# 1.3 Powers and Roots

## A. Powers

Exponents are repeated multiplication:

$3^5 = 3 \cdot 3 \cdot 3 \cdot 3 \cdot 3$ (5 of them), thus $3^5 = 243$

Variables are treated the same way:

$x^4y^2z^3 = x \cdot x \cdot x \cdot x \cdot y \cdot y \cdot z \cdot z \cdot z$

**WARNING**: Parentheses are important

$(-5)^2 = (-5) \cdot (-5) = 25$ but $-5^2 = -(5 \cdot 5) = -25$

## B. Square Roots

$\sqrt{\ }$ $\Leftarrow$ This asks for the **positive** number multiplied by itself to get the inside.

Examples:

1. Find $\sqrt{16}$

   $\sqrt{16} = 4$, because $4 \cdot 4 = 16$

2. Find $\sqrt{81}$

   $\sqrt{81} = 9$, because $9 \cdot 9 = 81$

3. Find $\sqrt{\frac{1}{4}}$

$\sqrt{\frac{1}{4}} = \frac{1}{2}$, because $\left(\frac{1}{2}\right)\left(\frac{1}{2}\right) = \frac{1}{4}$

## C. Comments on Square Roots

1. Since any real number multiplied by itself is positive, we can't take the square root of a negative number!

$\sqrt{-4} \quad \Rightarrow \quad$ no real number exists!

2. **Square Root of a Fraction Shortcut**:

We can take the square root of a fraction by doing the numerator and denominator separately.

Example:

$\sqrt{\frac{4}{9}} = \frac{\sqrt{4}}{\sqrt{9}} = \frac{2}{3}$ (Notice that $\frac{2}{3} \cdot \frac{2}{3} = \frac{4}{9}$)

## D. Order of Operations II

( ), [ ], { }, | |, $\sqrt{\ }$ act as grouping symbols. We use [ ] and { } when you have too many parentheses.

Throwing grouping symbols into the mix with exponents, we have a longer sequence/order of operations to consider.

Remember the acronym "PEMDAS".

PEMDAS:

1. **P**arentheses and Grouping Symbols First

2. **E**xponents and Roots: Evaluate them!

3. **M**ultiplications and **D**ivisions (simultaneously) left to right

4. **A**dditions and **S**ubtractions (simultaneously) left to right

Remember our strategy is to just do one thing, and recopy the problem line by line. Eventually, you have the answer (DON'T try to do it all at once)

Examples:

1. Find $12 - (4 + 3 - 10)$

   $12 - (4 + 3 - 10)$ Do parentheses first. On the inside, A/S left to right

   $12 - (7 - 10)$

   $12 - (-3)$

   $12 + 3$

   $\boxed{15}$

**Note**: More than one set of grouping symbols means that you start with the innermost one.

2. Find $9 - 4[6 - (5 - 8 \cdot 2)]$

   $9 - 4[6 - (5 - 8 \cdot 2)]$ Start with the inner parentheses. M/D first!

   $9 - 4[6 - (5 - 16)]$ Inner parentheses: A/S

$9 - 4[6 - (-11)]$

$9 - 4[6 + 11]$ Now do what's inside the brackets

$9 - 4(17)$ M/D first!

$9 - 68$

$\boxed{-59}$

3. Find $|6 - 5 \cdot 2^3 + \sqrt{6 + 10}|$

$|6 - 5 \cdot 2^3 + \sqrt{6 + 10}|$ The inner group is inside the square root.

$|6 - 5 \cdot 2^3 + \sqrt{16}|$ Now inside abs. value, "do E" left to right

$|6 - 5 \cdot 8 + \sqrt{16}|$

$|6 - 5 \cdot 8 + 4|$ Now M/D!

$|6 - 40 + 4|$ Now A/S!

$|-34 + 4|$

$|-30|$

$\boxed{30}$