Lesson 2-8
Use Powers of 10 to Estimate Quantities

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I can...
estimate large and small quantities using a power of 10.

Explain It!

ACTIVITY

Keegan and Jeff did some research and found that there are approximately 7,492,000,000,000,000,000 grains of sand on Earth. Jeff says that it is about 7×10^{15} grains of sand. Keegan says that this is about 7×10^{18} grains of sand.

7,492,000,000,000,000,000

A. How might Jeff have determined his estimate? How might Keegan have determined his estimate?

B. Whose estimate, Jeff's or Keegan's, is more logical? Explain.

Focus on math practices

Be Precise Do you think the two estimates are close in value? Explain your reasoning.

Essential Question When would you use a power of 10 to estimate a quantity?

EXAMPLE 1 Estimate Very Large Quantities

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Janelle is comparing the estimated populations of Japan and China. The estimated population of Japan is 126,818,019. The estimated population of China is shown. How can Janelle compare the two populations more easily?

Use Structure You can estimate large quantities and write them in a format that is easier to compare.

STEP 1 Estimate each population by rounding to the greatest place value. Then write the number as a single digit times a power of 10.

Population of China		Population of Japan
1,402,941,487	Count the zeros to determine the power of 10.	126,818,019
rounds to 1,000,000,000		rounds to 100,000,000
1×10^9		1×10^8

STEP 2 Compare the estimated values.

$10^9 > 10^8$

$1 \times 10^9 > 1 \times 10^8$

Janelle can use estimates using powers of 10 to compare the populations more easily.

Try It!

Light travels 299,792,458 meters per second. Sound travels at 332 meters per second. About how much faster is the speed of light than the speed of sound?

299,792,458 rounded to the greatest place value is _____.

There are _____ zeros in the rounded number.

The estimated speed of light is _____ $\times 10^{\square}$ meters per second.

322 rounded to the greatest place value is _____.

There are _____ zeros in the rounded number.

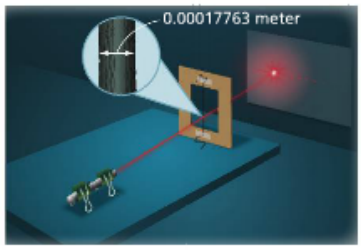
The estimated speed of sound is _____ $\times 10^{\square}$.

The speed of light is $3 \times 10^{\square} - 3 \times 10^{\square}$, or $3 \times 10^{\square}$, meters per second faster.

Convince Me! Country A has a population of 1,238,682,005 and Country B has a population of 1,106,487,394. How would you compare these populations?

EXAMPLE 2 Estimate Very Small Quantities

Matthias used a laser to measure the average thickness of a human hair. A sheet of paper is about 0.0013 meter thick. How do the two thicknesses compare?



Write the estimated thickness of a human hair using a single digit and a power of 10.

Round 0.00017763 to 0.0002.

Write 0.0002 as 2×10^{-4}.

Write the estimated thickness of a sheet of paper using a single digit and a power of 10.

Round 0.0013 to 0.001.

Write 0.001 as 1×10^{-3}.

Compare the estimates.

$2 \times 10^{-4} < 1 \times 10^{-3}$

A human hair is thinner than a sheet of paper.

EXAMPLE 3 Find How Many Times as Much

How does the Gross Domestic Product (GDP) of Canada compare to that of the United States?

Gross Domestic Product	
Canada	$1,785,387,000,000,000
USA	$17,348,075,000,000,000

STEP 1 Write each GDP as a single digit times a power of 10.

Canada: $1{,}785{,}387{,}000{,}000{,}000 \approx 2{,}000{,}000{,}000{,}000{,}000 = 2 \times 10^{15}$

Count the zeros to determine the power of 10.

USA: $17{,}348{,}075{,}000{,}000{,}000 \approx 20{,}000{,}000{,}000{,}000{,}000 = 2 \times 10^{16}$

STEP 2 Compare the two estimates.

$(2 \times 10^{16}) > (2 \times 10^{15})$

The U.S. GDP is about 10 times greater than that of Canada.

Try It!

There are approximately 1,020,000,000 cars in the world. The number of cars in the United States is approximately 239,800,000.

Compare the number of cars in the world to that in the United States.

Name: _____ Squares and Square Roots Date: _____

n	Squared² n^2	Square Root √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	Squared² n^2	Square Root √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 √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 √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 √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

You can estimate a very large or very small number by rounding the number to its greatest place value, and then writing that number as a single digit times a power of 10.

Very Large Numbers

$3{,}564{,}879{,}000 \approx 4{,}000{,}000{,}000$

$= 4 \times 10^9$

The number is greater than 1, so the exponent is positive.

Count the number of zeros to determine the power of 10.

Very Small Numbers

$0.000000235 \approx 0.0000002$

$= 2 \times 10^{-7}$

The number is less than 1, so the exponent is negative.

Do You Understand?

1. **Essential Question** When would you use powers of 10 to estimate a quantity?

2. **Construct Arguments** Kim writes an estimate for the number 0.00436 as 4×10^3. Explain why this cannot be correct.

3. **Be Precise** Raquel estimated 304,900,000,000 as 3×10^8. What error did she make?

Do You Know How?

4. Use a single digit times a power of 10 to estimate the height of Mt. Everest to the nearest ten thousand feet.

Mt. Everest is 29,035 feet tall.

5. A scientist records the mass of a proton as 0.00000000000000000000000016726231 gram. Use a single digit times a power of 10 to estimate the mass.

6. The tanks at the Georgia Aquarium hold approximately 8.4×10^6 gallons of water. The tanks at the Audubon Aquarium of the Americas hold about 400,000 gallons of water. Use a single digit times a power of 10 to estimate how many times greater the amount of water is at the Georgia Aquarium.

Name: _____

Practice & Problem Solving

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Leveled Practice **In 7–9, use powers of 10 to estimate quantities.**

7. A city has a population of 2,549,786 people. Estimate this population to the nearest million. Express your answer as the product of a single digit and a power of 10.

Rounded to the nearest million, the population is about ☐.

Written as the product of a single digit and a power of ten, this number is ☐ × 10☐.

8. Use a single digit times a power of 10 to estimate the number 0.00002468.

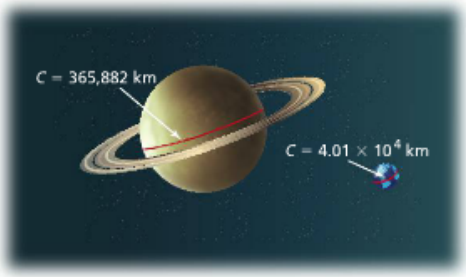
Rounded to the nearest hundred thousandth, the number is about ☐.

Written as a single digit times a power of ten, the estimate is ☐ × 10☐.

9. The approximate circumferences of Earth and Saturn are shown. How many times greater is the circumference of Saturn than the circumference of Earth?

The circumference of Saturn is ☐ × 10☐ km.

Saturn's circumference is about ☐ times greater than the circumference of Earth.



10. Estimate 0.037854921 to the nearest hundredth. Express your answer as a single digit times a power of ten.

11. Compare the numbers 6×10^{-6} and 2×10^{-8}.

a. Which number has the greater value?

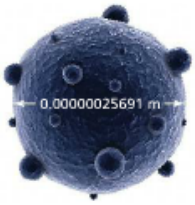
b. Which number has the lesser value?

c. How many times greater is the greater number?

12. Taylor made $43,785 last year. Use a single digit times a power of ten to express this value rounded to the nearest ten thousand.

13. The length of plant cell A is 8×10^{-5} meter. The length of plant cell B is 0.000004 meter. How many times greater is plant cell A's length than plant cell B's length?

14. Critique Reasoning The diameter of one species of bacteria is shown. Bonnie approximates this measure as 3×10^{-11} meter. Is she correct? Explain.



15. The populations of Cities A and B are 2.6×10^5 and 1,560,000, respectively. The population of City C is twice the population of City B.

The population of City C is how many times the population of City A?

Assessment Practice

16. Earth is approximately 5×10^9 years old. For which of these ages could this be an approximation? Select all that apply.

- ☐ 4,762,100,000 years
- ☐ 4,849,000,000 years
- ☐ 48,000,000,000 years
- ☐ 4.45×10^9 years
- ☐ 4.849999999×10^9 years

17. PART A

Express 0.000000298 as a single digit times a power of ten rounded to the nearest ten millionth.

PART B

Explain how negative powers of 10 make small numbers to write and compare.