Exponents and Powers

An exponent is used to signify repeated multiplication. For example, the expression $\mathbf{5^6}$ ("five to the sixth power") simply means we multiply number 5 by itself, repeatedly, six times:

$$\mathbf{5^6} = 5 \times 5 \times 5 \times 5 \times 5 \times 5$$

The number 5 is called the **base**. It tells us what number we are multiplying repeatedly. The little raised number is the **exponent**, and it tells us how many times the number is repeatedly multiplied.

Example 1. 2^4 means $2 \times 2 \times 2 \times 2$. It is read as "two to the fourth power." Its value is 16.

Example 2. 9^2 means 9×9 and is commonly read as "nine squared" (think of the area of a square with side length 9). Similarly, 11^2 is read as "eleven squared". (What is its value?)

Example 3. 4^3 means $4 \times 4 \times 4$ and is commonly read as "four cubed" (because of the volume of a cube with edges 4 units). Similarly, 10^3 is read as "ten cubed". (What is its value?)

1. Write using exponents, and solve.

a. $4 \times 4 \times 4 =$ ☐$^{\square}$ = _____

b. eight squared = ☐$^{\square}$ = _____

c. $10 \times 10 \times 10 =$ ☐$^{\square}$ = _____

d. $1 \times 1 \times 1 \times 1 \times 1 =$ ☐$^{\square}$ = _____

e. five cubed = ☐$^{\square}$ = _____

f. two to the fifth power = ☐$^{\square}$ = _____

g. $3 \times 3 \times 3 \times 3 =$ ☐$^{\square}$ = _____

h. zero to the tenth power = ☐$^{\square}$ = _____

2. Multiplication is repeated addition, and a power is repeated multiplication. Compare.

a. $2 + 2 + 2 + 2 = 4 \times 2 =$ _____

$2 \times 2 \times 2 \times 2 =$ ☐$^{\square}$ = _____

b. $5 + 5 + 5 =$ ___ × ___ = _____

$5 \times 5 \times 5 =$ ☐$^{\square}$ = _____

3. Read the powers aloud. Then find their values.

a. $5^2 =$

b. $2^3 =$

c. $3^3 =$

d. $7^2 =$

e. $1^6 =$

f. $0^7 =$

Powers of ten are expressions where the number **10 is multiplied by itself.** For example, 100 is a power of ten because it is 10×10 or 10^2. Or, 100,000 is a power of ten because it is 10 multiplied by itself, five times (10^5).

4. Write these powers of ten as normal numbers. Notice there is a shortcut and a pattern!

a. 10^2 = _____	**d.** 10^5 = _____
b. 10^3 = _____	**e.** 10^6 = _____
c. 10^4 = _____	**f.** 10^7 = _____

SHORTCUT: In a power of ten, the exponent tells us how many _____ the number has after the digit 1.

Example 4. Let's say a child asked you how much in total is five $100-bills. You would think that's easy— the total is five hundred dollars! In symbols, $5 \times 10^2 = 500$.

Similarly, seven copies of (or seven times) one million equals seven million.
In symbols, $7 \times 1{,}000{,}000 = 7{,}000{,}000$ or $7 \times 10^6 = 7{,}000{,}000$.

5. Fill in.

a. nine copies of a hundred thousand ____ × _____ = _____	**b.** eight copies of ten thousand ____ × _____ = _____	
c. 5×10^4 = _____	**d.** 7×10^6 = _____	**e.** 3×10^8 = _____

6. Study the patterns in these powers of ten, and fill in the missing parts.

a. 10×10^2 = *1,000* $10 \times 10 \times 10^2$ = _____ $10 \times 10 \times 10 \times 10^2$ = _____	**b.** 10×10^3 = _____ = $10^{\square}$ 100×10^3 = _____ = $10^{\square}$ $1{,}000 \times 10^3$ = _____ = $10^{\square}$
c. _____ × 10^3 = 100,000 _____ × 10^4 = 100,000 _____ × 10^4 = 1,000,000	**d.** _____ × 10^5 = 1,000,000 _____ × 10^5 = 100,000,000 _____ × 10^3 = 10,000,000

7. Multiply a number times a power of ten. Compare the problems in each box.

a. $5 \times 100 =$ _____ $16 \times 100 =$ _____	**b.** $6 \times 10^3 =$ _____ $23 \times 10^3 =$ _____	**c.** $3 \times 10^4 =$ _____ $89 \times 10^4 =$ _____
d. $9 \times 10^5 =$ _____ $19 \times 10^5 =$ _____	**e.** $3 \times 10^7 =$ _____ $32 \times 10^7 =$ _____	

8. Luke says that 10^7 is three times as big as 10^4. Is he correct?

Explain why or why not.

9. Find the missing exponent or the entire power of ten.

a. $6 \times 10^{\square} = 6{,}000$ $71 \times 10^{\square} = 71{,}000{,}000$	**b.** $3 \times 10^{\square} = 300{,}000$ $9 \times 10^{\square} = 90{,}000{,}000$	**c.** $56 \times \square^{\square} = 560{,}000$ $295 \times \square^{\square} = 2{,}950{,}000{,}000$

10. Astronomy involves some really big numbers. Write these numbers in the normal manner.

Pluto's surface area is about 17×10^6 km^2.

The sun's average distance from Earth is 15×10^7 km.

Haumea is a dwarf planet located beyond Neptune's orbit.
The mass of Haumea is about 4×10^{21} kg.

Some challenges. Can you find a shortcut?

Puzzle Corner

a. $10^3 \times 10^2 =$ _____

b. $5 \times 10^2 \times 10^4 =$ _____

c. $10^5 \times 10^3 =$ _____

d. $8 \times 10^4 \times 2 \times 10^3 =$ _____

e. $10^6 \times 10^2 \times 10^2 = 10^{\square}$

f. $10^3 \times 10^5 \times 10^2 \times 10^4 = 10^{\square}$