

## 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*

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

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

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

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

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

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

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

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

*Concentration units must match;*  
*Volume units must match*

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

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

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

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

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

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

$$\text{Circumference of Circle} = (3.14)(\text{Diameter})$$

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

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

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

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

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

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

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

$$\text{Electromotive Force, volts}^* = (\text{Current, amps})(\text{Resistance, ohms})$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

**Horsepower, Motor, kW =**

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$\text{Reduction of Volatile Solids, \%} = \left( \frac{\text{VS in} - \text{VS out}}{\text{VS in} - (\text{VS in} \times \text{VS out})} \right) \times 100\% \quad \text{All information (In and Out) must be in decimal form}$$

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

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

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

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

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

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

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

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

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

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

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

**Solids Retention Time:** *see Mean Cell Residence Time*

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

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

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

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

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

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



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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

## Abbreviations

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<b>atm</b> .....	atmospheres	<b>MG</b> .....	million US gallons
<b>BOD<sub>5</sub></b> .....	biochemical oxygen demand	<b>MGD</b> .....	million US gallons per day
<b>C</b> .....	Celsius	<b>min</b> .....	minutes
<b>CBOD<sub>5</sub></b> .....	carbonaceous biochemical oxygen demand	<b>mL</b> .....	milliliters
<b>cfs</b> .....	cubic feet per second	<b>ML</b> .....	million liters
<b>cm</b> .....	centimeters	<b>MLD</b> .....	million liters per day
<b>COD</b> .....	chemical oxygen demand	<b>MLSS</b> .....	mixed liquor suspended solids
<b>DO</b> .....	dissolved oxygen	<b>MLVSS</b> .....	mixed liquor volatile suspended solids
<b>EMF</b> .....	electromotive force	<b>OCR</b> .....	oxygen consumption rate
<b>F</b> .....	Fahrenheit	<b>ORP</b> .....	oxidation reduction potential
<b>F/M ratio</b> .....	food to microorganism ratio	<b>OUR</b> .....	oxygen uptake rate
<b>ft</b> .....	feet	<b>PE</b> .....	population equivalent
<b>ft lb</b> .....	foot-pound	<b>ppb</b> .....	parts per billion
<b>g</b> .....	grams	<b>ppm</b> .....	parts per million
<b>gal</b> .....	US gallons	<b>psi</b> .....	pounds per square inch
<b>gfd</b> .....	US gallons flux per day	<b>Q</b> .....	flow
<b>gpcd</b> .....	US gallons per capita per day	<b>RAS</b> .....	return activated sludge
<b>gpd</b> .....	US gallons per day	<b>RBC</b> .....	rotating biological contactor
<b>gpg</b> .....	grains per US gallon	<b>RPM</b> .....	revolutions per minute
<b>gpm</b> .....	US gallons per minute	<b>SBOD<sub>5</sub></b> .....	Soluble BOD
<b>hp</b> .....	horsepower	<b>SDI</b> .....	sludge density index
<b>hr</b> .....	hours	<b>sec</b> .....	second
<b>in</b> .....	inches	<b>SOUR</b> .....	specific oxygen uptake rate
<b>kg</b> .....	kilograms	<b>SRT</b> .....	solids retention time
<b>km</b> .....	kilometer	<b>SS</b> .....	settleable solids
<b>kPa</b> .....	kilopascals	<b>SSV<sub>30</sub></b> .....	settled sludge volume 30 minute
<b>kW</b> .....	kilowatts	<b>SVI</b> .....	sludge volume index
<b>kWh</b> .....	kilowatt-hours	<b>TOC</b> .....	total organic carbon
<b>L</b> .....	liters	<b>TS</b> .....	total solids
<b>lb</b> .....	pounds	<b>TSS</b> .....	total suspended solids
<b>Lpcd</b> .....	liters per capita per day	<b>VS</b> .....	volatile solids
<b>Lpd</b> .....	liters per day	<b>VSS</b> .....	volatile suspended solids
<b>Lpm</b> .....	liters per minute	<b>W</b> .....	watts
<b>LSI</b> .....	Langelier Saturation Index	<b>WAS</b> .....	waste activated sludge

m ..... meters  
MCRT ..... mean cell residence time  
mg ..... milligrams

yd ..... yards  
yr ..... year

### Conversion Factors

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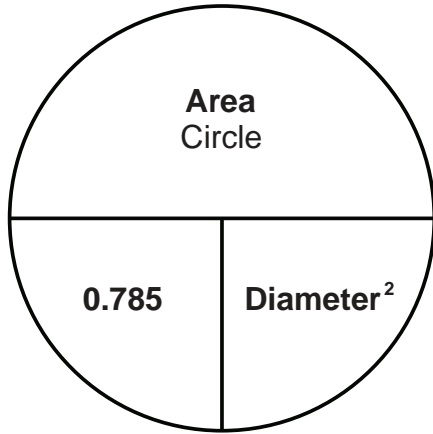
**1 acre** ..... = 43,560 ft<sup>2</sup>  
= 4,046.9 m<sup>2</sup>  
**1 acre foot of water** ..... = 326,000 gal  
**1 atm** ..... = 33.9 ft of water  
= 10.3 m of water  
= 14.7 psi  
= 101.3 kPa  
**1 cubic foot of water** ..... = 7.48 gal  
= 62.4 lb  
**1 cubic foot per second** = 0.646 MGD  
= 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<sup>2</sup>  
**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<sup>3</sup>/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<sup>2</sup>  
**1 ton** ..... = 2,000 lb  
**1%** ..... = 10,000 mg/L  
 $\pi$  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

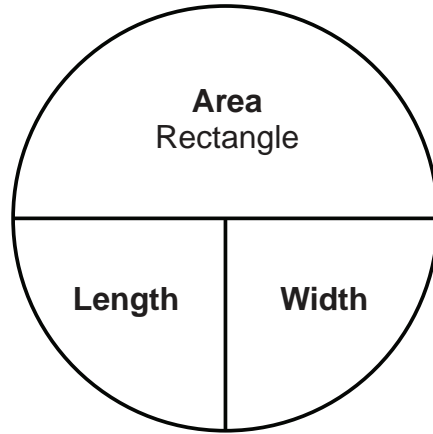
**\*Pie Wheels**

- 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<sup>2</sup>).

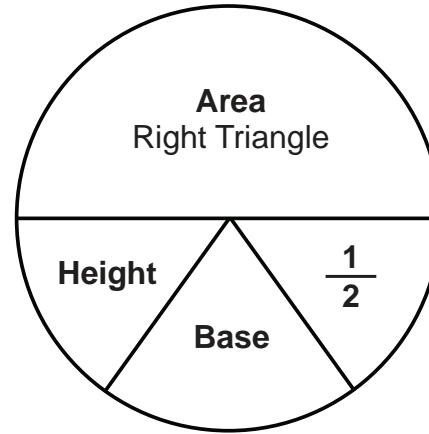
**Area of Circle**



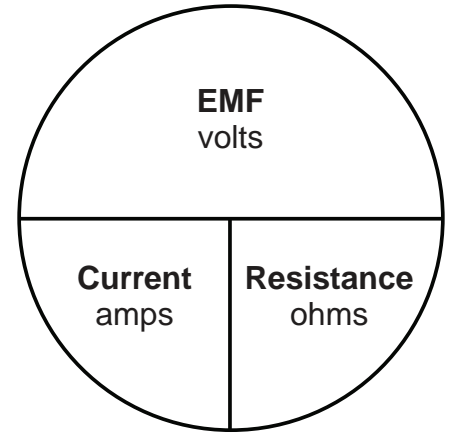
**Area of Rectangle**



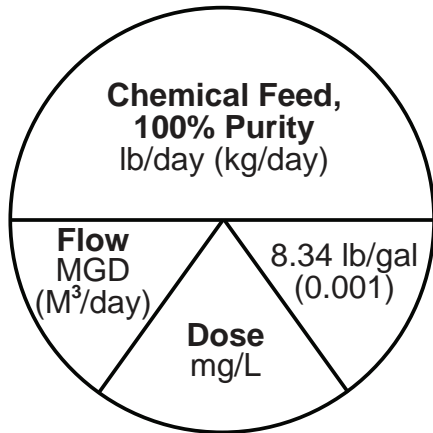
**Area of Right Triangle**



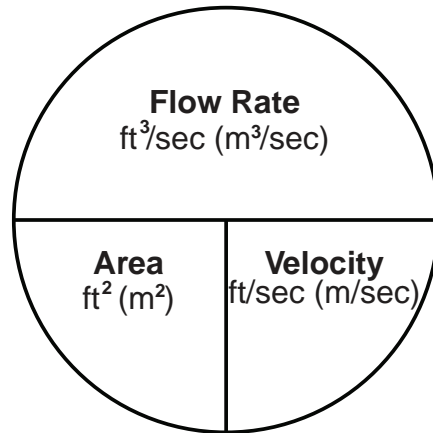
**Electromotive Force (EMF), volts**



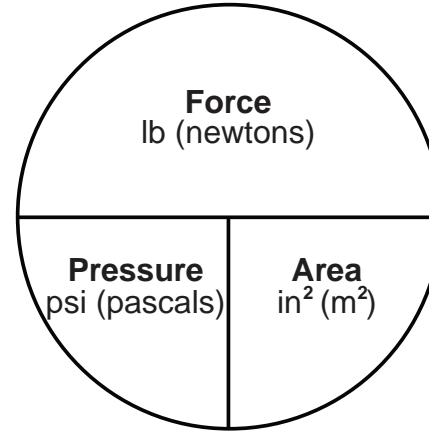
**Feed Rate, lb/day (kg/day)**



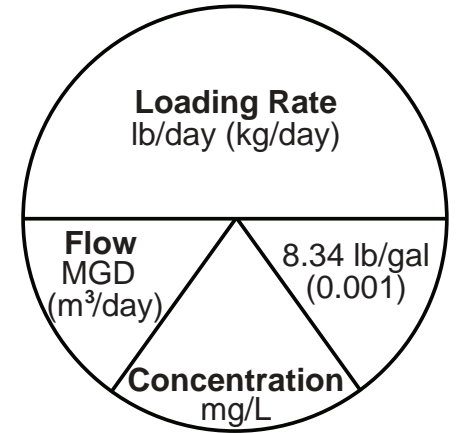
**Flow Rate, ft<sup>3</sup>/sec (m<sup>3</sup>/sec)**



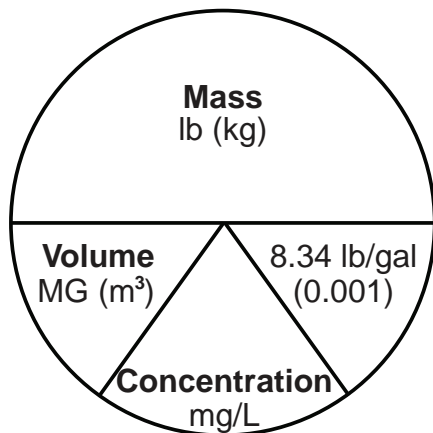
**Force, lb (newtons)**



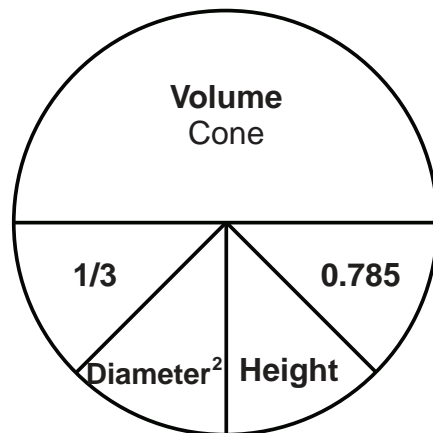
**Loading Rate, lb/day (kg/day)**



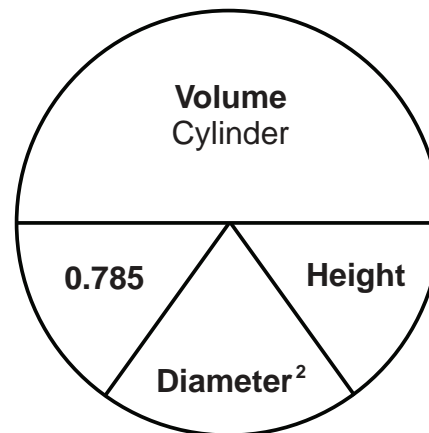
**Mass, lb (kg)**



**Volume of Cone**



**Volume of Cylinder**



**Volume of Rectangular Tank**

