OPERATOR MATH PDH WORKBOOK

Completion of this workbook will count for 1 PDH

Arizona Department of Environmental Quality
Operator Certification Program
1110 West Washington Street
Phoenix, AZ 85007
www.azdeq.gov

NAME____

OPCERT NUMBER OP0________________

DATE________________________________

Special Thanks to Amanda Lara and Gateway Community College

DIRECTIONS

A Professional Development Hour (PDH) is equal to one contact hour of continuing education. A total of 30 professional development hours are required for each 3-year renewal period regardless of the number of certificates that are held by an individual operator.

Answer the questions in the space provided with concise and accurate answers. Submit a copy of the completed workbook along with your renewal form when you renew your certificates. It is recommended that you keep a copy of the completed booklet for your records. Completion of this workbook will earn the operator one (1) PDH. Please print clearly. Workbooks that are illegible will not receive PDHs.

The type of PDH acceptable to the Department for certificate renewal include, but are not limited to: An approved college course, a course offered by a Certified Environmental Trainer, regulatory and tribal agency training, certain types of in-house training, technical conferences, correspondence courses, and manufacturer product training. An accredited college course is usually recorded in credit hours. In general, 1 college credit hour = 10 PDHs. If an operator has a question about a specific type of training, please contact the Operator Certification Program for approval before attending the training.

For additional training/PDHs click on the link below. This course provides 16 hours of PDH-approved training for drinking-water operators in the State of Arizona. These are available as individual lessons for credit or as a whole course.

http://www.waterhelp.org/index.php/client/arizona

FOR MORE INFORMATION, CONTACT:

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<u>Show the math steps taken to reach your answer</u>

1. You need to calculate the velocity in a grit channel at your plant's peak flow. Based on the flow charts, you determine that peak flows are usually about 2.75 MGD. The grit channel is **3ft wide**, and the flow depth is **17in** at peak flow. What is the velocity in the grit channel under these conditions?

2. A chlorinator treats a flow of 2 MGD. The chlorine demand is 9 mg/L and the desired residual is 1 mg/L. What should be the setting on the chlorinator in pounds of chlorine per 24 hours?

3. A reaction basin that is 4 meters in diameter and 1.2 meters deep can treat a flow of 0.9 *MLD*. What is the average detention time in minutes?

4. Calculate the pumping capacity of a pump in gallons per minute when 12 minutes are required for the water to rise 3 feet in an 8-foot by 6-foot rectangular tank. (Hint: calculate volume pumped in cu ft, convert cu ft to gal, calculate gpm)

5. What is 90% of 5?

6. What is the maximum volume (in gallons) of water that can be stored in a cylindrical tank that is 10ft in diameter and 20ft high with an overflow at 18ft from the base?

7. What is the external surface area for a cylindrical tank 10ft in diameter and 20ft high (not including the top and bottom)?

8. How many pounds of 68% calcium hypochlorite $Ca(ClO)_2$ are needed to make 200 gal of a 10% $Ca(ClO)_2$ solution?

9. A 15in diameter pipe is flowing full. What is the gpm flow rate in the pipe if the velocity is 110 ft/min?

10. The influent BOD to an activated sludge plant is 225 mg/L and the effluent BOD is 25 mg/L. What is the BOD removal efficiency of the plant?

11. What is the weight of dry solids in a ton (2,000lbs) of wastewater sludge containing 5% solids and 95% water?

12. If a tank is two-thirds full and it contains 8,000 gallons, what is the tank capacity?

13. A rectangle channel is 3ft wide and contains water 2ft deep, moving at 1.5 ft/sec. What is the flow rate in cfs?

14. Estimate the pounds of lime needed to neutralize a sour digester if the digester contains 0.25 mg of sludge with a volatile acid level of 2,400 mg/L as acetic acid.

15. A small chemical feed pump lowered a chemical solution in a 2.5-foot diameter tank by 2.25 ft during a seven-hour period. Estimate the flow delivered by the pump in gallons per day.

NAME____

OPCERT NUMBER OP0________________ DATE__________________________

ABC & C_2EP Formula/Conversion Table for Water Treatment, Distribution, & Laboratory Exams

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

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

*Area of Circle $= (.785)\ (\text{Diameter}^2)$

$= (\pi)\ (\text{Radius}^2)$

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

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

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

*Area of Rectangle = (Length) (Width)

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

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

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

Chemical Dry Feeder Calibration, lbs/day $= \dfrac{\text{(Dry Chemical Collected, grams) (60 min/hr) (24 hr/day)}}{\text{(454 grams/lb) (Time, min)}}$

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

Chemical Feed Pump Setting, mL/min $= \dfrac{\text{(Flow, MGD) (Dose, mg/L) (3.785 L/gal) (1,000,000 gal/MG)}}{\text{(Liquid, mg/mL) (24 hr/day) (60 min/hr)}}$

Circumference of Circle = (π) (Diameter)

= 2 (π) (Radius)

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

CT Calculation = (Disinfectant Residual Concentration, mg/L) (Time, min)

Degrees Celsius = (Degrees Fahrenheit - 32) ($^5/_9$)

$= \dfrac{(°F - 32)}{1.8}$

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

Degrees Fahrenheit $= (\text{Degrees Celsius})\left(\frac{9}{5}\right) + 32$

$= (\text{Degrees Celsius})(1.8) + 32$

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

*Electromotive Force (EMF), volts = (Current, amps) (Resistance, ohms) *or* E = IR

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

Feed Rate, gal/min (Fluoride Saturator) $= \dfrac{(\text{Plant capacity, gpm})(\text{Dosage, mg/L})}{18{,}000\ \text{mg/L}}$

Feed Rate, lbs/day (Fluoride) =

$$\frac{(\text{Dosage, mg/L})(\text{Capacity, MGD})(8.34\ \text{lbs/gal})}{(\text{Available Fluoride Ion, \% expressed as a decimal})(\text{Purity, \% expressed as a decimal})}$$

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

Filter Drop Test Velocity, ft/min $= \dfrac{\text{Water Drop, ft}}{\text{Time of Drop, min}}$

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

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

*Flow Rate, cfs = (Area, ft^2) (Velocity, ft/sec) *or* Q = AV *Units must be compatible*

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

Gallons/Capita/Day $= \dfrac{\text{Volume of Water Produced, gpd}}{\text{Population}}$

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

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

Horsepower, Motor (mhp) =

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

*Horsepower, Water (whp) $= \dfrac{(\text{Flow, gpm})(\text{Head, ft})}{3{,}960}$

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

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

$$\text{Hypochlorite Strength, \%} = \frac{\text{Chlorine Required, lbs}}{(\text{Hypochlorite Solution Needed, gal})(8.34\text{ lbs/gal})} \times 100\%$$

$$\text{Leakage, gpd} = \frac{\text{Volume, gallons}}{\text{Time, days}}$$

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

*Mass Flux, lbs/day = (Flow, MGD) (Concentration, mg/L) (8.34 lbs/gal)

Milliequivalent = (mL) (Normality)

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

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

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

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

$$\text{Reduction in Flow, \%} = \left(\frac{\text{Original Flow - Reduced Flow}}{\text{Original Flow}}\right) \times 100\%$$

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

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

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

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

$$\text{Specific Gravity} = \frac{\text{Specific Weight of Substance, lbs/gal}}{\text{Specific Weight of Water, lbs/gal}}$$

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

Three Normal Equation = $(N_1 \times V_1) + (N_2 \times V_2) = (N_3 \times V_3)$ *Where* $V_1 + V_2 = V_3$

Two Normal Equation = $N_1 \times V_1 = N_2 \times V_2$ *Where N = normality, V = volume or flow*

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

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

*Volume of Cone = (1/3) (.785) (Diameter^2) (Height)

= (1/3) [(π) (Radius^2) (Height)]

*Volume of Cylinder = (.785) (Diameter^2) (Height)

= (π) (Radius^2) (Height)

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

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

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

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

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

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

Abbreviations:

cfs	cubic feet per second
DO	dissolved oxygen
ft	feet
g	grams
gpd	gallons per day
gpg	grains per gallon
gpm	gallons per minute
hp	horsepower
hr	hour
in	inches
kW	kilowatt
lbs	pounds
mg/L	milligrams per liter
MGD	million gallons per day
mL	milliliter
min	minute
ppb	parts per billion
ppm	parts per million
psi	pounds per square inch
Q	flow
SS	settleable solids
TTHM	total trihalomethanes
TOC	total organic carbon
TSS	total suspended solids
VS	volatile solids

Conversion Factors:

1 acre = 43,560 square feet
1 acre foot = 326,000 gallons
1 cubic foot = 7.48 gallons
= 62.4 pounds
1 cubic foot per second = 0.646 MGD
1 foot = 0.305 meters
1 foot of water = 0.433 psi
1 gallon = 3.79 liters
= 8.34 pounds
1 grain per gallon = 17.1 mg/L
1 horsepower = 0.746 kW
= 746 watts
= 33,000 ft lbs/min
1 mile = 5,280 feet
1 million gallons per day = 694 gallons per minute
= 1.55 cubic feet per second (cfs)
1 pound = 0.454 kilograms
1 pound per square inch = 2.31 feet of water
1 ton = 2,000 pounds
1% = 10,000 mg/L
π or pi = 3.14159

Alkalinity Relationships: All Alkalinity expressed as mg/L as $CaCO_3$

Result of Titration	Hydroxide Alkalinity	Carbonate Alkalinity	Bicarbonate Concentration
P = 0	0	0	T
P < ½T	0	2P	T – 2P
P = ½T	0	2P	0
P > ½T	2P – T	2(T – P)	0
P = T	T	0	0

Key: P – phenolphthalein alkalinity T – total alkalinity

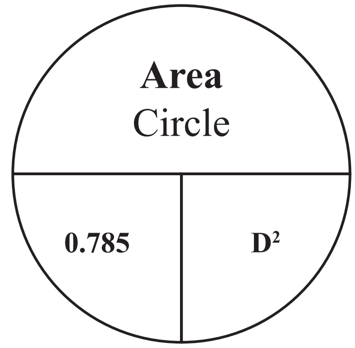
*Pie Wheel format for this equation is available at the end of this document.

***Pie Wheels:**

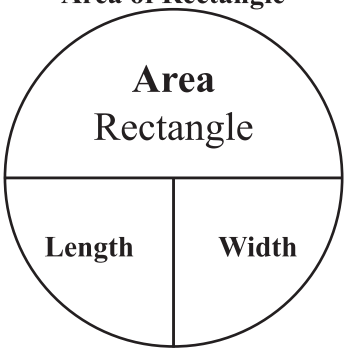
- To find the quantity above the horizontal line: multiply the pie wedges below the line together.
- To solve for one of the pie wedges below the horizontal line: cover that pie wedge, then divide the remaining pie wedge(s) into the quantity above the horizontal line.

Given units must match the units shown in the pie wheel.

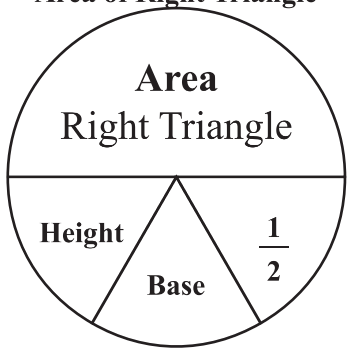
Area of Circle



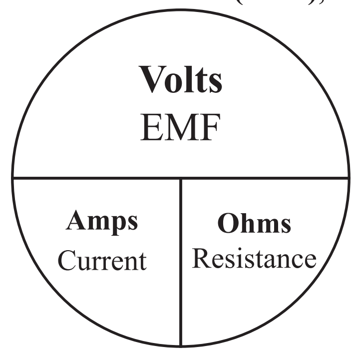
Area of Rectangle



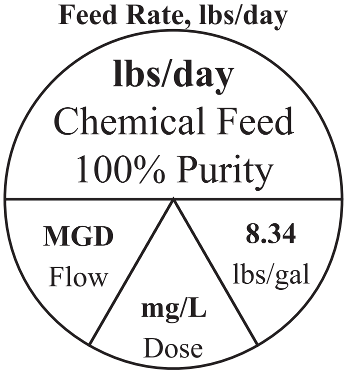
Area of Right Triangle



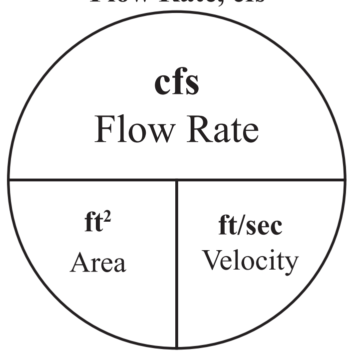
Electromotive Force (EMF), volts



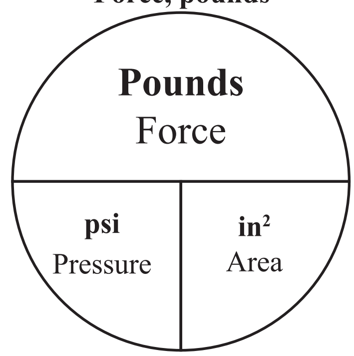
Feed Rate, lbs/day



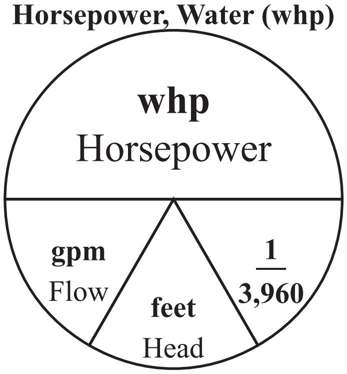
Flow Rate, cfs



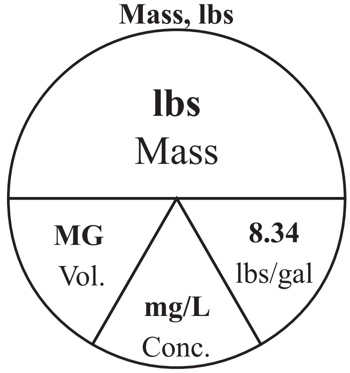
Force, pounds



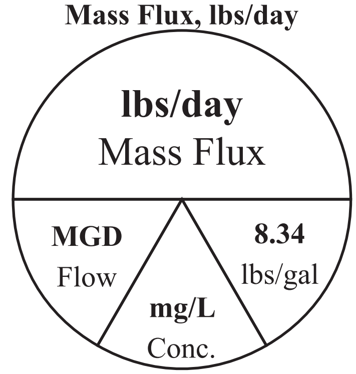
Horsepower, Water (whp)



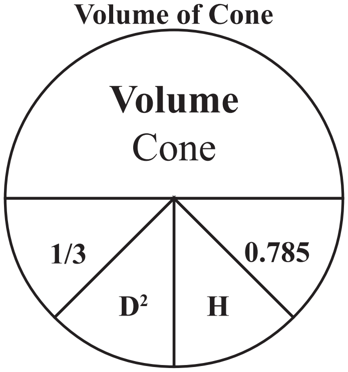
Mass, lbs



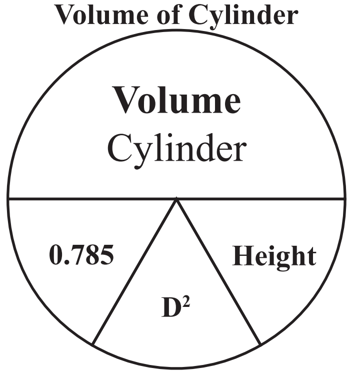
Mass Flux, lbs/day



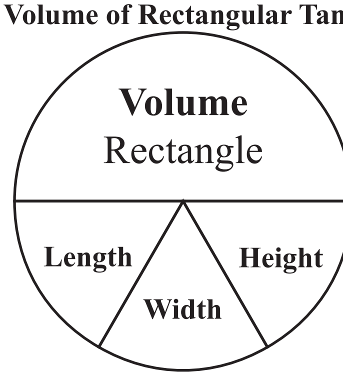
Volume of Cone



Volume of Cylinder



Volume of Rectangular Tank



ABC & C_2EP Formula/Conversion Table for Wastewater Treatment, Industrial, Collection, & Laboratory Exams

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

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

*Area of Circle = (.785) (Diameter^2)

= (π) (Radius^2)

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

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

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

*Area of Rectangle = (Length) (Width)

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

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

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

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

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

Chemical Feed Pump Setting, mL/min $= \dfrac{\text{(Flow, MGD) (Dose, mg/L) (3.785 L/gal) (1,000,000 gal/MG)}}{\text{(Liquid, mg/mL) (24 hr/day) (60 min/hr)}}$

Circumference of Circle = (π) (Diameter)

= 2 (π) (Radius)

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

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

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

Degrees Celsius = (Degrees Fahrenheit - 32) ($^5/_9$)

$$= \frac{(°F - 32)}{1.8}$$

Degrees Fahrenheit = (Degrees Celsius) ($^9/_5$) + 32

= (Degrees Celsius) (1.8) + 32

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

Dose = Demand + Residual

*Electromotive Force (EMF), volts = (Current, amps) (Resistance, ohms) *or* E = IR

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

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

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

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

*Flow Rate, cfs = (Area, ft^2) (Velocity, ft/sec) *or* Q = AV *Units must be compatible*

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

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

Gallons/Capita/Day = $\frac{\text{Volume of Water Produced, gpd}}{\text{Population}}$

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

Horsepower, Motor (mhp) =

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

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

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

$$\text{Leakage, gpd} = \frac{\text{Volume, gallons}}{\text{Time, days}}$$

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

*Mass Flux, lbs/day = (Flow, MGD) (Concentration, mg/L) (8.34 lbs/gal)

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

Milliequivalent = (mL) (Normality)

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

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

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

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

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

$$\text{Organic Loading Rate, lbs BOD}_5\text{/day/ft}^3 = \frac{\text{Organic Load, lbs BOD}_5\text{/day}}{\text{Volume, ft}^3}$$

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

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

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

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

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

$$\text{Reduction in Flow, \%} = \left(\frac{\text{Original Flow - Reduced Flow}}{\text{Original Flow}}\right) \times 100\%$$

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

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

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

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

$$\text{Return Sludge Rate-Solids Balance} = \frac{(\text{MLSS})(\text{Flow Rate})}{\text{Return Activated Sludge Suspended Solids} - \text{MLSS}}$$

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

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

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

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

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

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

Solids Retention Time (SRT): *see* Mean Cell Residence Time (MCRT)

$$\text{Specific Gravity} = \frac{\text{Specific Weight of Substance, lbs/gal}}{\text{Specific Weight of Water, lbs/gal}}$$

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

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

Three Normal Equation = $(N_1 \times V_1) + (N_2 \times V_2) = (N_3 \times V_3)$ *Where* $V_1 + V_2 = V_3$

Two Normal Equation = $N_1 \times V_1 = N_2 \times V_2$ *Where N = normality, V = volume or flow*

$$\text{Velocity, ft/sec} = \frac{\text{Flow Rate, ft}^3\text{/sec}}{\text{Area, ft}^2} \quad \textit{or} \quad \frac{\text{Distance, ft}}{\text{Time, sec}}$$

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

*Volume of Cone = (1/3) (.785) (Diameter^2) (Height)

= (1/3) [(π) (Radius^2) (Height)]

*Volume of Cylinder = (.785) (Diameter^2) (Height)

= (π) (Radius^2) (Height)

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

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

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

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

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

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

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

Abbreviations:

BOD	biochemical oxygen demand
CBOD	carbonaceous biochemical oxygen demand
cfs	cubic feet per second
COD	chemical oxygen demand
DO	dissolved oxygen
ft	feet
F/M ratio	food to microorganism ratio
g	grams
gpd	gallons per day
gpg	grains per gallon
gpm	gallons per minute
hp	horsepower
hr	hour
in	inches
kW	kilowatt
lbs	pounds
mg/L	milligrams per liter
MCRT	mean cell residence time
MGD	million gallons per day
min	minute
mL	milliliter
MLSS	mixed liquor suspended solids
MLVSS	mixed liquor volatile suspended solid
OCR	oxygen consumption rate
ORP	oxidation reduction potential
OUR	oxygen uptake rate
ppb	parts per billion
ppm	parts per million
psi	pounds per square inch
PE	population equivalent
Q	flow

Abbreviations(continued):

RAS	return activated sludge
RBC	rotating biological contactor
SDI	sludge density index
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
WAS	waste activated sludge

Conversion Factors:

1 acre = 43,560 square feet
1 acre foot = 326,000 gallons
1 cubic foot = 7.48 gallons
= 62.4 pounds
1 cubic foot per second = 0.646 MGD
1 foot = 0.305 meters
1 foot of water = 0.433 psi
1 gallon = 3.79 liters
= 8.34 pounds
1 grain per gallon = 17.1 mg/L
1 horsepower = 0.746 kW
= 746 watts
= 33,000 foot lbs/min
1 mile = 5,280 feet
1 million gallons per day = 694 gallons per minute
= 1.55 cubic feet per second (cfs)
1 pound = 0.454 kilograms
1 pound per square inch = 2.31 feet of water
1 ton = 2,000 pounds
1% = 10,000 mg/L
π or pi = 3.14159

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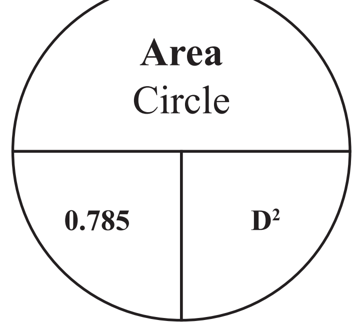
*Pie Wheel format for this equation is available at the end of this document.

***Pie Wheels:**

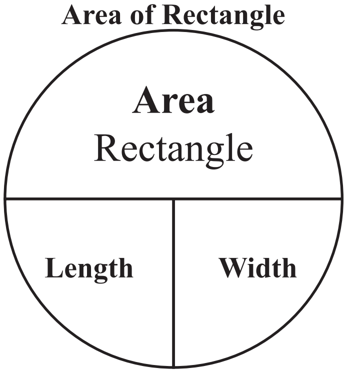
- To find the quantity above the horizontal line: multiply the pie wedges below the line together.
- To solve for one of the pie wedges below the horizontal line: cover that pie wedge, then divide the remaining pie wedge(s) into the quantity above the horizontal line.

Given units must match the units shown in the pie wheel.

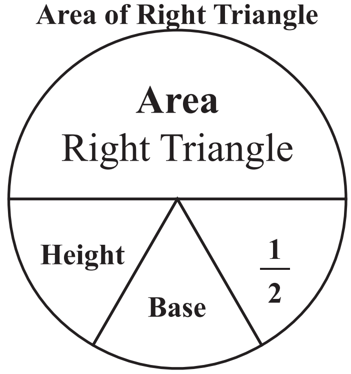
Area of Circle



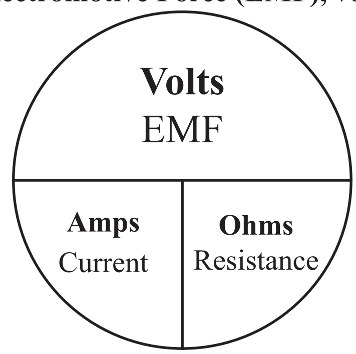
Area of Rectangle



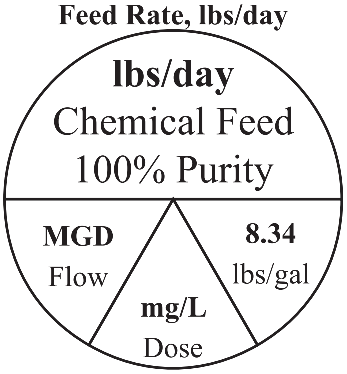
Area of Right Triangle



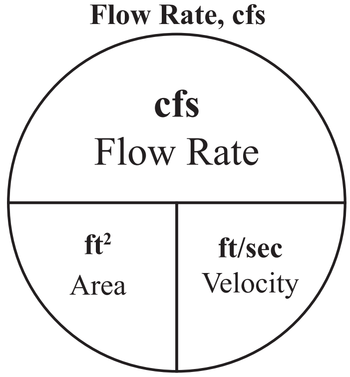
Electromotive Force (EMF), volts



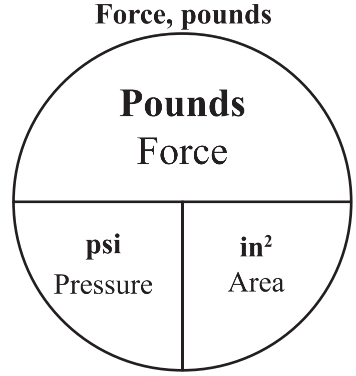
Feed Rate, lbs/day



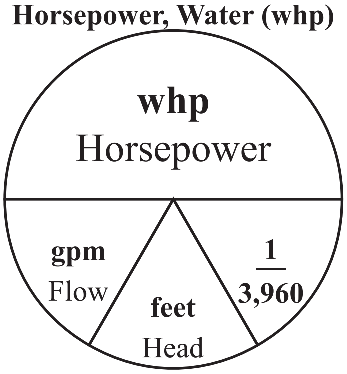
Flow Rate, cfs



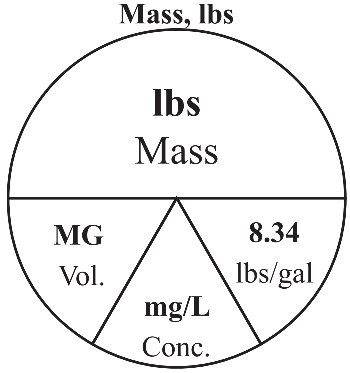
Force, pounds



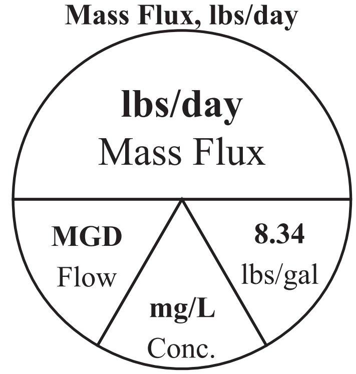
Horsepower, Water (whp)



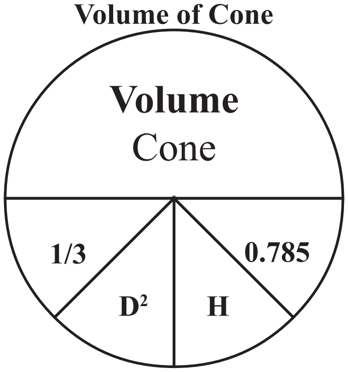
Mass, lbs



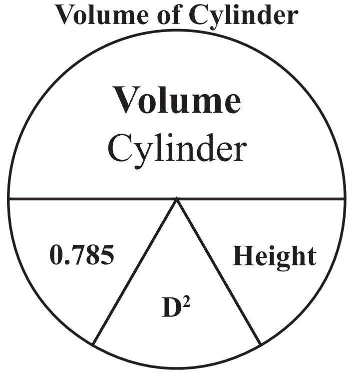
Mass Flux, lbs/day



Volume of Cone



Volume of Cylinder



Volume of Rectangular Tank