

# Exponents and Powers

If you multiply the same number by itself repeatedly, such as  $5 \times 5 \times 5 \times 5 \times 5 \times 5$ , it is **repeated multiplication**. We have a shorthand notation for it:  $5 \times 5 \times 5 \times 5 \times 5 \times 5 = 5^6$

Read  $5^6$  as “five to the sixth power.” 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 how many times the number is repeatedly multiplied.

We can also solve that  $5^6 = 5 \times 5 \times 5 \times 5 \times 5 \times 5 = 15,625$ .

These repeated multiplications are called **powers**. For example,  $10 \times 10 \times 10 \times 10$  is “ten to the fourth power,” and  $10^7$  is “ten to the seventh power.” They are both **powers of ten**.

We have two other special ways to read powers when the exponent is 2 or 3:

- $10^2$  is read “ten squared”, because it gives us the area of a square with a side length of 10 units.
- $4^3$  is read “four cubed”, because it gives us the volume of a cube with an edge length of 4 units.

1. Read the powers aloud. Then write out the repeated multiplications, and solve.

a.  $5^2 = 5 \times 5 = 25$

b.  $2^3 = \underline{\quad} \times \underline{\quad} \times \underline{\quad} = \underline{\quad}$

c.  $3^3 = \underline{\quad}$

d.  $10^2 = \underline{\quad}$

e.  $10^3 = \underline{\quad}$

f.  $7^2 = \underline{\quad}$

g.  $2^4 = \underline{\quad}$

h.  $1^6 = \underline{\quad}$

2. Write using exponents, and solve.

a.  $4 \times 4 \times 4 =$

b.  $9 \times 9 =$

c.  $10 \times 10 \times 10 \times 10 =$

d. five to the third power =

e.  $1 \times 1 \times 1 \times 1 \times 1 =$

f.  $2 \times 2 \times 2 \times 2 \times 2 =$

g.  $3 \times 3 \times 3 \times 3 =$

h. zero to the tenth power =

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

a.  $2 + 2 + 2 + 2 = 4 \times 2 = \underline{\quad}$

$2 \times 2 \times 2 \times 2 =$    $= \underline{\quad}$

b.  $5 + 5 + 5 = \underline{\quad} \times \underline{\quad} = \underline{\quad}$

$5 \times 5 \times 5 =$    $= \underline{\quad}$

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

|                   |                   |
|-------------------|-------------------|
| a. $10^2 =$ _____ | e. $10^6 =$ _____ |
| b. $10^3 =$ _____ | f. $10^7 =$ _____ |
| c. $10^4 =$ _____ | g. $10^8 =$ _____ |
| d. $10^5 =$ _____ | h. $10^9 =$ _____ |

**SHORTCUT:** In any power of ten, such as  $10^8$ , the exponent tells us how many \_\_\_\_\_ the number has after the digit 1.

**Remember?** When you multiply numbers ending in zeros, multiply the “parts” without zeros and tag as many zeros onto the result as there are in the factors. Look at these examples:

$$6,000 \times 500$$

Multiply  $6 \times 5 = 30$ ,  
and tag 5 zeros to the result:  
 $30 \leftarrow 00000 = 3,000,000$

$$2,300 \times 20,000$$

Multiply  $23 \times 2 = 46$ ,  
and tag 6 zeros to the result:  
 $46 \leftarrow 000000 = 46,000,000$

$$200 \times 5,000 \times 70$$

Multiply  $2 \times 5 \times 7 = 70$ ,  
and tag 6 zeros to the result:  
 $70 \leftarrow 000000 = 70,000,000$

5. Calculate the products mentally.

|                                         |                                                  |                                    |
|-----------------------------------------|--------------------------------------------------|------------------------------------|
| a. $200 \times 30,000$                  | b. $40 \times 2 \times 200,000$                  | c. $500,000 \times 3,000$          |
| d. $100 \times 15,000$                  | e. $30 \times 900,000$                           | f. $50,000 \times 200 \times 6$    |
| g. $120 \times 20 \times 200 \times 50$ | h. $40 \times 20 \times 10 \times 50 \times 200$ | i. $50,000 \times 20,000 \times 8$ |

6. Calculate.

|                            |                            |                             |
|----------------------------|----------------------------|-----------------------------|
| a. $5 \times 10^2 =$ _____ | b. $7 \times 10^6 =$ _____ | c. $51 \times 10^3 =$ _____ |
| $5 \times 10^3 =$ _____    | $2 \times 10^4 =$ _____    | $161 \times 10^6 =$ _____   |
| $5 \times 10^4 =$ _____    | $6 \times 10^7 =$ _____    | $29 \times 10^4 =$ _____    |

### Why does this work?

It is because we can break down such multiplications so that we multiply the single-digit numbers and the powers of ten separately.

For example,  $300 \times 9,000$  is the same as  $3 \times 100 \times 9 \times 1,000$ . Since we can multiply in any order, we can multiply  $3 \times 9$  and  $100 \times 1,000$  separately, to get  $27 \times 100,000$ . And that equals 2,700,000.

7. Did you understand the above explanation? Fill in.

a.  $200 \times 3,000$  is equal to

\_\_\_  $\times$  100  $\times$  \_\_\_  $\times$  1,000, which is equal to

\_\_\_  $\times$  \_\_\_  $\times$  100  $\times$  1,000

= \_\_\_  $\times$  \_\_\_\_\_

= \_\_\_\_\_

b.  $6,000 \times 200 \times 50$  is equal to

( \_\_\_  $\times$  1000 )  $\times$  ( \_\_\_  $\times$  100 )  $\times$  ( \_\_\_  $\times$  10 )

= \_\_\_  $\times$  \_\_\_  $\times$  \_\_\_  $\times$  1000  $\times$  100  $\times$  10

= \_\_\_  $\times$  \_\_\_\_\_

= \_\_\_\_\_

8. Find the missing exponent or power of ten.

a.  $6 \times 10^{\text{■}} = 6,000$

$71 \times 10^{\text{■}} = 71,000,000$

b.  $3 \times 10^{\text{■}} = 300,000$

$9 \times 10^{\text{■}} = 90,000,000$

c.  $56 \times \text{■}^{\text{■}} = 560,000$

$295 \times \text{■}^{\text{■}} = 2,950,000,000$

9. Some challenges. Can you find a shortcut?

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.  $10^6 \times 10^2 \times 10^2 = 10^{\text{■}}$

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

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

Pluto's surface area is about  $17 \times 10^6 \text{ km}^2$ .

The Sun's average distance from Earth is  $15 \times 10^7 \text{ km}$ .

Haumea is a dwarf planet located beyond Neptune's orbit.

The mass of Haumea is about  $4 \times 10^{21} \text{ kg}$ .

The Sun's mass is about  $2 \times 10^{30} \text{ kg}$  and Jupiter's mass is about  $2 \times 10^{27} \text{ kg}$ . About how many times heavier is the Sun than Jupiter?

**Puzzle Corner**