

Oregon Operators Conference

Operator Math Workshop

Module I

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JACOBS[®]

Units of Measure

- A different approach but one that will make your life with math easier
- Engineers versus operators
- I'm not trying to make engineers out of you (nor would you want me too)
- Let the units tell you what to do

Percents, Decimals, and Fractions

Percent is simply:

$$\frac{\text{Part}}{\text{Whole}} \times 100$$

Decimal is simply:

$$\frac{\text{Part}}{\text{Whole}}$$

**Divide Whole
into Part**

Fraction is simply:

$$\frac{\text{Part}}{\text{Whole}}$$

**Fill in the
Numbers and
Round**

Percent Example

Jose Altuve on the Astros road trip was 3 for 12. What percentage of plate appearances did he get a hit?

Percent is simply: $\frac{\text{Part}}{\text{Whole}} \times 100$

So... $\frac{3}{12} (x 100) = 25\%$

Decimal Fraction Example

Jose Altuve on the Astros road trip was 3 for 12.

What is his batting average (decimal)?

Decimal is simply: $\frac{\text{Part}}{\text{Whole}}$ **Divide Whole
into Part**

So.... $\frac{3}{12} = 0.25$

Fraction Example

Jose Altuve on the Astros road trip was 3 for 12.

How do we write this as a fraction?

Fraction is simply:

$$\frac{\text{Part}}{\text{Whole}}$$

Fill in the
Numbers and
Round

So....

$$\frac{3}{12} = \frac{1}{4}$$

Percent Continued

Example:

12 is what percent of 30?

Remember this?

Percent is simply: $\frac{\text{Part}}{\text{Whole}} \times 100$

$$\frac{12}{30} = 0.40$$

$$\mathbf{0.40 \times 100 = 40\%}$$

Percent Continued

Example:

What is 35% of 60?

First, convert 35% to a decimal value.

$$\frac{35}{100} = 0.35 \quad \text{or} \quad 35.0 = 0.35$$

←
Move the decimal two
places to the left

$$0.35 \times 60 = 21$$

Percent to Fraction Conversion

- First drop the percent sign
- Place that number in the numerator
- Place 100 in denominator
- Reduce the fraction

Fraction Simple Math

- First step is to reduce fractions to most simple form
- Denominators must be the same when adding and subtracting fractions
- Use 2, 3, 5 method to reduce fractions

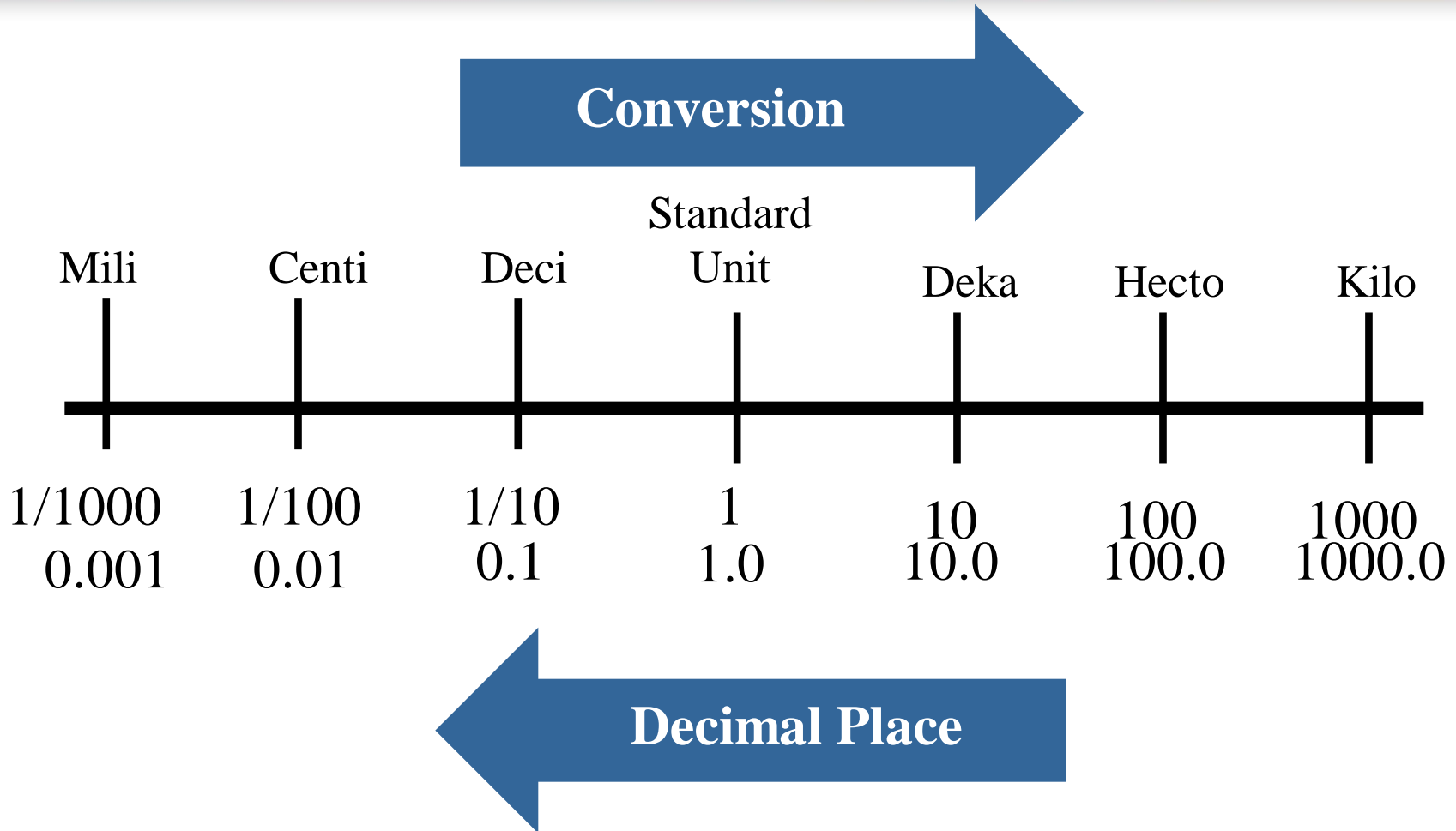
Fraction Reduction: 2, 3, 5 Method

- If the digit is even it's divisible by 2.
- If the sum of the digits is divisible by three....the number is divisible by three
- If the last digit is 0 or 5 the number is divisible by 5

Conversion Math

Metric

Metric Conversion



.....And Vice Versa

Metric Conversion.....Smaller

Conversion



Unit	Value
Nano	$1/1,000,000,000$ 0.00000001
Micro	$1/1,000,000$ 0.000001
Mili	$1/1,000$ 0.001

Nano

Micro

Mili

$1/1,000,000,000$
0.00000001

$1/1,000,000$
0.000001

$1/1,000$
0.001

Decimal Place

.....And Vice Versa

Something to Think About

$$\frac{3.785 \text{ Liters}}{\text{Gallon}}$$

$$\text{mL} = \text{cm}^3 = \text{g}$$

1 Gallon =

- 3,785 mL
- 3,785 cm³
- 3,785 g

Something Else to Think About

1 Gallon = 8.34 lbs

1 Gallon = 3,785 mL

mL = g

So....

How many kilograms
in a pound?

Fraction Math

Proportions

Three Steps to Proportions

- Group like terms
- Place smaller units in numerator
- Solve for X

Example 1. Proportions

2.0 lbs of chlorine are dissolved in 50 gallons of water. To maintain the same concentration how many pounds should be dissolved in 125 gallons of water?

Group like terms: $\frac{\text{lbs}}{\text{lbs}} = \frac{\text{Gallons}}{\text{Gallons}}$

Place smaller number in numerator: $\frac{2}{x} = \frac{50}{125}$

Solve for X: $50 X = 250 \quad X = 5 \text{ lbs}$

Example 2. Proportions

It takes 3 men 60 hours to complete a job. At the same rate how many hours would it take 5 men to complete the same job?

Group like terms: $\frac{\text{Men}}{\text{Men}} = \frac{\text{Hours}}{\text{Hours}}$

Place smaller number in numerator: $\frac{3}{5} = \frac{x}{60}$

Solve for X: $5 X = 180$ $X = 36$ hours

Conversion Math

Most all of water and wastewater math is about converting from one set of units to another.

Conversions to Remember

The “Big Five”

- 8.34 lbs. / gallon
- 7.48 gallons / Ft³ (cubic foot)
- PSI (pounds per in.²) = 2.31 ft.
- 1% = 10,000 mg/L
- 3,785 mL / gallon

Conversion Math

From	To	Multiply by
Meters	Millimeters	1,000
Foot ²	Inch ²	144
Lbs. of Water	Gallons	0.1198
MGD	Ft ³ /sec	1.547
Ft ³ /sec	GPM	448.8
GPM	Ft ³ /sec	2.228×10^{-3}

Conversions to Remember

- 8.34 lbs. / gallon
- 7.48 gallons / Ft³ (cubic foot)
- PSI (pounds per in.²) = 2.31 ft.
- 1% = 10,000 mg/L
- 3,785 mL / gallon

Conversion Math: Temperature

Celsius and Fahrenheit

$$^{\circ}\text{C to } ^{\circ}\text{F} = (^{\circ}\text{C} \times 1.8) + 32$$

$$^{\circ}\text{F to } ^{\circ}\text{C} = \frac{(^{\circ}\text{F} - 32)}{1.8}$$

Ratios

$$\text{PSI} = \frac{\text{lbs.}}{\text{Inch}^2} \rightarrow = \text{"Per"}$$

$$\frac{7.48 \text{ gallons}}{\text{Ft}^3 \text{ (cubic foot)}}$$

$$\frac{8.34 \text{ lbs.}}{\text{Gallon}}$$

Three Steps to Conversions

Remember manipulate your ratio to cancel the units! i.e.

$$\frac{7.48 \text{ gallons}}{1 \text{ Cubic ft. (Ft}^3\text{)}} = \frac{1 \text{ Cubic ft. (Ft}^3\text{)}}{7.48 \text{ gallons}}$$

Three Steps to Conversions

- Locate the given
- Locate the ratio (the “per”)
- Determine units in final answer

Box Method Example 1

Determine how many seconds are in a day.

Three Steps to Conversions

- Locate the given
- Locate the ratio (the “per”)
- Determine units in final answer

Conversion Example 1



d

Conversion Example 1

d

24 hr

d

Conversion Example 1

~~d~~

24 hr

~~d~~

Conversion Example 1

~~d~~

24 hr

60 min

~~d~~

hr

Conversion Example 1

~~d~~

24 ~~hr~~

60 min

~~d~~

~~hr~~

Conversion Example 1

~~d~~

24 ~~hr~~

60 min

60 s

~~d~~

~~hr~~

min

Conversion Example 1

$$\begin{array}{c|c|c|c} \cancel{\text{d}} & 24 \cancel{\text{hr}} & 60 \cancel{\text{min}} & 60 \text{ s} \\ \hline \cancel{\text{d}} & \cancel{\text{hr}} & \cancel{\text{min}} & \text{s} \end{array}$$

| = Multiply — = Divide

Conversion Example 1

86,400 s

Conversion Example 1

Therefore the conversion factor is:

$$86,400 \text{ s/d}$$

OR

The ratio is: $\frac{86,400 \text{ sec}}{\text{day}}$

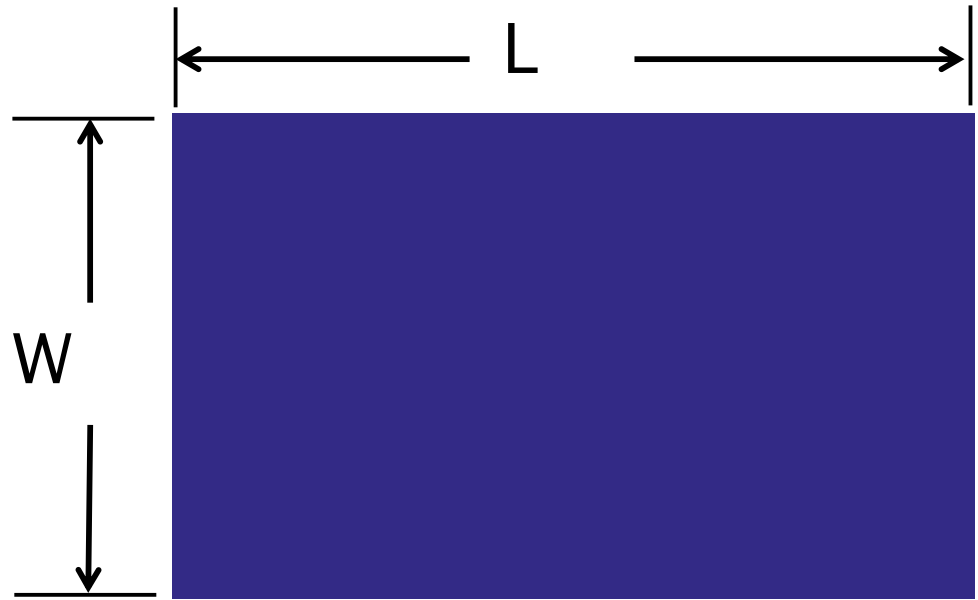
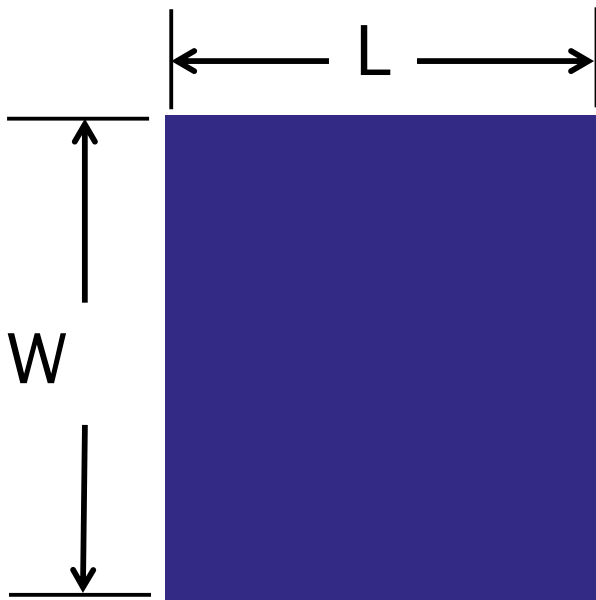
Dimensional Analysis

Area

- The amount of space within the boundaries of a flat, two-dimensional object
- Units will be squared (ft^2 , in^2 , yd^2 , m^2)
- Area shapes: Square, Rectangle, Triangle, Circle

Area: Square/Rectangle

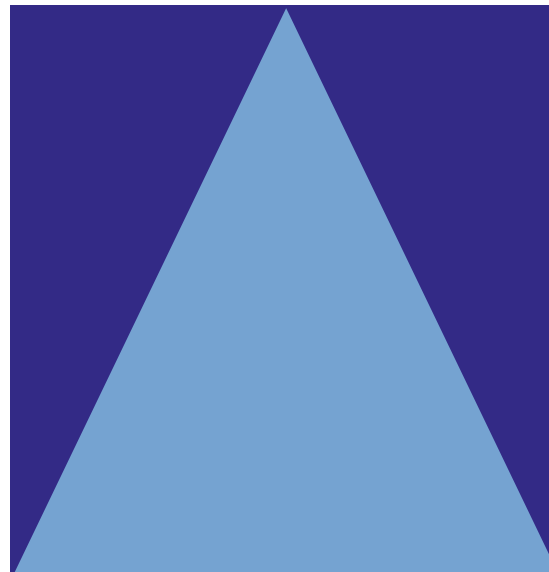
A Square is: Length x Width



Area: Triangle

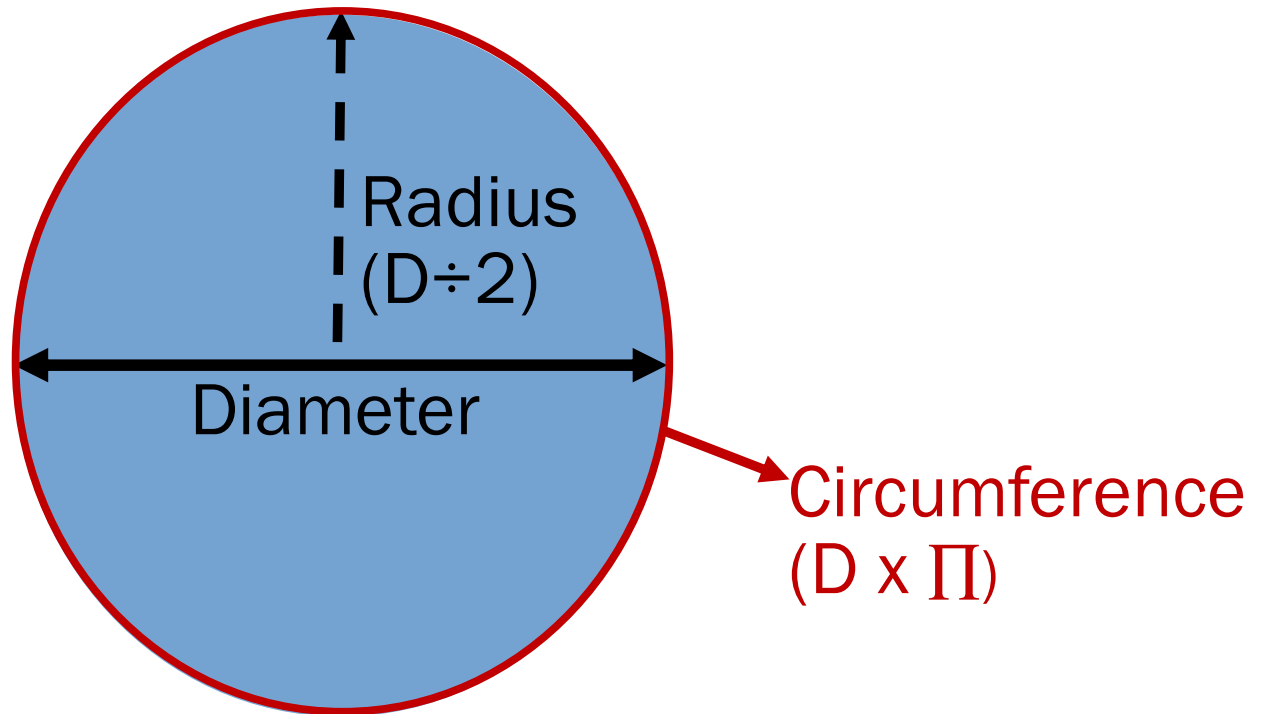
A Triangle is: $\frac{\text{Base} \times \text{Height}}{2}$

OR Half the area of a square with the same dimensions



Dimensional Analysis: Circle

Circle Terms:



Area: Circle

Area of a Circle is: Πr^2

OR

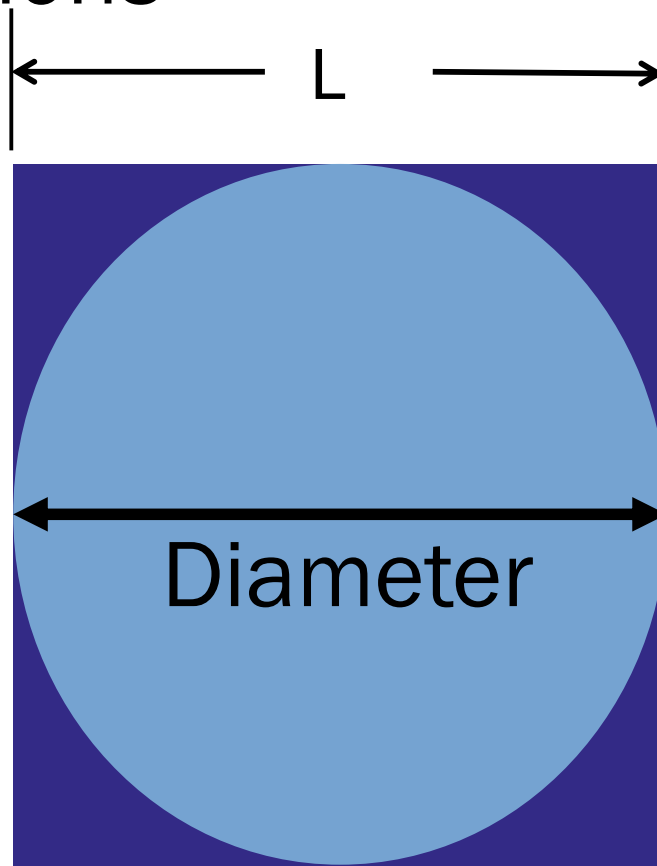
$$D^2 \times 0.785$$

OR

$$D^2 \times \frac{\Pi}{4}$$

Area: Circle

78.5% the area of a square of the same dimensions

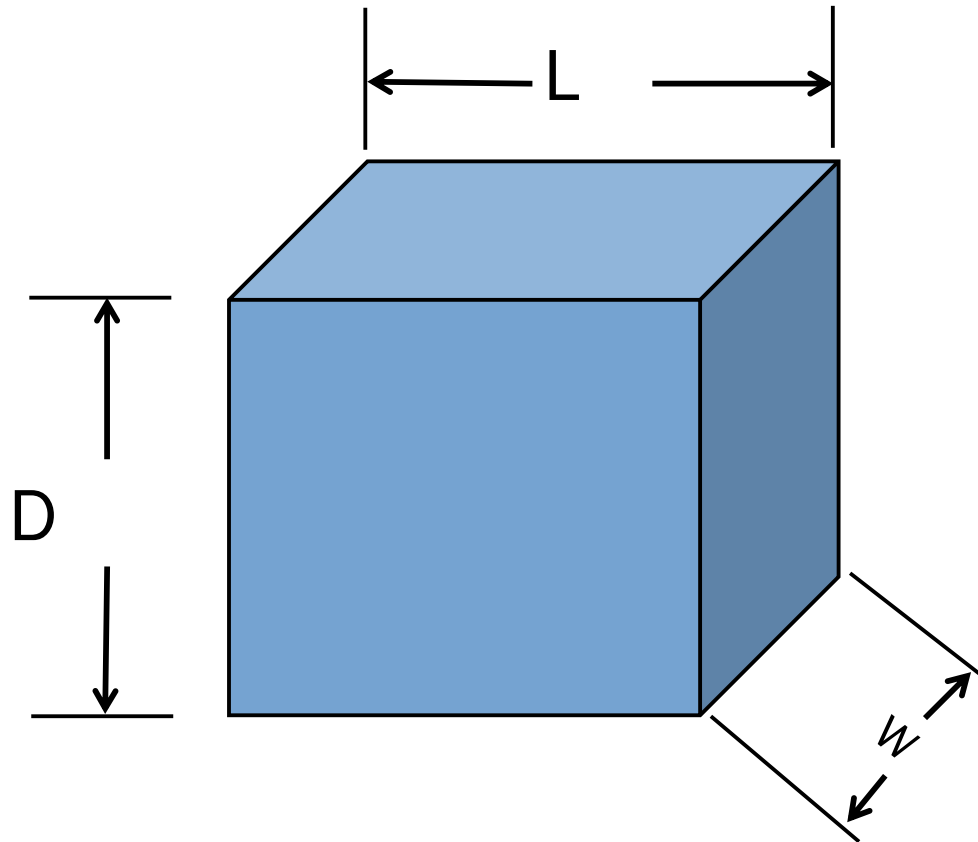


Volume

- The amount of three-dimensional space an object occupies.
- Some Units will be cubed (ft^3 , yd^3 , cm^3 , m^3)
- Some Won't! (Gallons, Liters, Quarts, Ounces)
- Volume shapes: Cylinder, Cube, Sphere, Cone

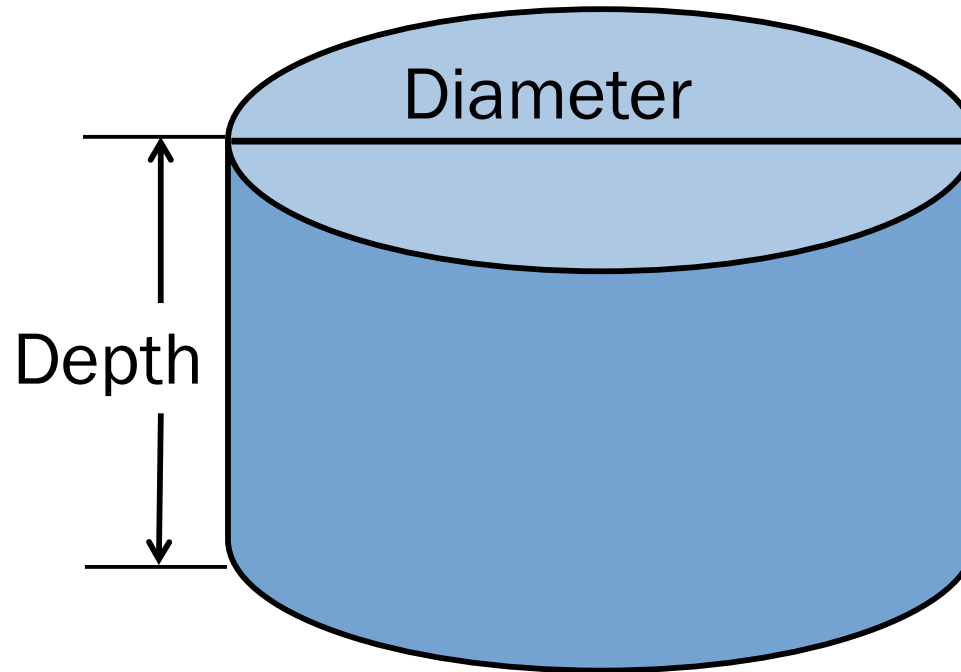
Volume: Cube

The volume of a cube is Length x Width x Depth



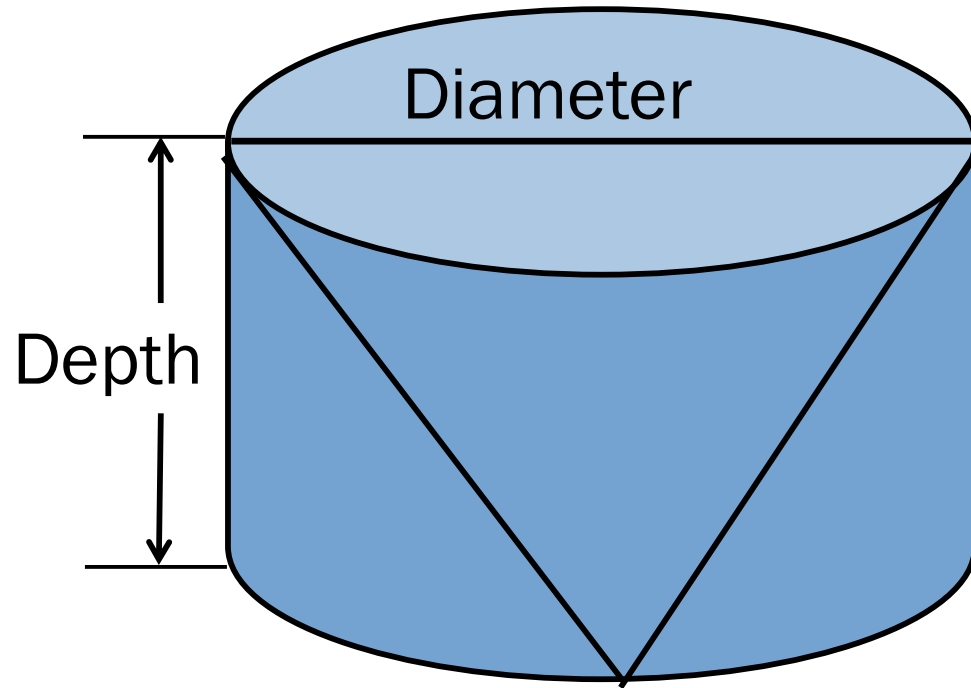
Volume: Cylinder

The area of a circle x the third dimension
or $D^2 \times 0.785 \times \text{Depth}$



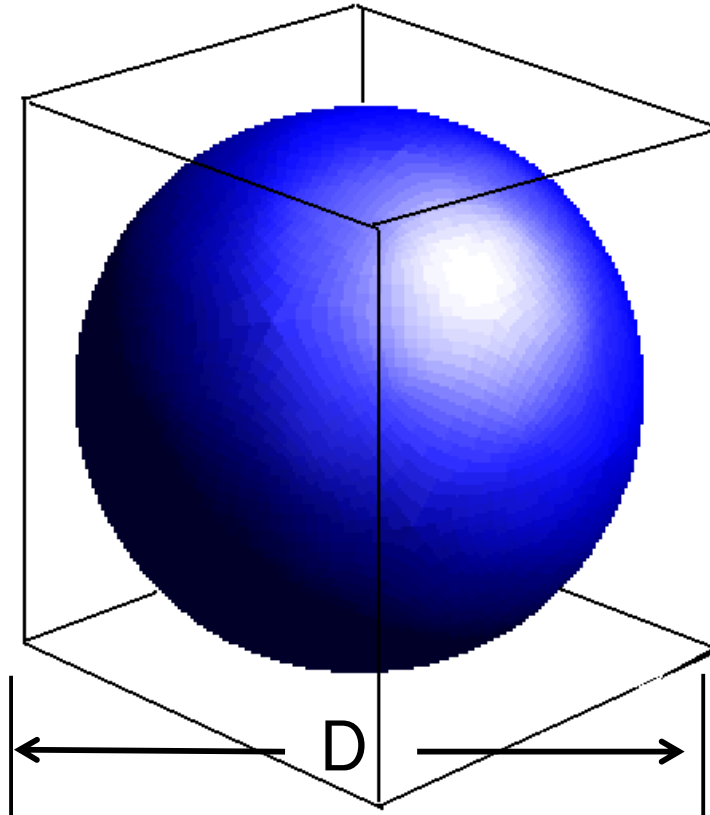
Volume: Cone

1/3 the volume of a cylinder with the same dimensions



Volume: Sphere

3/4 the volume of a cube with the same dimensions



Rectangular Tank Example Problem

An aeration basin is 58 feet long and has a width of 18 feet.

What is the surface area of the tank? What is the volume in Ft³ if the depth is 20 feet? Gallons?

$$\text{Area} = 58 \text{ Ft.} \times 18 \text{ Ft.} = 1,044 \text{ Ft}^2$$

$$\text{Volume} = 58 \text{ Ft.} \times 18 \text{ Ft.} \times 20 \text{ Ft.} = 20,880 \text{ Ft}^3$$

20,880 Ft³	7.48 Gal.
	Ft³

$$20,880 \times 7.48 = 156,182 \text{ Gallons}$$

Circular Tank Example Problem

A clarifier has a diameter of 90 feet. What is the surface area of the tank? What is the volume in Ft³ if the depth is 17 feet? Gallons?

$$\text{Area} = (90 \text{ Ft.})^2 \times 0.785 = 6,359 \text{ Ft}^2$$

$$\text{Volume} = 6,359 \text{ Ft}^2 \times 17 \text{ Ft} = 108,103 \text{ Ft}^3$$

108,103 Ft³	7.48 Gal.	108,103 x 7.48 = 808,610 Gallons
	Ft³	

Cylinder (Pipe) Example Problem

A pipe has a diameter of 18 inches. What is the surface area of the pipe? What is the volume in Ft³ if the pipe is 200 feet in length? Gallons?

18 in.	1 Foot
	12 in.

$$\frac{18}{12} = 1.5 \text{ Feet}$$

$$\text{Area} = (1.5 \text{ Ft.})^2 \times 0.785 = 1.8 \text{ Ft}^2$$

$$\text{Volume} = 1.8 \text{ Ft}^2 \times 200 \text{ Ft} = 360 \text{ Ft}^3$$

Cylinder (Pipe) Example Problem Continued

A pipe has a diameter of 18 inches. What is the surface area of the pipe? What is the volume in Ft³ if the pipe is 200 feet in length? Gallons?

360 Ft³	7.48 Gal.
	Ft³

$$360 \times 7.48 = 2,693 \text{ Gallons}$$

Certification Problem: Percent Removal

The plant you're operating has a permit requirement to have 85% BOD removal. Your latest lab data is as follows:

Influent BOD = 268 mg/L

Effluent BOD = 8 mg/L

How did you do?

Certification Problem: Percent Removal

Remember:

$$\frac{\text{Part}}{\text{Whole}} = \text{Divide Whole into Part}$$
$$\frac{(268 - 8)}{268} = 0.97 \times 100$$

97%

Certification Problem: Metric Conversion

The lab results for mercury have just come in and the result is 210 micrograms/liter ($\mu\text{g/L}$) and your DMR needs the result in milligrams/liter (mg/L). What should your number look like?

Certification Problem: Metric Conversion

$$\frac{210 \cancel{\mu\text{g}}}{1,000 \cancel{\mu\text{g}}} \left| \begin{array}{l} 1 \text{ mg} \\ \hline \end{array} \right.$$

$$\frac{210}{1,000} = 0.21 \text{ mg}$$

Certification Problem: Ratios

How much does the water weigh (in pounds) in a full ten gallon bucket?

$$\frac{1 \text{ gallon}}{8.34 \text{ lbs.}} = \frac{8.34 \text{ lbs.}}{1 \text{ gallon}}$$

10 gal.	8.34 lbs.
	1 gal.

$$10 \times 8.34 = 83.4 \text{ Pounds}$$

Certification Problem: Area and Volume

A clarifier has a diameter of 60 feet. What is the surface area of the tank? What is the volume in Ft³ if the depth is 15 feet? Gallons?

$$\text{Area} = (60 \text{ Ft.})^2 \times 0.785 = 2,826 \text{ Ft}^2$$

$$\text{Volume} = 2,826 \text{ Ft}^2 \times 15 \text{ Ft} = 42,390 \text{ Ft}^3$$

42,390 Ft³	7.48 Gal.	42,390 x 7.48 = 317,077 Gallons
	Ft³	