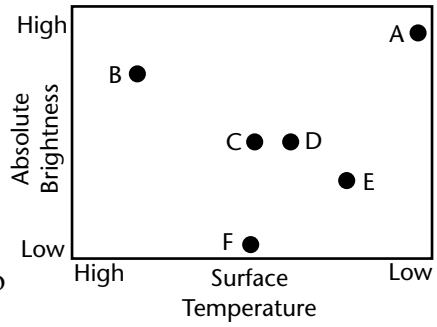
Characteristics of Stars

Understanding Main Ideas

Use the H-R diagram on the right to answer questions 1–3. Write your answers in the spaces provided.



____ **1.** Which star has the greatest brightness?

____ **2.** Which star has the hottest surface?

3. Stars C and D have the same absolute brightness. What would you need to know to determine their apparent brightnesses?

_____

Answer the following questions on a separate sheet of paper.

4. Explain how astronomers measure the distance to nearby stars.

5. What are the main characteristics used to classify stars?

6. How would you classify the sun based on each of these characteristics?

Building Vocabulary

From the list below, choose the term that best completes each sentence and write it in the space provided.

spectrograph	parallax	Hertzsprung-Russell diagram
constellation	apparent brightness	
light-year	absolute brightness	main sequence

7. A star's brightness as if it were a standard distance from Earth is its _____.

8. A device that breaks light into colors and produces an image is a(n) _____.

9. A unit that is often used to measure distances between stars is a(n) _____.

10. The region of the Hertzsprung-Russell diagram that most stars fall within is the _____.

11. A graph of stars showing surface temperature on the *x*-axis and absolute brightness on the *y*-axis is a(n) _____.

12. _____ is often used to determine the distance to nearby stars.

13. A _____ is a(n) imaginary pattern of stars.

14. The brightness of a star as seen from Earth is its _____.

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The Apparent Magnitude Scale

The apparent magnitude of stars was first recorded by the Greek astronomer Hipparchus about 160 B.C. Hipparchus grouped stars according to their brightness or *magnitude.* He called the twenty brightest stars *first magnitude* stars. Stars half that bright were *second magnitude. Third magnitude* stars were half as bright as second magnitude stars, and so on.

Modern astronomers have changed Hipparchus's system a little. In the modern system, an object of magnitude 1 appears 100 times as bright as one of magnitude 6. This means that if two objects are separated by one unit of magnitude, the brighter object appears about 2.5 times as bright as the dimmer one. A star of magnitude 1 is about 2.5 times as bright as a star of magnitude 2. Using this scale, the *dimmer* the object, the *larger* the magnitude number.

What about very bright objects? Remember, the brighter an object appears, the lower its magnitude number. Very bright objects have negative magnitudes. Sirius, the brightest star in the sky (except for the sun), has a magnitude of –1.5. Venus is the brightest planet. Its brightness varies, but at its brightest, its magnitude is –4. The sun's magnitude is –26.5.

Object	**Apparent Magnitude**
Sun	–26.50
Venus (maximum brightness)	–4.00
Mars (maximum brightness)	–2.00
Procyon	0.36
Regulus	1.36
Dimmest visible to the naked eye	6.00
Dimmest visible with binoculars	10.00

Refer to the table above to answer the questions below on a separate sheet of paper.

1. What is the difference between the magnitudes of the bright stars Regulus and Procyon? Which is brighter? How much brighter is it than the dimmer one?
2. How much brighter is Venus than Mars?
3. What is the difference between the magnitude of the dimmest star that is visible with the naked eye and the magnitude of the dimmest that can be seen with binoculars? How much brighter is the former than the latter?

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How Far Is That Star?

When astronomers measure parallax, they record the positions of stars on film in cameras attached to telescopes. In this lab, you will set up a model of a telescope and use it to estimate distances.

Problem

How can parallax be used to determine distances?

Materials

masking tape	black and red pencils	meter stick
paper clips	metric ruler	calculator
pen	paper	

lamp without a shade, with 100-watt light bulb
copier paper box (without the lid)
flat rectangular table, about 1 m wide

Procedure

Review the safety guidelines in Appendix A.

Part 1 Telescope Model

1. Place the lamp on a table in the middle of the classroom.
2. Carefully use the tip of the pen to make a small hole in the middle of one end of the box. The box represents a telescope.
3. At the front of the classroom, place the box on a flat table so the hole points toward the lamp. Line up the left side of the box with the left edge of the table.
4. Put a small piece of tape on the table below the hole. Use the pen to make a mark on the tape directly below the hole. The mark represents the position of the telescope when Earth is on one side of its orbit.

Part 2 Star 1

5. Label a sheet of paper Star 1 and place it inside the box as shown in the drawing. Hold the paper in place with two paper clips. The paper represents the film in a telescope.
6. Darken the room. Turn on the light to represent the star.
7. With the red pencil, mark the paper where you see a dot of light. Label this dot A. Dot A represents the image of the star on the film.
8. Move the box so the right edge of the box lines up with the right edge of the table. Repeat Step 4. The mark on the tape represents the position of the telescope six months later, when Earth is on the other side of its orbit.
9. Repeat Step 7, and use a black pencil to mark the second dot B. Dot B represents the image of the star as seen 6 months later from the other side of Earth's orbit.

How Far Is That Star? *(continued)*

10. Remove the paper. Use the data table provided to record the data that you will collect in the following steps.

11. Measure and record the distance in millimeters between dots A and B. This distance represents the parallax shift of Star 1.

12. Measure and record the distance from the hole in the box to the lamp. This distance represents the actual distance to the star.

13. Measure and record the distance from the hole (lens) to the back of the box in millimeters. This distance represents the focal length of your telescope.

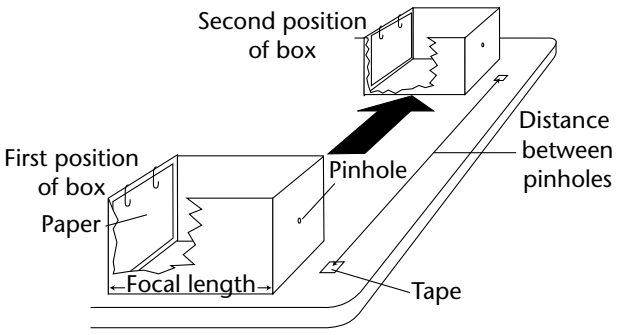
14. Measure and record the distance in millimeters between the marks on the two pieces of masking tape. This distance represents the diameter of Earth's orbit.

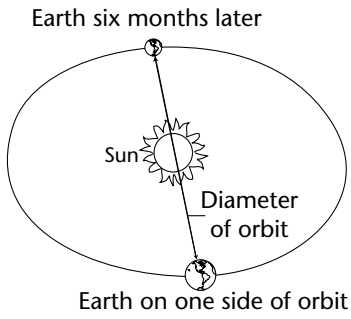
Part 3 Stars 2 and 3

15. Move the lamp away from the table—about half the distance to the back of the room. The bulb now represents Star 2. Predict what you think will happen to the light images on your paper.

16. Repeat Steps 6–12 with a new sheet of paper to find the parallax shift for Star 2.

17. Move the lamp to the back of the classroom. The bulb now represents Star 3. Repeat Steps 6–12 with a new sheet of paper to find the parallax shift for Star 3.





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Data Table

Star	Parallax Shift (mm)	Focal Length (mm)	Diameter of Orbit (mm)	Calculated Distance to Star (mm)	Calculated Distance to Star (m)	Actual Distance to Star (m)
1						
2						
3						

Analyze and Conclude

Write your answers on a separate sheet of paper.

1. **Inferring** What caused the apparent change in position of the dots of light for each star? Explain.
2. **Calculating** Use the following formula to calculate the distance from the telescope to Star 1.

$$\text{Distance} = \frac{\text{Diameter} \times \text{Focal length}}{\text{Parallax shift}}$$

3. **Calculating** Divide your result from Question 2 by 1,000 to get the distance to the light bulb in meters.
4. **Calculating** Repeat Questions 2 and 3 for Stars 2 and 3.
5. **Predicting** Was your prediction in Step 15 correct? Why or why not?
6. **Interpreting Data** How did your calculation for Star 3 compare with the actual distance? What could you do to improve your results?
7. **Communicating** Write a paragraph that explains how a parallax shift varies with distance. Relate each star's parallax shift to its distance from Earth.

Design an Experiment

What would happen if you kept moving the lamp away from the box? Is there a distance at which you can no longer find the distance to the star? Design an experiment to find out.