## TOPIC: INTRODUCTION TO RADICAL EXPRESSIONS

### Introduction to Square Roots

◆ The ____________ of squaring a number is taking the square root.

► Positive real numbers always have TWO roots: A ____________ ("principal") and a ____________ root.

| Square Roots | |
|---|---|
| $(\ \ )^2$ → 9 ← $(\ \ )^2$    $\sqrt{9}$ = ___   $\sqrt{9}$ = ___ | $-9$    $\sqrt{-9}$ = ____________ <br> Negative #s _________ be square rooted! |

**Radical Symbol**
- $\sqrt{\ }$ means positive root;
- $-\sqrt{\ }$ means negative root;
- $\pm\sqrt{\ }$ means means both

**Radicand**: Term inside the radical

**Warning!** $\sqrt{9} \neq \pm 3$

| MEMORY TOOL |
|---|
| Negatives _____*side* $\sqrt{\ }$ → __*kay* |
| Negatives _____*side* $\sqrt{\ }$ → __*maginary* |

EXAMPLE: Evaluate the radicals.

**(A)** $\sqrt{36}$

**(B)** $-\sqrt{36}$

**(C)** $\sqrt{-36}$

**PRACTICE** Evaluate the radical.

$$\sqrt{(-5)^2}$$

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**PRACTICE** Extract the following square roots.

(***A***) $\sqrt{144}$

(***B***) $-\sqrt{121}$

**PRACTICE** Determine if the following square roots evaluate to a real number.

(***A***) $-\sqrt{4}$

**[ REAL | NOT REAL ]**

(***B***) $\sqrt{64}$

**[ REAL | NOT REAL ]**

(***C***) $-\sqrt{-25}$

**[ REAL | NOT REAL ]**

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### Finding Higher Roots: Even Roots

◆ The reverse of raising a number to the $n$th power is taking the $n$th root; the **index** $n$ is written at top-left of radical.

**Even Roots ($n = 2, 4, 6, \ldots$)**

| **Square Roots ($n = 2$)** | | | *Index* | | |
|---|---|---|---|---|---|
| | $a^2 = b \leftrightarrow \sqrt{b} = a$ | | | $a^n = b \leftrightarrow \sqrt[n]{b} = a$ | |
| **Positive Root:** | $3^2 = 9$ | $\leftrightarrow \quad \sqrt{9} = 3$ | **Positive Root:** | $2^4 = 16$ | $\leftrightarrow \quad \sqrt[4]{\phantom{16}} =$ |
| **Negative Root:** | $(-3)^2 = 9$ | $\leftrightarrow \quad -\sqrt{9} = -3$ | **Negative Root:** | $(-2)^4 = 16$ | $\leftrightarrow \quad -\sqrt[4]{\phantom{16}} =$ |
| **Imaginary:** | $(?)^2 = -9$ | $\leftrightarrow \quad \sqrt{-9} =$ imaginary | **Imaginary:** | $(?)^4 = -16$ | $\leftrightarrow \quad \sqrt[4]{\phantom{16}} =$ |

**EXAMPLE** Evaluate each root.

**(A)** $\sqrt[4]{81} =$

**(B)** $-\sqrt[8]{256} =$

**PRACTICE** Simplify the root.

**(A)** $\sqrt[4]{256}$

**(B)** $-\sqrt[4]{10{,}000}$

**(C)** $\sqrt[4]{-625}$

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### Finding Higher Roots: Odd Roots

◆ Unlike even roots, odd $n$th roots can have a negative radicand.

$$a^n = b \leftrightarrow \sqrt[n]{b} = a$$

| Recall — Even Index ($n = 2, 4, 6, \ldots$) | New — Odd Index ($n = 3, 5, 7, \ldots$) |
|---|---|
| $2^4 = 16 \leftrightarrow \sqrt[4]{16} = 2$ | $2^3 = 8 \leftrightarrow \sqrt[3]{\phantom{00}} =$ |
| $(-2)^4 = 16 \leftrightarrow -\sqrt[4]{16} = -2$ | $(-2)^3 = -8 \leftrightarrow \sqrt[3]{\phantom{00}} =$ |
| $(?)^4 = -16 \leftrightarrow \sqrt[4]{-16} =$ imaginary | |
| **[ 2 \| 1 ]** root(s): 1 positive & 1 negative | **[ 2 \| 1 ]** root(s): always _____ sign as radicand |
| Negative radicand → **[ IMAGINARY \| NEGATIVE]** | Negative radicand → **[ IMAGINARY \| NEGATIVE]** |

**EXAMPLE** Evaluate the following.

**(A)** $\sqrt[3]{27} =$

**(B)** $\sqrt[5]{-32} =$

**PRACTICE** Simplify the root.

**(A)** $\sqrt[5]{243}$

**(B)** $\sqrt[3]{-125}$

**(C)** $-\sqrt[5]{1024}$

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### Approximating Roots Using a TI-84

◆ The square root of #s that aren't perfect squares are **irrational numbers** that we can approx. using a calculator.

► For square roots, press 2nd $x^2$ ($\sqrt{\phantom{x}}$). For $n$th roots, press MATH 5 ($\sqrt[x]{\phantom{x}}$)

**EXAMPLE** Approximate each radical to three decimal places.

**(A)** $\sqrt{90}$

**(B)** $\sqrt[3]{45}$

**(C)** $\sqrt[4]{12}$

**PRACTICE** Estimate the square root between two consecutive whole numbers.

$\sqrt{138}$

**PRACTICE** Use a calculator to evaluate the following and round to the nearest hundredths.

**(A)** $\sqrt[5]{75}$

**(B)** $-\sqrt[8]{\frac{45}{29}}$

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### Simplifying $n$th Root of $n$th Power

◆ Taking the $n$th root of something raised to the $n$th power ($\sqrt[n]{a^n}$ ) "cancels" the exponent.

**New** — **$n^{th}$ Root of $n^{th}$ Powers**

If $n$ is **odd**: $\sqrt[n]{a^n} =$ _____

If $n$ is **even**: $\sqrt[n]{a^n} =$ _____

$\sqrt[3]{(-24)^3} =$

$\sqrt{(-24)^2} =$

**EXAMPLE** Simplify.

**(A)** $\sqrt[5]{(9)^5} =$

**(B)** $\sqrt[8]{(x-2)^8} =$

**(C)** $\sqrt{16x^4} =$

◆ Sometimes, the radicand may need to be rewritten if it doesn't have the same power as the root.

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**PRACTICE** Simplify the following.

**(A)** $\sqrt[3]{(-5)^3}$

**(B)** $\sqrt[4]{(-x)^4}$

**(C)** $\sqrt[4]{x^4y^8}$

**PRACTICE** Simplify the following.

**(A)** $\sqrt[4]{(2-a)^4}$

**(B)** $\sqrt[7]{(-x-1)^7}$

**(C)** $-\sqrt[8]{(x+1)^8}$