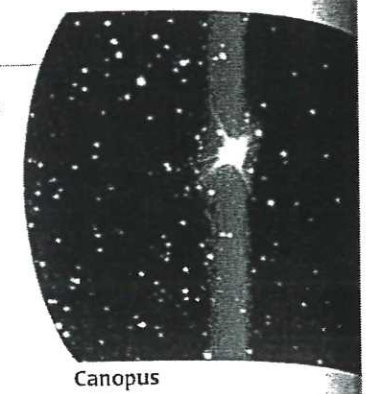
EXAMPLE 5 Solve a real-world problem



Canopus

ASTRONOMY The luminosity (in watts) of a star is the total amount of energy emitted from the star per unit of time. The order of magnitude of the luminosity of the sun is 10^{26} watts. The star Canopus is one of the brightest stars in the sky. The order of magnitude of the luminosity of Canopus is 10^{30} watts. How many times more luminous is Canopus than the sun?

Solution

$$\frac{\text{Luminosity of Canopus (watts)}}{\text{Luminosity of the sun (watts)}} = \frac{10^{30}}{10^{26}} = 10^{30-26} = 10^4$$

▸ Canopus is about 10^4 times as luminous as the sun.

✓ **GUIDED PRACTICE** for Example 5

10. **WHAT IF?** Sirius is considered the brightest star in the sky. Sirius is less luminous than Canopus, but Sirius appears to be brighter because it is much closer to Earth. The order of magnitude of the luminosity of Sirius is 10^{28} watts. How many times more luminous is Canopus than Sirius?

7.2 EXERCISES

HOMEWORK KEY

- ◯ = See WORKED-OUT SOLUTIONS Exs. 33 and 51
- ★ = STANDARDIZED TEST PRACTICE Exs. 2, 19, 37, 46, and 54
- ❖ = MULTIPLE REPRESENTATIONS Ex. 49

SKILL PRACTICE

1. **VOCABULARY** Copy and complete: In the power 4^3, 4 is the ? and 3 is the ?.

2. ★ **WRITING** *Explain* when and how to use the quotient of powers property.

EXAMPLES 1 and 2 for Exs. 3–20

3-17 odd

SIMPLIFYING EXPRESSIONS Simplify the expression. Write your answer using exponents.

3. $\frac{5^6}{5^2}$
4. $\frac{2^{11}}{2^6}$
5. $\frac{3^9}{3^5}$
6. $\frac{(-6)^8}{(-6)^5}$
7. $\frac{(-4)^7}{(-4)^4}$
8. $\frac{(-12)^9}{(-12)^3}$
9. $\frac{10^5 \cdot 10^5}{10^4}$
10. $\frac{6^7 \cdot 6^4}{6^6}$
11. $\left(\frac{1}{3}\right)^5$
12. $\left(\frac{3}{2}\right)^4$
13. $\left(-\frac{5}{4}\right)^4$
14. $\left(-\frac{2}{5}\right)^5$
15. $7^9 \cdot \frac{1}{7^2}$
16. $\frac{1}{9^5} \cdot 9^{11}$
17. $\left(\frac{1}{3}\right)^4 \cdot 3^{12}$
18. $4^9 \cdot \left(-\frac{1}{4}\right)^5$

#19

19. ★ **MULTIPLE CHOICE** Which expression is equivalent to 16^6?

Ⓐ $\frac{16^4}{16^2}$ Ⓑ $\frac{16^{12}}{16^2}$ Ⓒ $\left(\frac{16^6}{16^3}\right)^2$ Ⓓ $\left(\frac{16^9}{16^6}\right)^3$

20. **ERROR ANALYSIS** *Describe* and correct the error in simplifying $\frac{9^5 \cdot 9^3}{9^4}$.

$\frac{9^5 \cdot 9^3}{9^4} = \frac{9^8}{9^4} = 9^{12}$ ✗

EXAMPLES 1, 2, and 3 for Exs. 21–37

#21 - 35 odd

SIMPLIFYING EXPRESSIONS **Simplify the expression.**

21. $\frac{1}{y^8} \cdot y^{15}$ 22. $z^8 \cdot \frac{1}{z^7}$ 23. $\left(\frac{a}{y}\right)^9$ 24. $\left(\frac{j}{k}\right)^{11}$

25. $\left(\frac{p}{q}\right)^4$ 26. $\left(-\frac{1}{x}\right)^5$ 27. $\left(-\frac{4}{x}\right)^3$ 28. $\left(-\frac{a}{b}\right)^4$

29. $\left(\frac{4c}{d^2}\right)^3$ 30. $\left(\frac{a^7}{2b}\right)^5$ 31. $\left(\frac{x^2}{3y^3}\right)^2$ 32. $\left(\frac{3x^5}{7y^2}\right)^3$

33. $\left(\frac{3x^3}{2y}\right)^2 \cdot \frac{1}{x^2}$ 34. $\left(\frac{2x^3}{y}\right)^3 \cdot \frac{1}{6x^3}$ 35. $\frac{3}{8m^5} \cdot \left(\frac{m^4}{n^2}\right)^3$ 36. $\left(-\frac{5}{x}\right)^2 \cdot \left(\frac{2x^4}{y^3}\right)^2$

#37

37. ★ **MULTIPLE CHOICE** Which expression is equivalent to $\left(\frac{7x^3}{2y^4}\right)^2$?

Ⓐ $\frac{7x^5}{2y^6}$ Ⓑ $\frac{7x^5}{2y^8}$ Ⓒ $\frac{49x^5}{4y^6}$ Ⓓ $\frac{49x^6}{4y^8}$

SIMPLIFYING EXPRESSIONS **Find the missing exponent.**

38. $\frac{(-8)^7}{(-8)^?} = (-8)^3$ 39. $\frac{7^? \cdot 7^2}{7^4} = 7^6$ 40. $\frac{1}{p^5} \cdot p^? = p^9$ 41. $\left(\frac{2c^3}{d^2}\right)^? = \frac{16c^{12}}{d^8}$

#42 #44

SIMPLIFYING EXPRESSIONS **Simplify the expression.**

42. $\left(\frac{2f^2g^3}{3fg}\right)^4$ 43. $\frac{2s^3t^3}{st^2} \cdot \frac{(3st)^3}{s^2t}$ 44. $\left(\frac{2m^5n}{4m^2}\right)^2 \cdot \left(\frac{mn^4}{5n}\right)^2$ 45. $\left(\frac{3x^3y}{x^2}\right)^3 \cdot \left(\frac{y^2x^4}{5y}\right)^2$

46. ★ **OPEN-ENDED** Write three expressions involving quotients that are equivalent to 14^7.

47. **REASONING** Name the definition or property that justifies each step to show that $\frac{a^m}{a^n} = \frac{1}{a^{n-m}}$ for $m < n$.

Let $m < n$. Given

$\frac{a^m}{a^n} = \frac{a^m}{a^n}\left(\frac{\frac{1}{a^m}}{\frac{1}{a^m}}\right)$?

$= \frac{1}{\frac{a^n}{a^m}}$?

$= \frac{1}{a^{n-m}}$?

48. **CHALLENGE** Find the values of x and y if you know that $\frac{b^x}{b^y} = b^9$ and $\frac{b^x \cdot b^2}{b^{3y}} = b^{13}$. *Explain* how you found your answer.