

Exponents give us a shorthand for repeated multiplication.

Recall an exponent's purpose. What does  $5^3$  really mean?

$$5^3 = 5 \cdot 5 \cdot 5$$

Can be thought of as "repeated multiplication".

"5 multiplied by itself 3 times"

What about  $(-2)^4$ ?

$$(-2)^4 = (-2)(-2)(-2)(-2)$$

"-2 multiplied by itself 4 times"

What is the value of  $(-2)^4$ ? How is that different than  $-2^4$ ? The parentheses are very important.

We will also be simplifying expressions like  $-4 \times 3^3$  and  $5 \times 6^2 - 3^4$ . Order of operations will become important when we have more complicated expressions.

expl 1: Evaluate.

$$-4^3$$

expl 2: Evaluate.

$$(-4)^3$$

What difference do the parentheses make?

Earlier we saw  $(-2)^4$  and  $-2^4$  were different. But  $(-4)^3$  and  $-4^3$  were the same. Why?

## Order of Operations:

When we see something like  $2 \times 3^2$ , we could either multiply first and then apply the exponent, or we could apply the exponent and then multiply. *But those would get us different answers! Eek! So, that's no good!* Luckily for us, old men, long ago, have set down rules for the rest of us to follow.

(Spoken in an authoritative old man, old-timey voice):

Let it be known henceforth that whensoever he encountereth numerical expressions such as  $2 \times 3^3$  and  $5 \times 6^2 - 3^4$ , a plebeian shall forever after apply these rules!

**First**, simplify all within thine parentheses.

**Second**, apply any exponents thou encountereth.

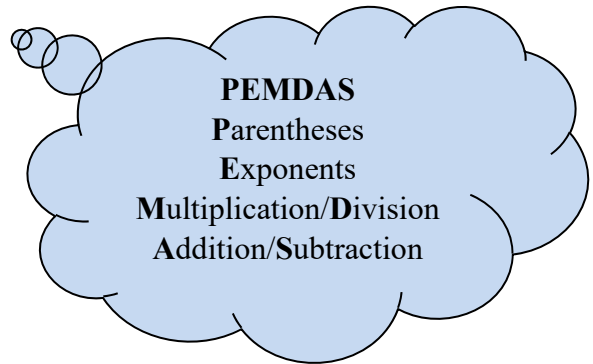
**Third**, performeth any multiplications or divisions (from left to right).

**Fourth**, performeth subtractions or additions (from left to right).

Try it with thine  $2 \times 3^3$  henceforth and with no delay or off with ye head!

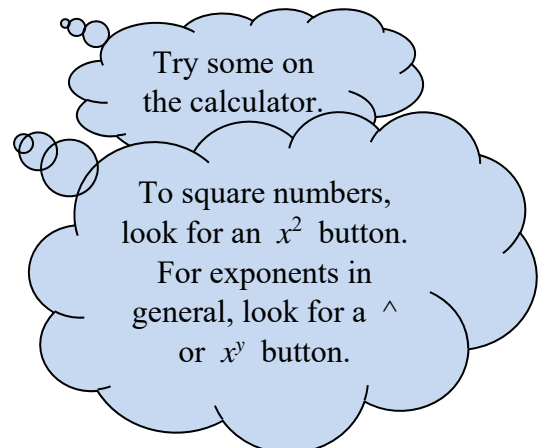
expl 3: Evaluate.

$$(7-5)^4$$



expl 4: Find the value of this expression.

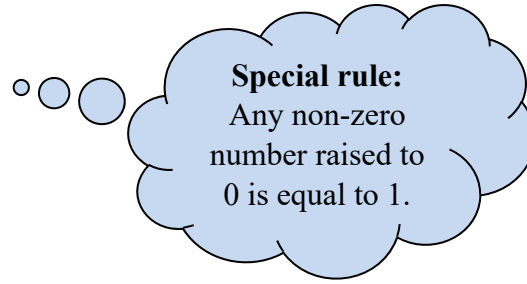
$$-4 \times 3^3$$



expl 5: Find the value of this expression.

$$3^3 \times 5^2$$

expl 6: Find the value of this expression.  
 $23^0$



expl 7: Find the value of this expression.  
 $5 \times 6^2 - 3^4$

### Square Roots:

We know that  $6^2$  is equal to  $6 \times 6$  and so is 36. Now, we go the other way. We will find the square root of non-negative numbers. It will look like  $\sqrt{36}$ .

By using this notation (called a radical), we mean **find the non-negative number that when squared would give us 36**. (This is technically called the *principal* square root.) Being comfortable with the perfect squares is helpful for some of these problems.

Perfect Squares			
$1^2 = 1$	$6^2 = 36$	$11^2 = 121$	$16^2 = 256$
$2^2 = 4$	$7^2 = 49$	$12^2 = 144$	$17^2 = 289$
$3^2 = 9$	$8^2 = 64$	$13^2 = 169$	$18^2 = 324$
$4^2 = 16$	$9^2 = 81$	$14^2 = 196$	$19^2 = 361$
$5^2 = 25$	$10^2 = 100$	$15^2 = 225$	$20^2 = 400$

expl 8: Use the table above to evaluate the following.

a.)  $\sqrt{121}$

b.)  $\sqrt{64}$

c.)  $\sqrt{324}$

### Square Roots of Non-Perfect Squares:

Some problems will ask for the square root of a number that is in between two perfect squares. For instance, if we asked for  $\sqrt{40}$ , we *cannot* find 40 on our table. We will evaluate these using the calculator. You will likely get an answer with a long string of decimal digits so you will be told how to round.

Since you *cannot* square a number and ever get a negative number, we *cannot* square root a negative number. In other words, to compute  $\sqrt{-40}$  takes math we are *not* covering.

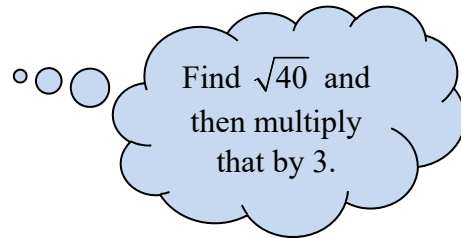
expl 9: Evaluate. Round to two decimal places.

a.)  $\sqrt{40}$

b.)  $\sqrt{250}$

expl 10: Evaluate. Round to two decimal places.

$3\sqrt{40}$



expl 11: The Golden Gate bridge expands on a warm day about 2 ft in length. Expansion joints are installed to accommodate this. If there were no expansion joints, a bulge would form on the

bridge where the calculation  $\sqrt{\left(\frac{5280}{2} + 1\right)^2 - \left(\frac{5280}{2}\right)^2}$  gives the height of the bulge. Find it to the nearest foot.

