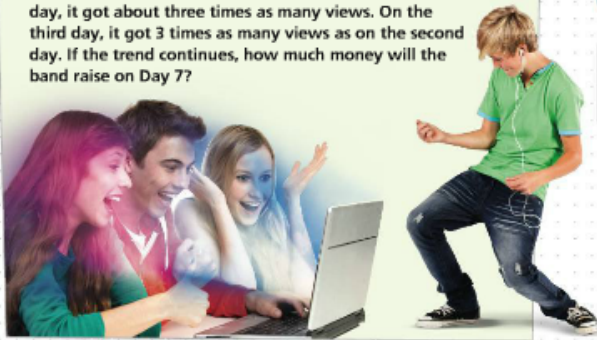


Solve & Discuss It!



One band's streaming video concert to benefit a global charity costs \$1.00 to view.

The first day, the concert got 2,187 views. The second day, it got about three times as many views. On the third day, it got 3 times as many views as on the second day. If the trend continues, how much money will the band raise on Day 7?



Lesson 2-6
Use Properties of Integer Exponents

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I can...
use the properties of exponents to write equivalent expressions.

Focus on math practices

Use Structure Use prime factorization to write an expression equivalent to the amount of money raised by the band on the last day of the week.

Essential Question How do properties of integer exponents help you write equivalent expressions?



EXAMPLE 1 **Multiply Exponential Expressions: Same Base**

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The weight of a newborn male caribou is shown on the right. On average, an adult male caribou weighs up to 2^6 times more than newborn. How can you determine the average weight of an adult male caribou?

2^3 pounds at birth



Look for Relationships How do the two weights relate?

ONE WAY Write the two expressions in expanded form.

$$\begin{array}{cc} 2^3 & 2^6 \\ \downarrow & \downarrow \\ \underline{2 \times 2 \times 2} & \underline{2 \times 2 \times 2 \times 2 \times 2 \times 2} \\ \text{2 is multiplied} & \text{2 is multiplied} \\ \text{3 times} & \text{6 times} \end{array}$$

Join the two expressions.

$$\underline{2 \times 2 \times 2 \times 2 \times 2 \times 2 \times 2 \times 2} = 2^9$$

2 is multiplied 9 times

ANOTHER WAY Use the Product of Powers Property.

$$2^3 \times 2^6 = 2^{3+6} = 2^9$$

The **Product of Powers Property** states that when multiplying two powers with the same base, add the exponents.

Try It!

The local zoo welcomed a newborn African elephant that weighed 3^4 kg. It is expected that at adulthood, the newborn elephant will weigh approximately 3^4 times as much as its birth weight. What expression represents the expected adult weight of the newborn elephant?

Convince Me! Explain why the Product of Powers Property makes mathematical sense.

EXAMPLE 2**Multiply Exponential Expressions: Different Base**

Find the volume in cubic inches of a cube with edge length of 2 feet.

$$V = 2^3 \text{ cubic feet} \quad 1 \text{ cubic foot} = 12^3 \text{ cubic inches}$$

$$2^3 \times 12^3 = 2 \times 2 \times 2 \times 12 \times 12 \times 12$$

$$= (2 \times 12) \times (2 \times 12) \times (2 \times 12)$$

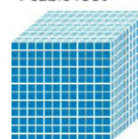
$$= (2 \times 12)^3$$

$$= 24^3 \text{ cubic inches}$$

Use the Associative and Commutative Properties.

Use the **Power of Products Property**: when multiplying two exponential expressions with the same exponent and different bases, multiply the bases and keep the exponent the same.

1 cubic foot

 12^3 cubic inches**EXAMPLE 3****Find the Power of a Power**Write an equivalent expression for $(5^2)^4$.

$$(5^2)^4 = (5^2)(5^2)(5^2)(5^2)$$

$$= 5^2 \text{ multiplied 4 times}$$

$$= 5^{(2+2+2+2)}$$

$$= 5^8$$

Use the Product of Powers Property to add the exponents.

The **Power of Powers Property** states that to find the power of a power, multiply the exponents.**EXAMPLE 4****Divide Exponential Expressions: Same Base**Write an equivalent expression for $6^5 \div 6^3$.

$$6^5 \div 6^3 = \frac{6^5}{6^3}$$

Write as a fraction.

$$= \frac{6 \times 6 \times 6 \times 6 \times 6}{6 \times 6 \times 6}$$

$$= \frac{6 \times 6 \times 6 \times 6 \times 6}{6 \times 6 \times 6}$$

$$= 6 \times \frac{6 \times 6 \times 6 \times 6}{6 \times 6 \times 6} \times 6$$

$$= 6 \times \frac{6 \times 6 \times 6 \times 6}{6 \times 6 \times 6} \times 6$$

$$= 6 \times 6 \text{ or } 6^2$$

Remember, $\frac{6}{6} = 1$.The **Quotient of Powers Property** states that when dividing two exponential expressions with the same base, subtract the exponents.**Try It!**

Write equivalent expressions using the properties of exponents.

a. $(7^3)^2$

b. $(4^5)^3$

c. $9^4 \times 8^4$

d. $8^9 \div 8^3$



Name: _____

Squares and Square Roots

Date: _____

n	Squared ² n ²	Square Root \sqrt{n}
1	1	1.000
2	4	1.414
3	9	1.732
4	16	2.000
5	25	2.236
6	36	2.449
7	49	2.646
8	64	2.828
9	81	3.000
10	100	3.162
11	121	3.317
12	144	3.464
13	169	3.606
14	196	3.742
15	225	3.873
16	256	4.000
17	289	4.123
18	324	4.243
19	361	4.359
20	400	4.472
21	441	4.583
22	484	4.690
23	529	4.796
24	576	4.899
25	625	5.000
26	676	5.099
27	729	5.196
28	784	5.292
29	841	5.385
30	900	5.477
31	961	5.568
32	1024	5.657
33	1089	5.745
34	1156	5.831
35	1225	5.916
36	1296	6.000
37	1369	6.083
38	1444	6.164
39	1521	6.245
40	1600	6.325
41	1681	6.403
42	1764	6.481
43	1849	6.557
44	1936	6.633
45	2025	6.708
46	2116	6.782
47	2209	6.856
48	2304	6.928
49	2401	7.000
50	2500	7.071

n	Squared ² n ²	Square Root \sqrt{n}
51	2601	7.141
52	2704	7.211
53	2809	7.280
54	2916	7.348
55	3025	7.416
56	3136	7.483
57	3249	7.550
58	3364	7.616
59	3481	7.681
60	3600	7.746
61	3721	7.810
62	3844	7.874
63	3969	7.937
64	4096	8.000
65	4225	8.062
66	4356	8.124
67	4489	8.185
68	4624	8.246
69	4761	8.307
70	4900	8.367
71	5041	8.426
72	5184	8.485
73	5329	8.544
74	5476	8.602
75	5625	8.660
76	5776	8.718
77	5929	8.775
78	6084	8.832
79	6241	8.888
80	6400	8.944
81	6561	9.000
82	6724	9.055
83	6889	9.110
84	7056	9.165
85	7225	9.220
86	7396	9.274
87	7569	9.327
88	7744	9.381
89	7921	9.434
90	8100	9.487
91	8281	9.539
92	8464	9.592
93	8649	9.644
94	8836	9.695
95	9025	9.747
96	9216	9.798
97	9409	9.849
98	9604	9.899
99	9801	9.950
100	10000	10.000

n	Square Root \sqrt{n}
101	10.050
102	10.100
103	10.149
104	10.198
105	10.247
106	10.296
107	10.344
108	10.392
109	10.440
110	10.488
111	10.536
112	10.583
113	10.630
114	10.677
115	10.724
116	10.770
117	10.817
118	10.863
119	10.909
120	10.954
121	11.000
122	11.045
123	11.091
124	11.136
125	11.180
126	11.225
127	11.269
128	11.314
129	11.358
130	11.402
131	11.446
132	11.489
133	11.533
134	11.576
135	11.619
136	11.662
137	11.705
138	11.747
139	11.790
140	11.832
141	11.874
142	11.916
143	11.958
144	12.000
145	12.042
146	12.083
147	12.124
148	12.166
149	12.207
150	12.247

n	Square Root \sqrt{n}
151	12.288
152	12.329
153	12.369
154	12.410
155	12.450
156	12.490
157	12.530
158	12.570
159	12.610
160	12.649
161	12.689
162	12.728
163	12.767
164	12.806
165	12.845
166	12.884
167	12.923
168	12.961
169	13.000
170	13.038
171	13.077
172	13.115
173	13.153
174	13.191
175	13.229
176	13.266
177	13.304
178	13.342
179	13.379
180	13.416
181	13.454
182	13.491
183	13.528
184	13.565
185	13.601
186	13.638
187	13.675
188	13.711
189	13.748
190	13.784
191	13.820
192	13.856
193	13.892
194	13.928
195	13.964
196	14.000
197	14.036
198	14.071
199	14.107
200	14.142

n	Square Root \sqrt{n}
201	14.177
202	14.213
203	14.248
204	14.283
205	14.318
206	14.353
207	14.387
208	14.422
209	14.457
210	14.491
211	14.526
212	14.560
213	14.595
214	14.629
215	14.663
216	14.697
217	14.731
218	14.765
219	14.799
220	14.832
221	14.866
222	14.900
223	14.933
224	14.967
225	15.000
226	15.033
227	15.067
228	15.100
229	15.133
230	15.166
231	15.199
232	15.232
233	15.264
234	15.297
235	15.330
236	15.362
237	15.395
238	15.427
239	15.460
240	15.492
241	15.524
242	15.556
243	15.588
244	15.620
245	15.652
246	15.684
247	15.716
248	15.748
249	15.780
250	15.811

KEY CONCEPT



Use these properties when simplifying expressions with exponents (when a , m , and $n \neq 0$).

Product of Powers Property

When the bases are the same,

$$a^m \times a^n = a^{m+n}$$

add the exponents.

Power of Products Property

When the bases are different,

$$a^n \times b^n = (a \times b)^n$$

multiply the bases and keep the exponent the same.

Power of a Power Property

To find the power of a power,

$$(a^m)^n = a^{m \times n}$$

multiply the exponents.

Quotient of Powers Property

When the bases are the same,

$$a^m \div a^n = a^{m-n}$$

subtract the exponents.

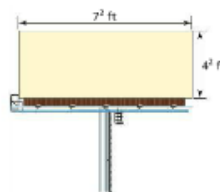
Do You Understand?

- Essential Question** How do properties of integer exponents help you write equivalent expressions?
- Look for Relationships** If you are writing an equivalent expression for $2^3 \cdot 2^4$, how many times would you write 2 as a factor?
- Construct Arguments** Kristen wrote 5^8 as an expression equivalent to $(5^2)^4$. Her math partner writes 5^5 . Who is correct?
- Critique Reasoning** Tyler says that an equivalent expression for $2^3 \times 5^3$ is 10^9 . Is he correct? Explain.

Do You Know How?

- Write an equivalent expression for $7^{12} \cdot 7^4$.
- Write an equivalent expression for $(8^2)^4$.

- A billboard has the given dimensions.




Using exponents, write two equivalent expressions for the area of the rectangle.

- Write an equivalent expression for $18^9 \div 18^4$.

Name: _____


 PRACTICE
  TUTORIAL

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Practice & Problem Solving

Leveled Practice In 9–12, use the properties of exponents to write an equivalent expression for each given expression.

9. $2^8 \cdot 2^4$

$$2^8 \cdot 2^4 = 2^{\boxed{}}^{\boxed{}}$$

$$= \boxed{}$$

10. $\frac{8^7}{8^3}$

$$\frac{8^7}{8^3} = 8^{\boxed{}}^{\boxed{}}$$

$$= \boxed{}$$

11. $(3^4)^5$

$$(3^4)^5 = 3^{\boxed{}}^{\boxed{}}$$

$$= \boxed{}$$

12. $3^9 \cdot 2^9$

$$3^9 \cdot 2^9 = (\boxed{} \cdot \boxed{})^{\boxed{}}$$

13. a. How do you multiply powers that have the same base?

b. How do you divide powers that have the same base?

c. How do you find the power of a power?

d. How do you multiply powers with different bases but the same exponent?

14. Which expressions are equivalent to 2^{11} ? Select all that apply.

- $\frac{2^{23}}{2^{12}}$
 $2^7 \cdot 2^4$
 $\frac{2^9}{2^2}$
 $2^2 \cdot 2^9$

In 15–18, use the properties of exponents to write an equivalent expression for each given expression.

15. $(4^4)^3$

16. $\frac{3^{12}}{3^3}$

17. $4^5 \cdot 4^2$

18. $6^4 \cdot 2^4$

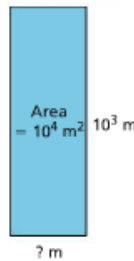
19. **Critique Reasoning** Alberto incorrectly stated that $\frac{5^7}{5^2} = 1^3$. What was Alberto's error? Explain your reasoning and find the correct answer.

20. Is the expression 8×8^5 equivalent to $(8 \times 8)^5$? Explain.

21. Is the expression $(3^2)^{-3}$ equivalent to $(3^3)^{-2}$? Explain.

22. Is the expression $3^2 \cdot 3^{-3}$ equivalent to $3^3 \cdot 3^{-2}$? Explain.

23. **Model with Math** What is the width of the rectangle written as an exponential expression?



24. Simplify the expression $\left(\frac{1}{2}\right)^3$.

25. **Higher Order Thinking** Use a property of exponents to write $(3b)^5$ as a product of powers.

Assessment Practice

26. Simplify the expression $4^5 \cdot 4^{10}$. Write your answer using exponential notation.

27. Your teacher asks the class to evaluate the expression $(2^3)^4$. Your classmate gives an incorrect answer of 16.

a. Evaluate the expression.

b. What was the likely error?

- Ⓐ Your classmate divided the exponents.
- Ⓑ Your classmate multiplied the exponents.
- Ⓒ Your classmate added the exponents.
- Ⓓ Your classmate subtracted the exponents.

