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) = $(3.14)(\text{Radius})\sqrt{\text{Radius}^2 + \text{Height}^2}$

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

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 =

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

Biochemical Oxygen Demand (unseeded), mg/L = $\frac{\text{[(Initial DO, mg/L) - (Final DO, mg/L)][300 mL]}}{\text{mL of Sample}}$

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

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

Chemical Feed Pump Setting, mL/min = $\frac{\text{(Flow, MGD)(Dose, mg/L)(3.785 L/gal)(1,000,000 gal/MG)}}{\text{(Feed Chemical Density, mg/mL)(1,440 min/day)}}$

Chemical Feed Pump Setting, mL/min =

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

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

Circumference of Circle = (3.14)(Diameter)

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

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

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

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***

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

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

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

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

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

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

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, ft²)(Velocity, ft/sec)

Flow Rate, m³/sec* = (Area, m²)(Velocity, m/sec)

Food/Microorganism Ratio = $\frac{\text{BOD}_5\text{, lb/day}}{\text{MLVSS, lb}}$

Food/Microorganism Ratio = $\frac{\text{BOD}_5\text{, kg/day}}{\text{MLVSS, kg}}$

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 =

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

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

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

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

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

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

Milliequivalent = (mL)(Normality)

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

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 = $\frac{\text{Total Weight}}{\text{Molecular Weight}}$

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

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

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

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

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

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

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

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

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

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

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

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

Solids Retention Time: *see Mean Cell Residence Time*

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

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

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

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

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

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

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

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

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

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

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)

Waste Milliequivalent = (mL)(Normality)

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	kilometers
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	million US gallons
MGD	million US gallons per day
mg/L	milligrams per liter
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	years

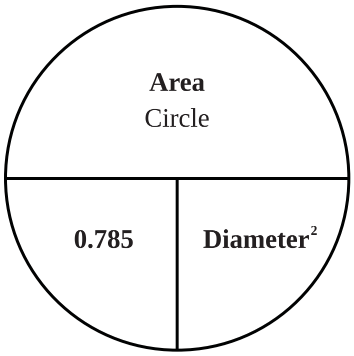
Conversion Factors

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

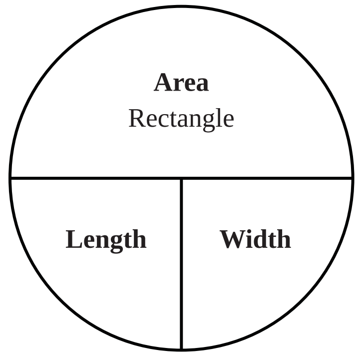
*Pie Wheels

- 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).

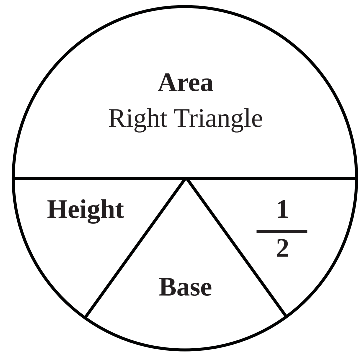
Area of Circle



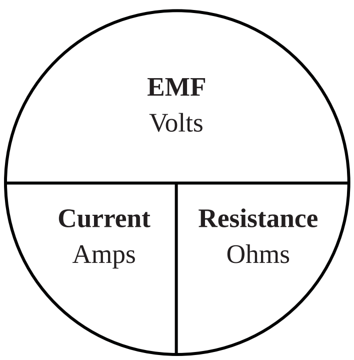
Area of Rectangle



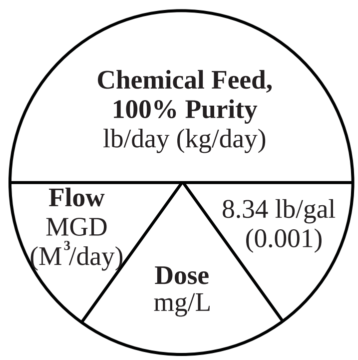
Area of Right Triangle



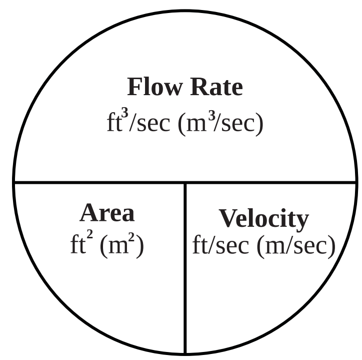
Electromotive Force (EMF), Volts



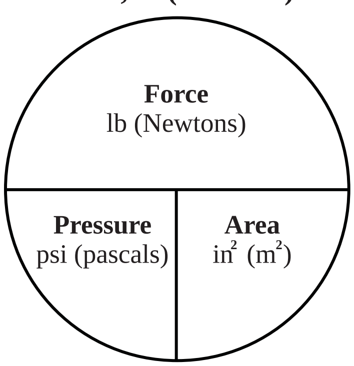
Feed Rate, lb/day (kg/day)



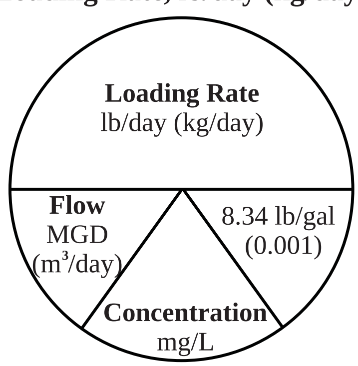
Flow Rate, ft^3/sec (m^3/sec)



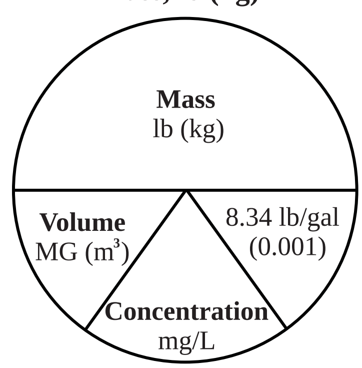
Force, lb (Newtons)



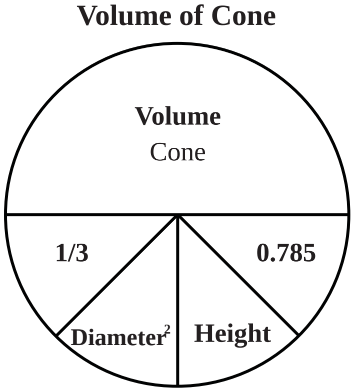
Loading Rate, lb/day (kg/day)



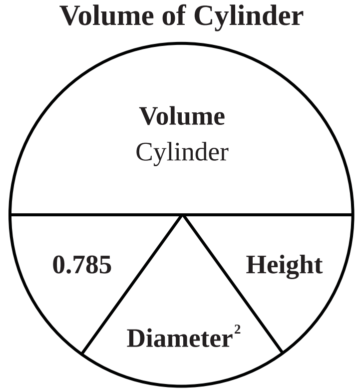
Mass, lb (kg)



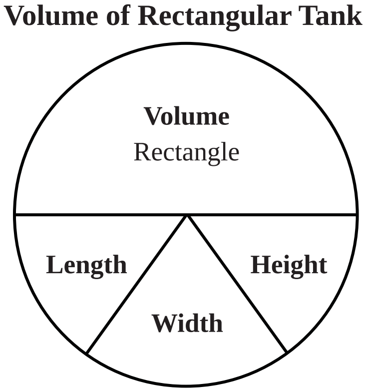
Volume of Cone



Volume of Cylinder



Volume of Rectangular Tank



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