

Formula/Conversion Table

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



$$\text{Alkalinity, mg/L as CaCO}_3 = \frac{(\text{Titrant Volume, mL})(\text{Acid Normality})(50,000)}{\text{Sample Volume, mL}}$$

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

$$\text{Area of Circle}^* = (0.785)(\text{Diameter}^2)$$

$$\text{Area of Circle} = (3.14)(\text{Radius}^2)$$

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

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

$$\text{Area of Cylinder (total exterior surface area)} = [\text{End \#1 SA}] + [\text{End \#2 SA}] + [(3.14)(\text{Diameter})(\text{Height or Depth})]$$

Where SA = surface area

$$\text{Area of Rectangle}^* = (\text{Length})(\text{Width})$$

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

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

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

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

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

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

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

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

$$\text{Chemical Feed Pump Setting, mL/min} =$$

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

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

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)

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

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

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

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

$$\text{Degrees Fahrenheit} = (\text{°C})(1.8) + 32$$

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

$$\text{Dilution or Two Normal Equation} = (C_1 \times V_1) = (C_2 \times V_2) \quad \begin{array}{l} \text{Where } C = \text{Concentration, } V = \text{volume or flow;} \\ \text{Concentration units must match;} \\ \text{Volume units must match} \end{array}$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$\text{Force, lb}^* = (\text{Pressure, psi})(\text{Area, in}^2)$$

$$\text{Force, newtons}^* = (\text{Pressure, pascals})(\text{Area, m}^2)$$

$$\text{Hardness, as mg CaCO}_3/\text{L} = \frac{(\text{Titration Volume, mL})(1,000)}{\text{Sample Volume, mL}} \quad \text{Only when the titration factor is 1.00 of EDTA}$$

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

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

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

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

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

$$\text{Horsepower, Water, kW} = (9.8)(\text{Flow, m}^3/\text{sec})(\text{Head, m})$$

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

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

$$\text{Loading Rate, lb/day}^* = (\text{Flow, MGD})(\text{Concentration, mg/L})(8.34 \text{ lb/gal})$$

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

$$\text{Mass, lb}^* = (\text{Volume, MG})(\text{Concentration, mg/L})(8.34 \text{ lb/gal})$$

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

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

$$\text{Mean Cell Residence Time or Solids Retention Time, days} = \frac{(\text{Aeration Tank TSS, lb}) + (\text{Clarifier TSS, lb})}{(\text{TSS Wasted, lb/day}) + (\text{Effluent TSS, lb/day})}$$

$$\text{Milliequivalent} = (\text{mL})(\text{Normality})$$

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

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

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

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

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

$$\text{Organic Loading Rate-RBC, lb SBOD}_5/\text{day}/1,000 \text{ ft}^2 = \frac{\text{Organic Load, lb SBOD}_5/\text{day}}{\text{Surface Area of Media, } 1,000 \text{ ft}^2}$$

$$\text{Organic Loading Rate-RBC, kg SBOD}_5/\text{m}^2 \text{ days} = \frac{\text{Organic Load, kg SBOD}_5/\text{day}}{\text{Surface Area of Media, m}^2}$$

$$\text{Organic Loading Rate-Trickling Filter, lb BOD}_5/\text{day}/1,000 \text{ ft}^3 = \frac{\text{Organic Load, lb BOD}_5/\text{day}}{\text{Volume, } 1,000 \text{ ft}^3}$$

$$\text{Organic Loading Rate-Trickling Filter, kg/m}^3 \text{ days} = \frac{\text{Organic Load, kg BOD}_5/\text{day}}{\text{Volume, m}^3}$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Solids Retention Time: *see Mean Cell Residence Time*

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

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

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

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

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

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

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

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

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

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

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

$$\text{Volume of Cone*} = (1/3)(0.785)(\text{Diameter}^2)(\text{Height})$$

$$\text{Volume of Cylinder*} = (0.785)(\text{Diameter}^2)(\text{Height})$$

$$\text{Volume of Rectangular Tank*} = (\text{Length})(\text{Width})(\text{Height})$$

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

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

$$\text{Watts (AC circuit)} = (\text{Volts})(\text{Amps})(\text{Power Factor})$$

$$\text{Watts (DC circuit)} = (\text{Volts})(\text{Amps})$$

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

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

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

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

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

Abbreviations

atm	atmospheres	mg	milligrams
BOD₅	biochemical oxygen demand	MG	million US gallons
C	Celsius	MGD	million US gallons per day
CBOD₅	carbonaceous biochemical oxygen demand	min	minutes
cfs	cubic feet per second	mL	milliliters
cm	centimeters	ML	million liters
COD	chemical oxygen demand	MLD	million liters per day
DO	dissolved oxygen	MLSS	mixed liquor suspended solids
EMF	electromotive force	MLVSS	mixed liquor volatile suspended solids
F	Fahrenheit	OCR	oxygen consumption rate
F/M ratio	food to microorganism ratio	ORP	oxidation reduction potential
ft	feet	OUR	oxygen uptake rate
ft lb	foot-pound	PE	population equivalent
g	grams	ppb	parts per billion
gal	US gallons	ppm	parts per million
gfd	US gallons flux per day	psi	pounds per square inch
gpcd	US gallons per capita per day	Q	flow
gpd	US gallons per day	RAS	return activated sludge
gpg	grains per US gallon	RBC	rotating biological contactor
gpm	US gallons per minute	RPM	revolutions per minute
hp	horsepower	SBOD₅	Soluble BOD
hr	hours	SDI	sludge density index
in	inches	sec	second
kg	kilograms	SOUR	specific oxygen uptake rate
km	kilometer	SRT	solids retention time
kPa	kilopascals	SS	settleable solids
kW	kilowatts	SSV₃₀	settled sludge volume 30 minute
kWh	kilowatt-hours	SVI	sludge volume index
L	liters	TOC	total organic carbon
lb	pounds	TS	total solids
Lpcd	liters per capita per day	TSS	total suspended solids
Lpd	liters per day	VS	volatile solids
Lpm	liters per minute	VSS	volatile suspended solids
LSI	Langelier Saturation Index	W	watts
m	meters	WAS	waste activated sludge
MCRT	mean cell residence time	yd	yards
		yr	year

Conversion Factors

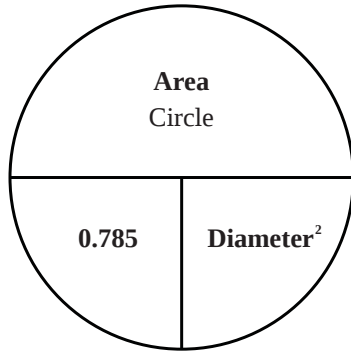
1 acre	= 43,560 ft ² = 4,046.9 m ²	1 inch	= 2.54 cm
1 acre foot of water	= 326,000 gal	1 liter per second	= 0.0864 MLD
1 atm	= 33.9 ft of water = 10.3 m of water = 14.7 psi = 101.3 kPa	1 meter of water	= 9.8 kPa
1 cubic foot of water	= 7.48 gal = 62.4 lb	1 metric ton	= 2,205 lb = 1,000 kg
1 cubic foot per second	= 0.646 MGD = 448.8 gpm	1 mile	= 5,280 ft = 1.61 km
1 cubic meter of water	= 1,000 kg = 1,000 L = 264 gal	1 million US gallons per day	= 694 gpm = 1.55 ft ³ /sec
1 foot	= 0.305 m	1 pound	= 0.454 kg
1 foot of water	= 0.433 psi	1 pound per square inch	= 2.31 ft of water = 6.89 kPa
1 gallon (US)	= 3.785 L = 8.34 lb of water	1 square meter	= 1.19 yd ²
1 grain per US gallon	= 17.1 mg/L	1 ton	= 2,000 lb
1 hectare	= 10,000 m ²	1%	= 10,000 mg/L
1 horsepower	= 0.746 kW = 746 W = 33,000 ft lb/min	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 Wheel Format for this equation
is available at the end of this document

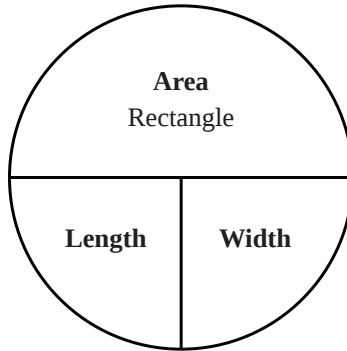
*Pie Wheels

- 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. (m²).

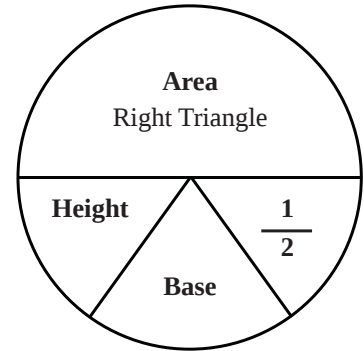
Area of Circle



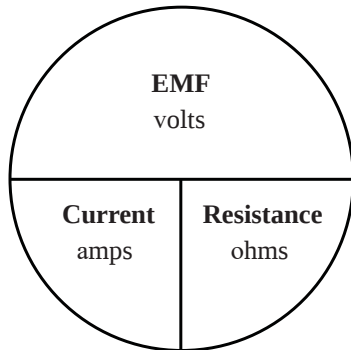
Area of Rectangle



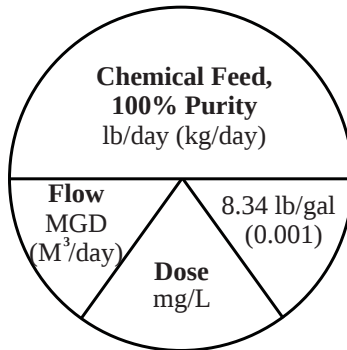
Area of Right Triangle



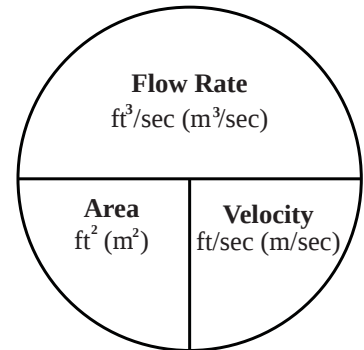
Electromotive Force (EMF), volts



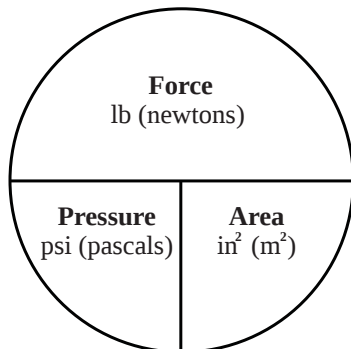
Feed Rate, lb/day (kg/day)



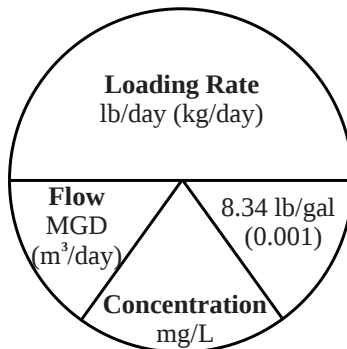
Flow Rate, ft³/sec (m³/sec)



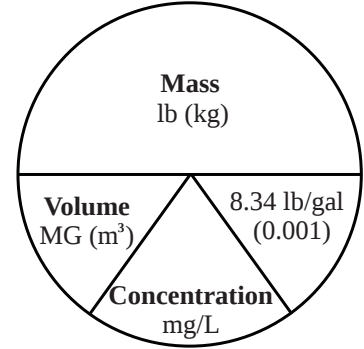
Force, lb (newtons)



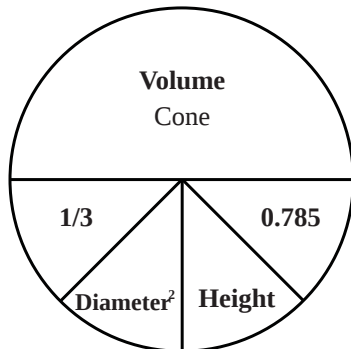
Loading Rate, lb/day (kg/day)



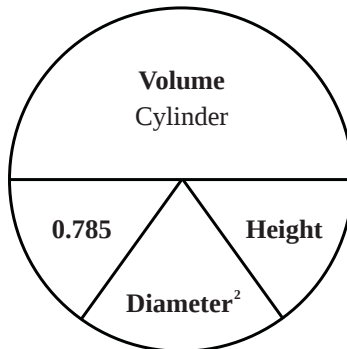
Mass, lb (kg)



Volume of Cone



Volume of Cylinder



Volume of Rectangular Tank

