Alkalinity, mg/L as $CaCO_3$ = $\frac{\text{(Titrant Volume, mL)(Acid Normality)(50,000)}}{\text{Sample Volume, mL}}$

Amps = $\frac{\text{Volts}}{\text{Ohms}}$

Area of Circle* = (0.785)(Diameter^2)

Area of Circle = (3.14)(Radius^2)

Area of Cone (lateral area) = (3.14)(Radius)$\sqrt{\text{Radius}^2 + \text{Height}^2}$

Area of Cone (total surface area) = (3.14)(Radius)(Radius + $\sqrt{\text{Radius}^2 + \text{Height}^2}$)

Area of Cylinder (total exterior surface area) = [End #1 SA] + [End #2 SA] + [(3.14)(Diameter)(Height or Depth)]
Where SA = surface area

Area of Rectangle* = (Length)(Width)

Area of Right Triangle* = $\frac{\text{(Base)(Height)}}{2}$

Average (arithmetic mean) = $\frac{\text{Sum of All Terms}}{\text{Number of Terms}}$

Average (geometric mean) = $[(X_1)(X_2)(X_3)(X_4)(X_n)]^{1/n}$ ***The nth root of the product of n numbers***

Biochemical Oxygen Demand (seeded), mg/L =

$$\frac{\text{[(Initial DO, mg/L) - (Final DO, mg/L) - (Seed Correction, mg/L)] [300 mL]}}{\text{Sample Volume, mL}}$$

Biochemical Oxygen Demand (unseeded), mg/L =

$$\frac{\text{[(Initial DO, mg/L) - (Final DO, mg/L)][300 mL]}}{\text{Sample Volume, mL}}$$

Blending or Three Normal Equation = $(C_1 \times V_1) + (C_2 \times V_2) = (C_3 \times V_3)$ ***Where $V_1 + V_2 = V_3$; C = concentration, V = volume or flow; Concentration units must match; Volume units must match***

 # CFU/100mL = $\frac{\text{[(\# of Colonies on Plate)(100)]}}{\text{Sample Volume, mL}}$

*Pie Wheel Format for this equation is available at the end of this document

Chemical Feed Pump Setting, % Stroke = $\frac{\text{Desired Flow}}{\text{Maximum Flow}} \times 100\%$

Chemical Feed Pump Setting, mL/min =

$$\frac{(\text{Flow, MGD})(\text{Dose, mg/L})(3.785 \text{ L/gal})(1{,}000{,}000 \text{ gal/MG})}{(\text{Feed Chemical Density, mg/mL})(\text{Active Chemical, \% expressed as a decimal})(1{,}440 \text{ min/day})}$$

Chemical Feed Pump Setting, mL/min =

$$\frac{(\text{Flow, m}^3\text{/day})(\text{Dose, mg/L})}{(\text{Feed Chemical Density, g/cm}^3)(\text{Active Chemical, \% expressed as a decimal})(1{,}440 \text{ min/day})}$$

Circumference of Circle = (3.14)(Diameter)

Composite Sample Single Portion = $\frac{(\text{Instantaneous Flow})(\text{Total Sample Volume})}{(\text{Number of Portions})(\text{Average Flow})}$

Cycle Time, min = $\frac{\text{Storage Volume, gal}}{(\text{Pump Capacity, gpm}) - (\text{Wet Well Inflow, gpm})}$

Cycle Time, min = $\frac{\text{Storage Volume, m}^3}{(\text{Pump Capacity, m}^3\text{/min}) - (\text{Wet Well Inflow, m}^3\text{/min})}$

Degrees Celsius = $\frac{(°\text{F} - 32)}{1.8}$

Degrees Fahrenheit = (ºC)(1.8) + 32

Detention Time = $\frac{\text{Volume}}{\text{Flow}}$ ***Units must be compatible***

Dilution or Two Normal Equation = $(C_1 \times V_1) = (C_2 \times V_2)$ ***Where C = Concentration, V = volume or flow; Concentration units must match; Volume units must match***

Electromotive Force, volts* = (Current, amps)(Resistance, ohms)

Feed Rate, lb/day* = $\frac{(\text{Dosage, mg/L})(\text{Flow, MGD})(8.34 \text{ lb/gal})}{\text{Purity, \% expressed as a decimal}}$

Feed Rate, kg/day* = $\frac{(\text{Dosage, mg/L})(\text{Flow Rate, m}^3\text{/day})}{(\text{Purity, \% expressed as a decimal})(1{,}000)}$

Filter Backwash Rate, gpm/ft² = $\frac{\text{Flow, gpm}}{\text{Filter Area, ft}^2}$

Filter Backwash Rate, L/sec/m² = $\frac{\text{Flow, L/sec}}{\text{Filter Area, m}^2}$

*Pie Wheel Format for this equation is available at the end of this document

Filter Backwash Rise Rate, in/min = $\frac{\text{(Backwash Rate, gpm/ft}^2\text{)(12 in/ft)}}{7.48 \text{ gal/ft}^3}$

Filter Backwash Rise Rate, cm/min = $\frac{\text{Water Rise, cm}}{\text{Time, min}}$

Filter Yield, lb/hr/ft² = $\frac{\text{(Solids Loading, lb/day)(Recovery, \% expressed as a decimal)}}{\text{(Filter Operation, hr/day)(Area, ft}^2\text{)}}$

Filter Yield, kg/hr/m² =

$$\frac{\text{(Solids Concentration, \% expressed as a decimal)(Sludge Feed Rate, L/hr)(10)}}{\text{(Surface Area of Filter, m}^2\text{)}}$$

Flow Rate, ft³/sec* = (Area, ft^2)(Velocity, ft/sec)

Flow Rate, m³/sec* = (Area, m^2)(Velocity, m/sec)

Food/Microorganism Ratio = $\frac{BOD_5\text{, lb/day}}{\text{MLVSS, lb}}$

Food/Microorganism Ratio = $\frac{BOD_5\text{, kg/day}}{\text{MLVSS, kg}}$

Force, lb* = (Pressure, psi)(Area, in^2)

Force, newtons* = (Pressure, pascals)(Area, m^2)

Hardness, as mg $CaCO_3$/L = $\frac{\text{(Titrant Volume, mL)(1,000)}}{\text{Sample Volume, mL}}$ ***Only when the titration factor is 1.00 of EDTA***

Horsepower, Brake, hp = $\frac{\text{(Flow, gpm)(Head, ft)}}{\text{(3,960)(Pump Efficiency, \% expressed as a decimal)}}$

Horsepower, Brake, kW = $\frac{\text{(9.8)(Flow, m}^3\text{/sec)(Head, m)}}{\text{(Pump Efficiency, \% expressed as a decimal)}}$

Horsepower, Motor, hp =

$$\frac{\text{(Flow, gpm)(Head, ft)}}{\text{(3,960)(Pump Efficiency, \% expressed as a decimal)(Motor Efficiency, \% expressed as a decimal)}}$$

Horsepower, Motor, kW =

$$\frac{\text{(9.8)(Flow, m}^3\text{/sec)(Head, m)}}{\text{(Pump Efficiency, \% expressed as a decimal)(Motor Efficiency, \% expressed as a decimal)}}$$

*Pie Wheel Format for this equation is available at the end of this document

Horsepower, Water, hp = $\frac{\text{(Flow, gpm)(Head, ft)}}{3{,}960}$

Horsepower, Water, kW = (9.8)(Flow, m^3/sec)(Head, m)

Hydraulic Loading Rate, gpd/ft² = $\frac{\text{Total Flow Applied,gpd}}{\text{Area, ft}^2}$

Hydraulic Loading Rate, m³/day/m² = $\frac{\text{Total Flow Applied, m}^3\text{/day}}{\text{Area, m}^2}$

Loading Rate, lb/day* = (Flow, MGD)(Concentration, mg/L)(8.34 lb/gal)

Loading Rate, kg/day* = $\frac{\text{(Flow, m}^3\text{/day)(Concentration, mg/L)}}{1{,}000}$

Mass, lb* = (Volume, MG)(Concentration, mg/L)(8.34 lb/gal)

Mass, kg* = $\frac{\text{(Volume, m}^3\text{)(Concentration, mg/L)}}{1{,}000}$

Mean Cell Residence Time or **Solids Retention Time, days** =

$$\frac{\text{(Aeration Tank TSS, lb) + (Clarifier TSS, lb)}}{\text{(TSS Wasted, lb/day)+(Effluent TSS, lb/day)}}$$

Mean Cell Residence Time or **Solids Retention Time, days** =

$$\frac{\text{(Aeration Tank TSS, kg) + (Clarifier TSS, kg)}}{\text{(TSS Wasted, kg/day) + (Effluent TSS, kg/day)}}$$

Milliequivalent = (mL)(Normality)

Molarity = $\frac{\text{Moles of Solute}}{\text{Liters of Solution}}$

Motor Efficiency, % = $\frac{\text{Brake hp}}{\text{Motor hp}} \times 100\%$

Normality = $\frac{\text{Number of Equivalent Weights of Solute}}{\text{Liters of Solution}}$

Number of Equivalent Weights = $\frac{\text{Total Weight}}{\text{Equivalent Weight}}$

Number of Moles = $\frac{\text{Total Weight}}{\text{Molecular Weight}}$

*Pie Wheel Format for this equation
is available at the end of this document

Organic Loading Rate-RBC, lb $SBOD_5$/day/1,000 ft^2 = $\frac{\text{Organic Load, lb } SBOD_5\text{/day}}{\text{Surface Area of Media, 1,000 } ft^2}$

Organic Loading Rate-RBC, kg $SBOD_5/m^2$ days = $\frac{\text{Organic Load, kg } SBOD_5\text{/day}}{\text{Surface Area of Media, } m^2}$

Organic Loading Rate-Trickling Filter, lb BOD_5/day/1,000 ft^3 = $\frac{\text{Organic Load, lb } BOD_5\text{/day}}{\text{Volume, 1,000 } ft^3}$

Organic Loading Rate-Trickling Filter, kg/m^3 days = $\frac{\text{Organic Load, kg } BOD_5\text{/day}}{\text{Volume, } m^3}$

Oxygen Uptake Rate or **Oxygen Consumption Rate, mg/L/min** = $\frac{\text{Oxygen Usage, mg/L}}{\text{Time, min}}$

Population Equivalent, Organic = $\frac{\text{(Flow, MGD)(BOD, mg/L)(8.34 lb/gal)}}{\text{0.17 lb BOD/day/person}}$

Population Equivalent, Organic = $\frac{\text{(Flow, } m^3\text{/day)(BOD, mg/L)}}{\text{(1,000)(0.077 kg BOD/day/person)}}$

Power, kW = $\frac{\text{(Flow, L/sec)(Head, m)(9.8)}}{1{,}000}$

Recirculation Ratio-Trickling Filter = $\frac{\text{Recirculated Flow}}{\text{Primary Effluent Flow}}$

Reduction of Volatile Solids, % = $\left(\frac{\text{VS in- VS out}}{\text{VS in-}\left(\text{VS in} \times \text{VS out}\right)}\right) \times 100\%$

All information (In and Out) must be in decimal form

Removal, % = $\left(\frac{\text{In - Out}}{\text{In}}\right) \times 100\%$

Return Rate, % = $\frac{\text{Return Flow Rate}}{\text{Influent Flow Rate}} \times 100\%$

Return Sludge Rate-Solids Balance, MGD = $\frac{\text{(MLSS, mg/L)(Flow Rate, MGD)}}{\text{(RAS Suspended Solids, mg/L) - (MLSS, mg/L)}}$

Slope, % = $\frac{\text{Drop or Rise}}{\text{Distance}} \times 100\%$

Sludge Density Index = $\frac{100}{\text{SVI}}$

Sludge Volume Index, mL/g = $\frac{(SSV_{30}\text{, mL/L)(1,000 mg/g)}}{\text{MLSS, mg/L}}$

Solids, mg/L = $\frac{(\text{Dry Solids, g})(1{,}000{,}000)}{\text{Sample Volume, mL}}$

Solids Capture, % (Centrifuges) =

$$\left[\frac{\text{Cake TS, \%}}{\text{Feed Sludge TS, \%}}\right]\times\left[\frac{(\text{Feed Sludge TS, \%}) - (\text{Centrate TSS, \%})}{(\text{Cake TS, \%}) - (\text{Centrate TSS, \%})}\right]\times 100\%$$

Solids Concentration, mg/L = $\frac{\text{Weight, mg}}{\text{Volume, L}}$

Solids Loading Rate, lb/day/ft² = $\frac{\text{Solids Applied, lb/day}}{\text{Surface Area, ft}^2}$

Solids Loading Rate, kg/day/m² = $\frac{\text{Solids Applied, kg/day}}{\text{Surface Area, m}^2}$

Solids Retention Time: *see Mean Cell Residence Time*

Specific Gravity = $\frac{\text{Specific Weight of Substance, lb/gal}}{8.34\text{ lb/gal}}$

Specific Gravity = $\frac{\text{Specific Weight of Substance, kg/L}}{1.0\text{ kg/L}}$

Specific Oxygen Uptake Rate or **Respiration Rate, (mg/g)/hr** = $\frac{(\text{OUR, mg/L/min})(60\text{ min})}{(\text{MLVSS, g/L})(1\text{ hr})}$

Surface Loading Rate or **Surface Overflow Rate, gpd/ft²** = $\frac{\text{Flow, gpd}}{\text{Area, ft}^2}$

Surface Loading Rate or **Surface Overflow Rate, Lpd/m²** = $\frac{\text{Flow, Lpd}}{\text{Area, m}^2}$

Total Solids, % = $\frac{(\text{Dried Weight, g}) - (\text{Tare Weight, g})}{(\text{Wet Weight, g}) - (\text{Tare Weight, g})}\times 100\%$

Velocity, ft/sec = $\frac{\text{Flow Rate, ft}^3\text{/sec}}{\text{Area, ft}^2}$

Velocity, ft/sec = $\frac{\text{Distance, ft}}{\text{Time, sec}}$

Velocity, m/sec = $\frac{\text{Flow Rate, m}^3\text{/sec}}{\text{Area, m}^2}$

Velocity, m/sec = $\frac{\text{Distance, m}}{\text{Time, sec}}$

*Pie Wheel Format for this equation is available at the end of this document

Volatile Solids, % = $\left[\frac{\text{(Dry Solids, g) - (Fixed Solids, g)}}{\text{(Dry Solids, g)}}\right]\times 100\%$

Volume of Cone* = (1/3)(0.785)(Diameter^2)(Height)

Volume of Cylinder* = (0.785)(Diameter^2)(Height)

Volume of Rectangular Tank* = (Length)(Width)(Height)

Water Use, gpcd = $\frac{\text{Volume of Water Produced, gpd}}{\text{Population}}$

Water Use, Lpcd = $\frac{\text{Volume of Water Produced, Lpd}}{\text{Population}}$

Watts (AC circuit) = (Volts)(Amps)(Power Factor)

Watts (DC circuit) = (Volts)(Amps)

Weir Overflow Rate, gpd/ft = $\frac{\text{Flow, gpd}}{\text{Weir Length, ft}}$

Weir Overflow Rate, Lpd/m = $\frac{\text{Flow, Lpd}}{\text{Weir Length, m}}$

Wire-to-Water Efficiency, % = $\frac{\text{Water hp}}{\text{Motor hp}}\times 100\%$

Wire-to-Water Efficiency, % = $\frac{\text{(Flow, gpm)(Total Dynamic Head, ft)(0.746 kW/hp)(100\%)}}{\text{(3,960)(Electrical Demand, kW)}}$

*Pie Wheel Format for this equation is available at the end of this document

Abbreviations

- **atm** .... atmospheres
- **BOD_5** .... biochemical oxygen demand
- **C** .... Celsius
- **$CBOD_5$** .... carbonaceous biochemical oxygen demand
- **cfs** .... cubic feet per second
- **cm** .... centimeters
- **COD** .... chemical oxygen demand
- **DO** .... dissolved oxygen
- **EMF** .... electromotive force
- **F** .... Fahrenheit
- **F/M ratio** ...... food to microorganism ratio
- **ft** .... feet
- **ft lb** .... foot-pound
- **g** .... grams
- **gal** .... US gallons
- **gfd** .... US gallons flux per day
- **gpcd** .... US gallons per capita per day
- **gpd** .... US gallons per day
- **gpg** .... grains per US gallon
- **gpm** .... US gallons per minute
- **hp** .... horsepower
- **hr** .... hours
- **in** .... inches
- **kg** .... kilograms
- **km** .... kilometer
- **kPa** .... kilopascals
- **kW** .... kilowatts
- **kWh** .... kilowatt-hours
- **L** .... liters
- **lb** .... pounds
- **Lpcd** .... liters per capita per day
- **Lpd** .... liters per day
- **Lpm** .... liters per minute
- **LSI** .... Langelier Saturation Index
- **m** .... meters
- **MCRT** .... mean cell residence time
- **mg** .... milligrams
- **MG** .... million US gallons
- **MGD** .... million US gallons per day
- **min** .... minutes
- **mL** .... milliliters
- **ML** .... million liters
- **MLD** .... million liters per day
- **MLSS** .... mixed liquor suspended solids
- **MLVSS** .... mixed liquor volatile suspended solids
- **OCR** .... oxygen consumption rate
- **ORP** .... oxidation reduction potential
- **OUR** .... oxygen uptake rate
- **PE** .... population equivalent
- **ppb** .... parts per billion
- **ppm** .... parts per million
- **psi** .... pounds per square inch
- **Q** .... flow
- **RAS** .... return activated sludge
- **RBC** .... rotating biological contactor
- **RPM** .... revolutions per minute
- **$SBOD_5$** .... Soluble BOD
- **SDI** .... sludge density index
- **sec** .... second
- **SOUR** .... specific oxygen uptake rate
- **SRT** .... solids retention time
- **SS** .... settleable solids
- **SSV_{30}** .... settled sludge volume 30 minute
- **SVI** .... sludge volume index
- **TOC** .... total organic carbon
- **TS** .... total solids
- **TSS** .... total suspended solids
- **VS** .... volatile solids
- **VSS** .... volatile suspended solids
- **W** .... watts
- **WAS** .... waste activated sludge
- **yd** .... yards
- **yr** .... year

Conversion Factors

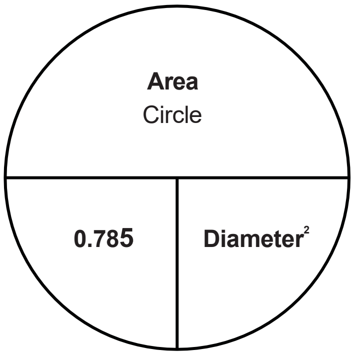
1 acre............................ = 43,560 ft^2
= 4,046.9 m^2
1 acre foot of water...... = 326,000 gal
1 atm............................. = 33.9 ft of water
= 10.3 m of water
= 14.7 psi
= 101.3 kPa
1 cubic foot of water.... = 7.48 gal
= 62.4 lb
1 cubic foot per second= 0.646 MGD
= 448.8 gpm
1 cubic meter of water..= 1,000 kg
= 1,000 L
= 264 gal
1 foot............................ = 0.305 m
1 foot of water .... = 0.433 psi
1 gallon (US)................. = 3.785 L
= 8.34 lb of water
1 grain per US gallon... = 17.1 mg/L
1 hectare ....= 10,000 m^2
1 horsepower................ = 0.746 kW
= 746 W
= 33,000 ft lb/min

1 inch............................ = 2.54 cm
1 liter per second......... = 0.0864 MLD
1 meter of water........... = 9.8 kPa
1 metric ton.................. = 2,205 lb
= 1,000 kg
1 mile .... = 5,280 ft
= 1.61 km
1 million US gallons per day = 694 gpm
= 1.55 ft^3/sec
1 pound .... = 0.454 kg
1 pound per square inch = 2.31 ft of water
= 6.89 kPa
1 square meter............. = 1.19 yd^2
1 ton............................. = 2,000 lb
1%................................. = 10,000 mg/L
π or **pi**............................ = 3.14
Population Equivalent, hydraulic .... = 100 gal/person/day
= 378.5 L/person/day
Population Equivalent, organic .... = 0.17 lb BOD/person/day
= 0.077 kg BOD/person/day

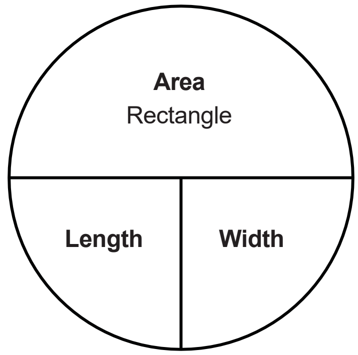
*Pie Wheels

- To find the quantity above the horizontal line: multiply the pie wedges below the line together.
- To solve for one of the pie wedges below the horizontal line: cover that pie wedge, then divide the remaining pie wedge(s) into the quantity above the horizontal line.
- Given units must match the units shown in the pie wheel.
- When US and metric units or values differ, the metric is shown in parentheses, e.g. (m^2).

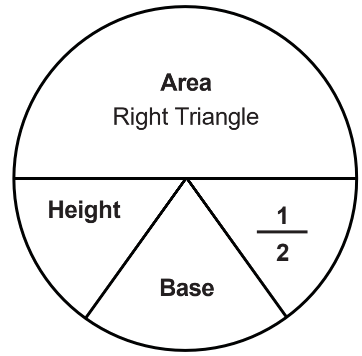
Area of Circle



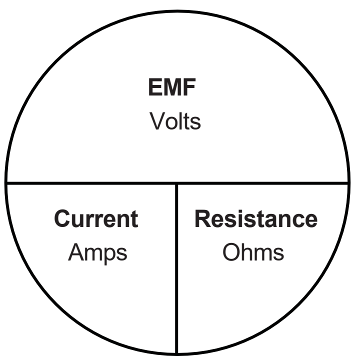
Area of Rectangle



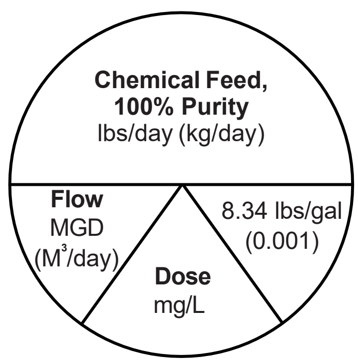
Area of Right Triangle



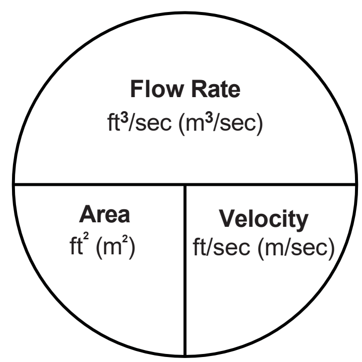
Electromotive Force (EMF), Volts



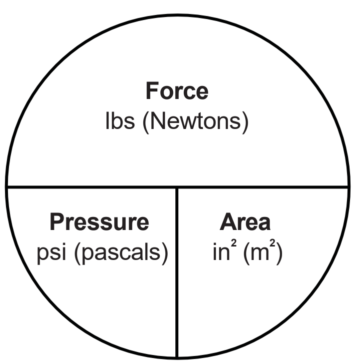
Feed Rate, lbs/day (kg/day)



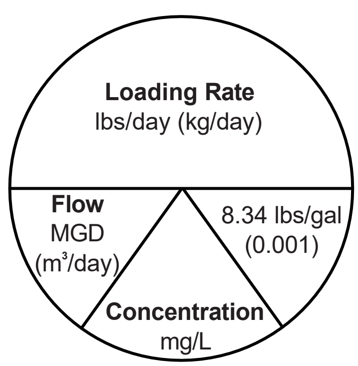
Flow Rate, ft^3/sec (m^3/sec)



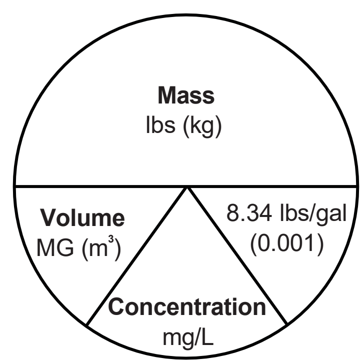
Force, lbs (Newtons)



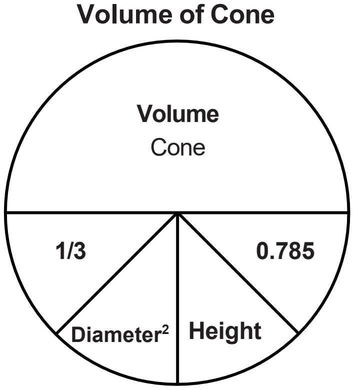
Loading Rate, lbs/day (kg/day)



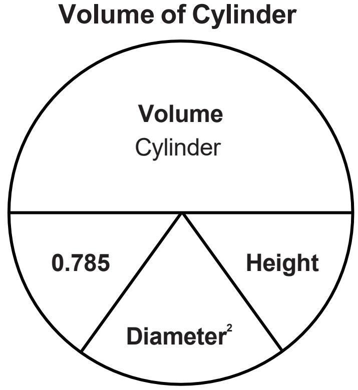
Mass, lbs (kg)



Volume of Cone



Volume of Cylinder



Volume of Rectangular Tank