



# FACTOR LABEL METHOD

## Unit Analysis

Converting from one unit to another

# A UNIT CONVERSION PROBLEM

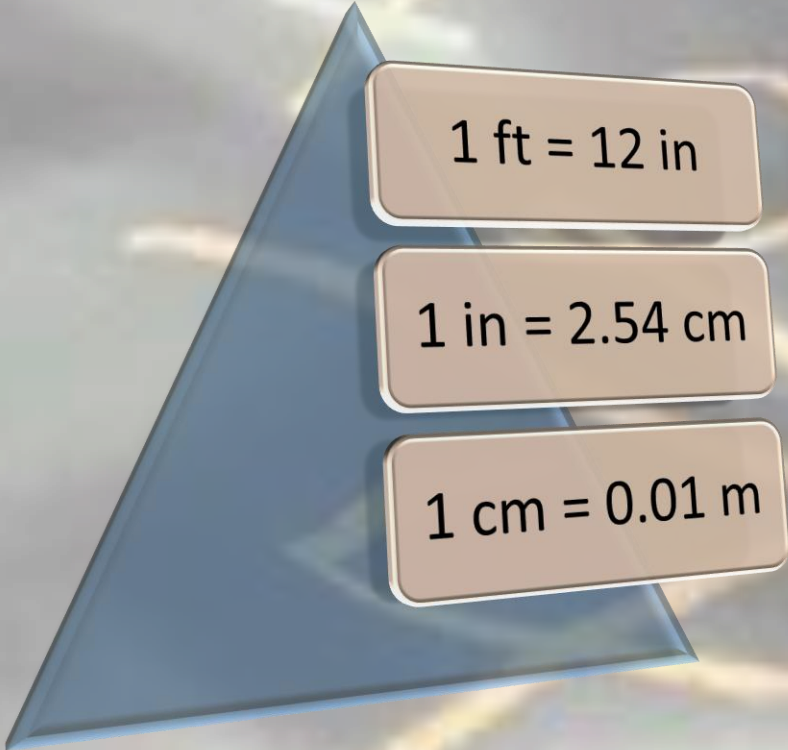
- Mount Everest, is the tallest mountain on earth. It is 8,848 meters high.
- How many feet high is Mount Everest?



# DEFINITIONS

Use relationships or *definitions* that you are given to figure out unit conversion problems.

We need the following definitions:

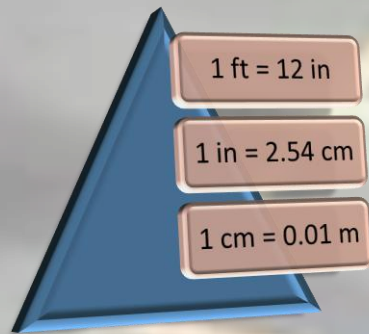

$$1 \text{ ft} = 12 \text{ in}$$

$$1 \text{ in} = 2.54 \text{ cm}$$

$$1 \text{ cm} = 0.01 \text{ m}$$

# CHOOSING DEFINITIONS TO USE

- We started with meters. (Everest is 8,848 m tall)
- We have three definitions:



- Only the last definition relates to meters
  - First we will use the last definition to convert meters to centimeters
  - Then we will use the middle definition to convert centimeters to inches
  - Finally we will use the first definition to convert inches to feet

# FACTORS

Factors are fractions formed from the two values in the definition

- If  $1 \text{ ft} = 12 \text{ in}$ , then  $\frac{1 \text{ ft}}{12 \text{ in}} = 1$  and  $\frac{12 \text{ in}}{1 \text{ ft}} = 1$ .
- If  $1 \text{ in} = 2.54 \text{ cm}$ , then  $\frac{1 \text{ in}}{2.54 \text{ cm}} = 1$  and  $\frac{2.54 \text{ cm}}{1 \text{ in}} = 1$ .
- If  $1 \text{ cm} = 0.01 \text{ m}$ , then  $\frac{1 \text{ cm}}{0.01 \text{ m}} = 1$  and  $\frac{0.01 \text{ m}}{1 \text{ cm}} = 1$ .

**NOTICE THAT THE FACTORS ALWAYS = 1**

# CONVERTING WITH FACTORS

Multiplying a number by a factor does not change its value, but it does change its units.

Remember, all factors = 1

$$\frac{1 \text{ cm}}{0.01 \text{ m}} \text{ and } \frac{0.01 \text{ m}}{1 \text{ cm}} \text{ are factors}$$

- $8,848 \text{ m} \times 1 = 8,848 \text{ m}$   
(multiplying by 1 doesn't change the value)
- $8,848 \text{ m} \times \frac{1 \text{ cm}}{0.01 \text{ m}} = 8,848 \text{ m}$ ,  
because multiplying by 1 doesn't change the value  
*and so*
- Multiplying by the right factor causes units to cancel
- $(8,848 \cancel{\text{ m}}) \left( \frac{1 \cancel{\text{ cm}}}{0.01 \cancel{\text{ m}}} \right) = 884,800 \text{ cm}$   
 $= 8,848 \text{ m}$

# SELECTING FACTORS

Choosing the right *factor* makes all the difference.

- $\frac{1 \text{ cm}}{0.01 \text{ m}}$  and  $\frac{0.01 \text{ m}}{1 \text{ cm}}$  are both *factors*.
- $(8,848 \text{ m})\left(\frac{1 \text{ cm}}{0.01 \text{ m}}\right)$  and  $(8,848 \text{ m})\left(\frac{0.01 \text{ m}}{1 \text{ cm}}\right)$  both = 8,848 m, but . . .
  - With  $(8,848 \text{ m})\left(\frac{0.01 \text{ m}}{1 \text{ cm}}\right)$ , the units don't cancel
  - With  $(8,848 \cancel{\text{ m}})\left(\frac{1 \text{ cm}}{0.01 \cancel{\text{ m}}}\right)$ , the units or *labels* cancel or *factor* out

# MULTIPLE UNIT CONVERSIONS

- To convert 8,848 m to feet, start with a factor that converts meters to centimeters
  - $(8,848 \text{ m}) \left( \frac{1 \text{ cm}}{0.01 \text{ m}} \right) = 884,800 \text{ cm} = 8,848 \text{ m}$
- After converting to centimeters, use a factor that converts centimeters to inches
  - $(884,800 \text{ cm}) \left( \frac{1 \text{ in}}{2.54 \text{ cm}} \right) = 348,346 \text{ in} = 8,848 \text{ m}$
- Finally, after converting to inches, use a factor that converts inches to feet
  - $(348,346 \text{ in}) \left( \frac{1 \text{ ft}}{12 \text{ in}} \right) = 29,029 \text{ ft} = 8,848 \text{ m}$



# SUMMARIZING THE PROBLEM

- The Problem: How many feet are in 8,848 m?
- **Step 1**: Write the definitions
- **Step 2**: Create factors by making fractions from the definitions
- **Step 3**: Multiply the starting value by the correct factors to make the units cancel

$$\circ (8,848 \text{ m}) \left( \frac{1 \text{ cm}}{0.01 \text{ m}} \right) \left( \frac{1 \text{ in}}{2.54 \text{ cm}} \right) \left( \frac{1 \text{ ft}}{12 \text{ in}} \right) = \mathbf{29,029 \text{ ft}}$$

**PROBLEM SOLVED!**

# CONVERTING AMONG METRIC UNITS

*Table C* of the *Reference Tables* has the definitions needed to convert among metric units

Kilo (k)	= 1,000	= $10^3$
Deci (d)	= 0.1	= $10^{-1}$
Centi (c)	= 0.01	= $10^{-2}$
Milli (m)	= 0.001	= $10^{-3}$
micro ( $\mu$ )	= 0.000001	= $10^{-6}$
nano (n)	= 0.000000001	= $10^{-9}$
pico (p)	= 0.000000000001	= $10^{-12}$

# A METRIC PROBLEM

How many millimeters are in 351 nanometers?

- **Step 1**: Write the needed definitions

- $1 \text{ mm} = 0.001 \text{ m}$        $1 \text{ nm} = 0.000000001 \text{ m}$

- **Step 2**: Create the factors

- $\frac{1 \text{ mm}}{0.001 \text{ m}} = 1$        $\frac{0.001 \text{ m}}{1 \text{ mm}} = 1$        $\frac{1 \text{ nm}}{0.000000001 \text{ m}} = 1$        $\frac{0.000000001 \text{ m}}{1 \text{ nm}} = 1$

- **Step 3**: Select and multiply by the right factors

- $(351 \text{ nm}) \left( \frac{0.000000001 \text{ m}}{1 \text{ nm}} \right) \left( \frac{1 \text{ mm}}{0.001 \text{ m}} \right) = \mathbf{0.000351 \text{ mm}}$

**PROBLEM SOLVED AGAIN!**