Formula/Conversion Table

Wastewater Treatment, Collection, Industrial Waste, & Wastewater Laboratory Exams

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 =

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

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 =

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

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

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

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

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

Flow Rate, ft^3/sec* = (Area, ft^2)(Velocity, ft/sec)

Flow Rate, m^3/sec* = (Area, m^2)(Velocity, m/sec)

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

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

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)

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

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

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

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

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

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

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 = $(C_1 \times V_1) = (C_2 \times V_2)$ ***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

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

Conversion Factors

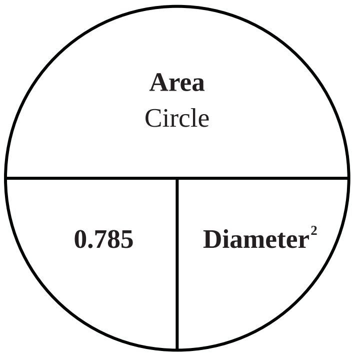
1 acre	= 43,560 ft^2	**1 inch**	= 2.54 cm
	= 4,046.9 m^2	**1 liter per second**	= 0.0864 MLD
1 acre foot of water	= 326,000 gal	**1 meter of water**	= 9.8 kPa
1 atm	= 33.9 ft of water	**1 metric ton**	= 2,205 lb
	= 10.3 m of water		= 1,000 kg
	= 14.7 psi	**1 mile**	= 5,280 ft
	= 101.3 kPa		= 1.61 km
1 cubic foot of water	= 7.48 gal	**1 million US gallons per day**	= 694 gpm
	= 62.4 lb		= 1.55 ft^3/sec
1 cubic foot per second	= 0.646 MGD	**1 pound**	= 0.454 kg
	= 448.8 gpm	**1 pound per square inch**	= 2.31 ft of water
1 cubic meter of water	= 1,000 kg		= 6.89 kPa
	= 1,000 L	**1 square meter**	= 1.19 yd^2
	= 264 gal	**1 ton**	= 2,000 lb
1 foot	= 0.305 m	**1%**	= 10,000 mg/L
1 foot of water	= 0.433 psi	π or **pi**	= 3.14
1 gallon (US)	= 3.785 L	**Population Equivalent, hydraulic**	= 100 gal/person/day
	= 8.34 lb of water		= 378.5 L/person/day
1 grain per US gallon	= 17.1 mg/L		
1 hectare	= 10,000 m^2	**Population Equivalent, organic**	= 0.17 lb BOD/person/day
1 horsepower	= 0.746 kW		= 0.077 kg BOD/person/day
	= 746 W		
	= 33,000 ft lb/min		

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

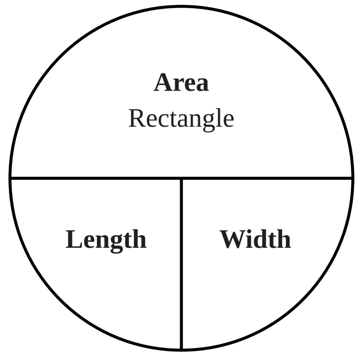
*Pie Wheels

- 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).

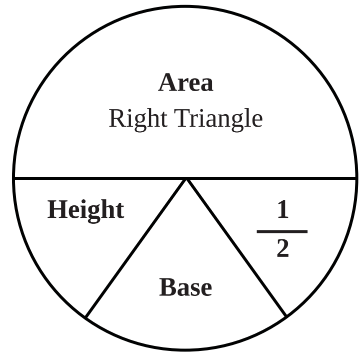
Area of Circle



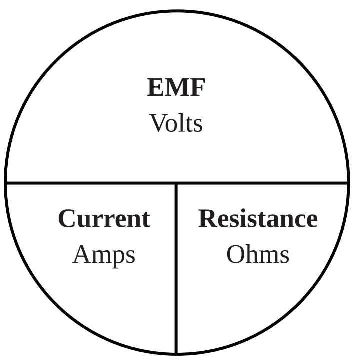
Area of Rectangle



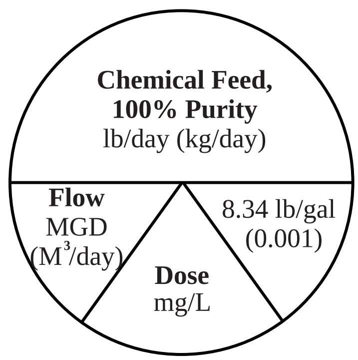
Area of Right Triangle



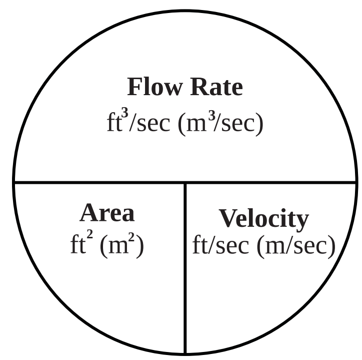
Electromotive Force (EMF), Volts



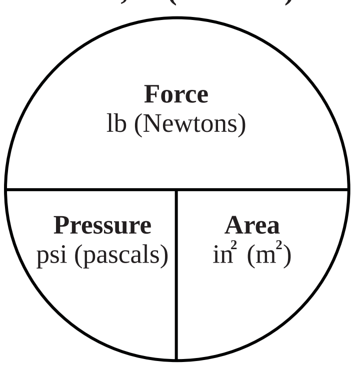
Feed Rate, lb/day (kg/day)



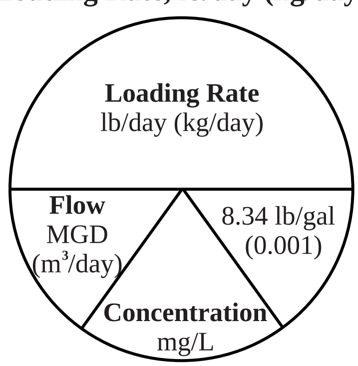
Flow Rate, ft^3/sec (m^3/sec)



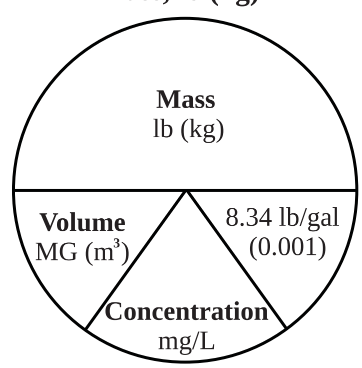
Force, lb (Newtons)



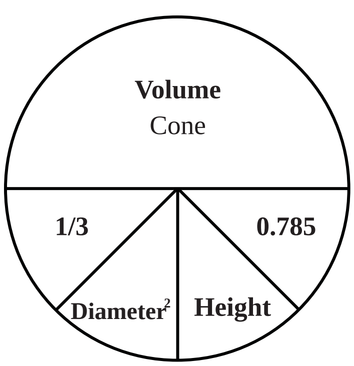
Loading Rate, lb/day (kg/day)



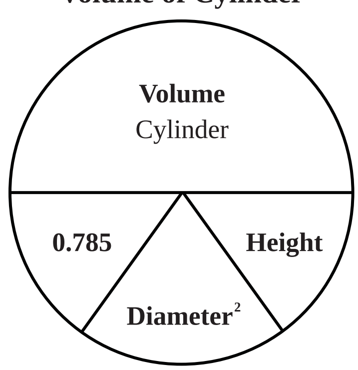
Mass, lb (kg)



Volume of Cone



Volume of Cylinder



Volume of Rectangular Tank