ABBREVIATIONS

English

ac-ft. = acre-foot or acre-feet

b = base (of right triangle)

°C = degrees Celsius

cfs or **ft^3/sec** = cubic feet per second

cfm or **ft^3/min** = cubic feet per minute

cfd or **ft^3/day** = cubic feet per day

D = diameter (circle)

°F = degrees Fahrenheit

fps or **ft./sec** = feet per second

ft. = feet

ft^2 or **sq. ft.** = square feet

ft^3 or **cu. ft.** = cubic feet

gpd = gallons per day

gpg = grains per gallon

gpm = gallons per minute

gps = gallons per second

h = height

hp = horsepower

hr = hour

hrs/day = hours per day

in = inches

in^2 = square inches

in^3 = cubic inches

lbs. = pounds

mi = miles

min = minute

MG = million gallons

mgd or **MGD** = million gallons per day

oz = ounces

ppb = parts per billion

ppm = parts per million

ppt = parts per trillion

psi = pounds per square inch

Q = flow

r = radius (circle)

sec = second

V = volume

W = watts

Metric

cm = centimeters

g = gram

Ha = Hectare

kg = kilogram

km = kilometer

kW = kilowatt

L or **l** = liters

m = meter

m^3 = cubic meter

mg = milligram

mg/L or **mg/l** = milligrams per liter

mL = ml or milliliter

mm = millimeter

CONVERSION FACTORS

LENGTH

English

1 foot = 12 in.
1 foot = 0.305 m
1 inch = 2.54 cm
1 mile = 5,280 ft.
1 mile = 1.609 km
1 yard = 3 ft.

Metric

1 centimeter = 0.3937 in.
1 kilometer = 0.6214 mi.
1 meter = 39.37 in.

AREA

English

1 acre (ac) = 43,560 ft^2
1 acre = 0.405 Hectare (Ha)
1ft^2 = 144 in^2
1 in^2 = 6.45 cm^2
1yd^2 = 9 ft^2

Metric

1 Hectare = 2.47 acres

VOLUME

English
1 acre-ft. = 325,828.8 gallons
1 acre-ft. = 43,560 ft^3
1 cfs = 0.646 MGD
1 ft^3 = 7.48 gallons
1 ft^3 = 1,728 in^3
1 gallon = 231 in^3
1 gallon = 0.1337 ft^3
1 gallon = 0.000001 MG
1 gallon = 3.785 liter
1 gallon = 3,785 mL
1yd^3 = 27 ft^3

Metric
1 liter = 1,000 mL
1 liter = 0.2642 gallons
1 m^3 = 264.2 gallons
1 m^3 = 35.315 ft^3

FLOW

1 ft^3/sec = 646,300 gpd
1 ft^3/sec = 0.6463 MGD
1 ft^3/sec = 448.8 gpm
1 gpm = 0.00144 MGD

1 MGD = 694.4 gpm
1 MGD = 1.545 cfs
1 MGD = 3.07 acre-ft/day

WEIGHT & MASS

English
1 ft^3 water = 62.4 lbs.
1 gallon water = 8.34 lbs.
1 gpg = 17.118 mg/L
1 lb. = 16 oz
1 lb. = 7,000 grains
1 lb. = 453.6 g
1 lb. = 0.4536 kg
1 ton = 2,000 lbs.

Metric
1 g = 1,000 mg
1 kg = 1,000 g
1 kg = 2.2 lbs.
1 mg/L = 0.0584 gpg
1% = 10,000 mg/L

DOSAGE

1% = 10,000 mg/L
1 gpg = 17.1 ppm
1 ppm = 1 mg/L
1 ppm = 8.34 lbs. per million gal

POWER

1 hp = 0.746kW
1 hp = 746 W
1 hp = 550 ft-lb/sec
1 hp = 33,000 ft-lbs/min
1 kW = 1.34 hp

PRESSURE

1 ft. water = 0.433 psi
1 psi = 2.31 ft. water

TIME

1 min = 60 sec
1 hr. = 60 min
1 day = 24 hrs
1 day = 1,440 min

FORMULAS

For the operator's convenience, both equation formulas and pie wheel formulas are included in this document. When using the pie wheel formula to solve a problem, multiply together the pie wedges below the horizontal line to solve for the quantity above the horizontal line. To solve for one of the pie wedges below the horizontal line, cover the pie wedge for which you are solving and divide the remaining pie wedge(s) below the horizontal line into the quantity above the horizontal line.

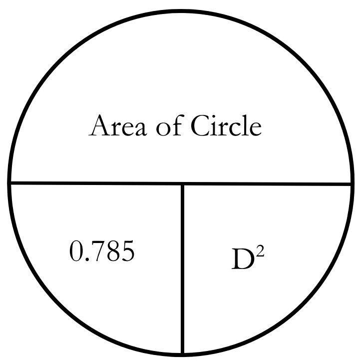
Area Formulas

Circle = $(0.785) \times (D^2)$

Where: Circle = area of circle
D = diameter of circle

Circle = $(\pi) \times (r^2)$

Where: Circle = area of circle
r = radius of circle
$\pi = 3.1416$



Cone (lateral area) = $(\pi) \times (r) \times (\sqrt{r^2 + h^2})$

Where: $\pi = 3.1416$
r = radius of circle
h = height of cone

Cone (area) = $[(b) \times (h)]/2$

Where: b = circumference
h = height

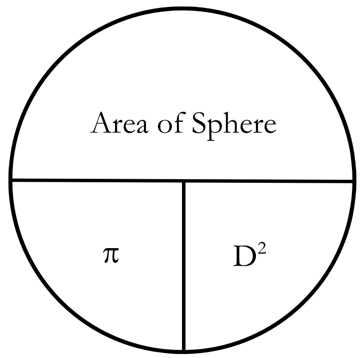
Cone (surface area) = $(\pi) \times (r) \times (r + \sqrt{r^2 + h^2})$

Where: $\pi = 3.1416$
r = radius of circle
h = height of cone

Sphere (area) = $(\pi) \times (D^2)$ or

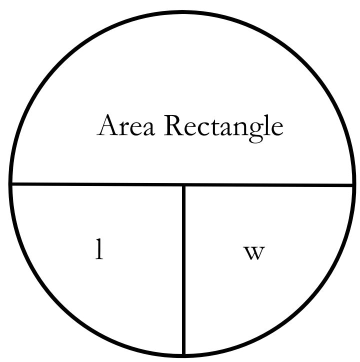
Sphere (area) = $4 \times (\pi) \times (r^2)$

Where: $\pi = 3.1416$
r = radius of circle
D = diameter of circle



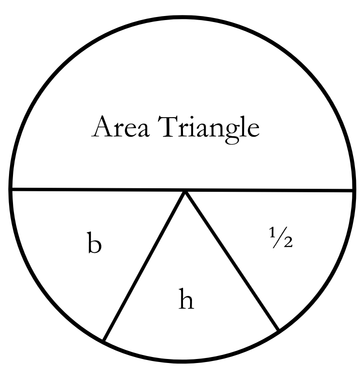
Rectangle = $(l) \times (w)$

Where: l = length of rectangle
w = width of rectangle



Triangle (area) = $[(b) \times (h)]/2$

Where: b = base of triangle
h = height of triangle



Circumference of Circle

Circumference = (π) x (D) Where: π = 3.1416
D = diameter of circle

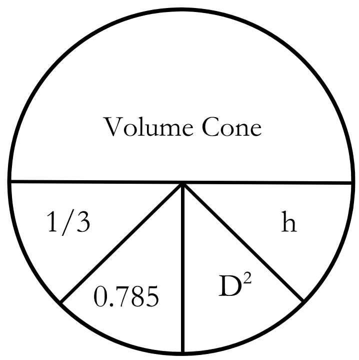
-.-

Circumference = (2) x (π) x (r) Where: π = 3.1416
r = radius of circle

-.-

Volume Formulas

Cone = (1/3) x (0.785) x (D^2) x (h) Where: D = diameter of cone
h = height of cone

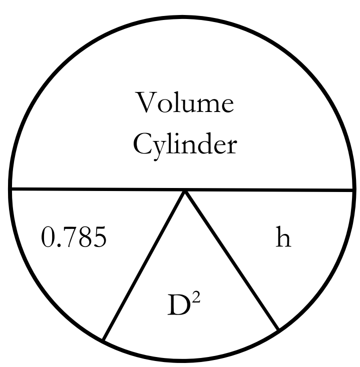


-.-

Cone = 1/3 x [(π) x (r^2) x (h)] Where: π = 3.1416
r = radius of cone
h = height of cone

-.-

Cylinder = (0.785) x (d^2) x (h) Where: D = diameter of cylinder
h = length of cylinder



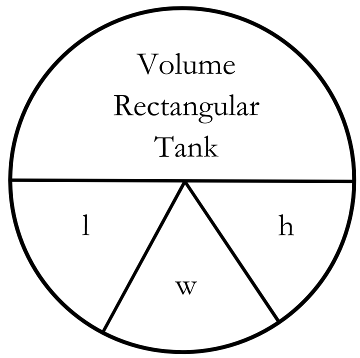
Cylinder = $(\pi) \times (r^2) \times (h)$

Where: $\pi = 3.1416$
r = radius of cylinder
h = length of cylinder

-.-

Rectangular Tank = $(l) \times (w) \times (h)$

Where: l = length of tank
w = width of tank
h = height of tank

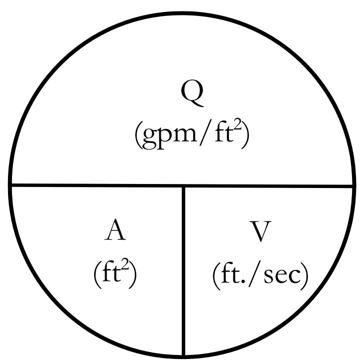


-.-

Flow Formulas

$Q = (A) \times (V)$

Where: Q = flow (ft^3/sec)
A = cross-section area (ft^2)
V = water velocity (ft./sec)



-.-

$Q = (w) \times (d) \times (V)$

Where: Q = flow in channel (ft^3/sec)
w = width (ft.)
d = depth (ft.)
V = velocity (ft./sec)

-.-

$Q = (0.785) \times (D)^2 \times (V)$

Where: Q = flow in full pipe (ft^3/sec)
D = diameter (ft.)
V = velocity (ft./sec)

$$Q = \{1.333 \times (h)^2 \times \sqrt{(D/h) - 0.608}\ \} \times (V)$$

Where:
Q = flow in partially full pipe (ft^3/sec)
h = height (ft.)
D = diameter (ft.)
V = velocity (ft./sec)

-.-

See also **Appendix A: Flow Through a Partially Full Pipe** (table)

-.-

$$V = (Q)/\{(0.785) \times (D)^2\}$$

Where:
V = velocity (ft./sec)
Q = flow (ft^3/sec)
D = diameter (ft.)

-.-

$$V = (d)/(T)$$

Where:
V = velocity (ft./sec)
d = distance (ft.)
T = time (sec)

-.-

$$Q = (\sum Q_{daily})/(n_{daily})$$

Where:
Q = avg. daily flow (MGD)
$\sum Q_{daily}$ = sum all daily flows (MGD)
n_{daily} = number of daily flows

-.-

$$Q = (\sum Q_{monthly})/(n_{monthly})$$

Where:
Q = avg. daily flow (MGD)
$\sum Q_{monthly}$ = sum all monthly avg. daily flows (MGD)
$n_{monthly}$ = number of monthly avg. daily flows

-.-

Q = (Water used)/(Population)

Where:
Q = daily flow (gal/capita/day)
water used or produced = gal/day
population = total # people served

-.-

Overflow rate = (Q)/(L)

Where:
overflow rate = weir overflow rate (gpd/ft.)
Q = flow (gpd)
L = weir length (ft.)

-.-

Dosage Formulas

$$\text{Dosage} = \frac{\text{Feed rate}}{(Q) \times (8.34 \text{ lbs./gal})}$$

Where:
dosage = mg/L
feed rate = chemical feed rate (lbs./day)
Q = flow rate (MGD)

$$\text{Dosage} = \frac{(\text{Feed rate}) \times (\text{Purity})}{(Q) \times (8.34\ \text{lbs./gal})}$$

Where:
dosage = mg/L
feed rate = chemical feed rate (lbs./day)
purity = chemical purity, % expressed as decimal
Q = flow rate (gal/min.)

-.-

$$\text{Dosage} = \frac{(\text{Feed rate}) \times (1{,}000\ \text{mg/g})}{(Q) \times (3.785\ \text{L/gal})}$$

Where:
dosage = mg/L
feed rate = chemical feed rate (lbs./day)
Q = flow rate (gal/min.)

-.-

Dose = Demand + Residual

-.-

Chemical Feed/Feed Rate Formulas (aka pounds)

$$\text{Chemical feed} = (d) \times (V) \times (8.34\ \text{lbs./gal})$$

Where:
chemical fee = lbs.
d = dose (mg/L)
V = volume (MG)

-.-

$$\text{Chemical feed} = \frac{(d) \times (V) \times (8.34\ \text{lbs./gal})}{\text{Chemical purity}}$$

Where:
chemical fee = lbs.
d = dose (mg/L)
V = volume (MG)
Chemical purity = %, expressed as decimal

-.-

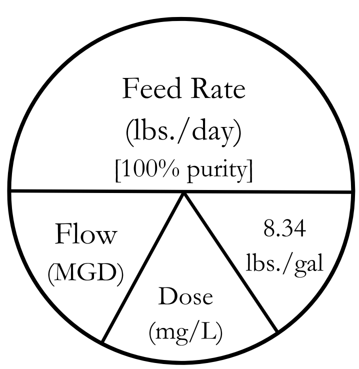
$$\text{Feed rate} = (d) \times (Q) \times (8.34\ \text{lbs./gal})$$

Where:
feed rate = lbs./day
d = dose (mg/L)
Q = flow (MGD)

-.-

$$\text{Feed rate} = \frac{(d) \times (Q) \times 8.34\ \text{lbs./gal}}{\text{Chemical Purity}}$$

Where:
feed rate = lbs./day
d = dose (mg/L)
Q = flow (MGD)
Chemical purity = %, expressed as decimal



$$\text{Feed rate} = \frac{(C) \times (V) \times (1{,}440 \text{ min/day})}{(T) \times (1{,}000 \text{ mg/g}) \times (453.6 \text{ g/lb.})}$$

Where:
feed rate = lbs./day
C = concentration (mg/mL)
V = volume pumped (mL)
T = time pumped (min.)

-.-

Chemical Feed Pump Formulas

$$\text{Chemical Feed Stroke} = (Q_d/Q_m) \times 100\%$$

Where:
chemical feed stroke, expressed as %
Q_d = desired flow
Q_m = maximum flow

-.-

$$\text{Feed pump rate} = \frac{(Q) \times (d) \times (3.785 \text{ L/gal}) \times (1{,}000{,}000 \text{ gal/MG})}{(L) \times (24 \text{ hr/day}) \times (60 \text{ min/hr})}$$

Where:
feed pump rate =mL/min
Q = flow (MDG)
d = dose (mg/L)
L = liquid (mg/mL)

-.-

Power Formulas

$$\text{AC circuit} = V \times A \times PF$$

Where:
AC = AC circuit
V = volts
A = amps
PF = power factor

-.-

$$\text{Amps (A)} = \frac{V}{O}$$

Where:
A = amps
V = volts
O = ohms

-.-

$$\text{Amps} = \frac{(746 \text{ watts/hp}) \times (hp)}{(V) \times (Eff) \times (Pf)}$$

Where:
Amps is single phase
hp = horsepower
V = volts
Eff = efficiency (%, as decimal)
Pf = power factor

-.-

$$\text{Amps} = \frac{(746 \text{ watts/hp}) \times (hp)}{(1.732) \times (V) \times (Eff) \times (Pf)}$$

Where:
Amps is three-phase
hp = horsepower
V = volts
Eff = efficiency (%, as decimal)
Pf = power factor

Watts = V x A

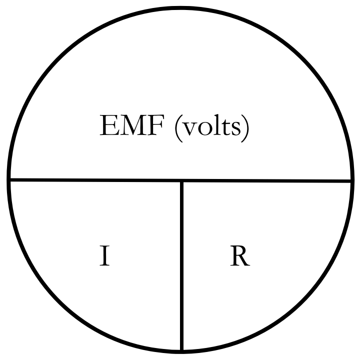
Where:
Watts = DC or AC circuit
V = volts
A = amps

-.-

Electromotive Force (EMF) = I x R

Where:
(volts)
EMF = electromotive force

I = current (amps)
R = resistance (ohms)



-.-

PUMPS

Pumping Formulas

Pumping Rate = V/T

Where:
pumping rate in gal/min
V = volume (gal.)
T = time (min.)

-.-

$$\text{Pumping Rate} = \frac{L \times W \times D \times 7.48\ \text{gal/ft}^3}{T}$$

Where:
pumping rate in gal/min
L = length (ft.)
W = width (ft.)
D = depth (ft.)
T = time (min.)

-.-

$$\text{Pumping Rate} = \frac{0.785 \times d^2 \times D \times 7.48\ \text{gal/ft}^3}{T}$$

Where:
pumping rate in gal/min
d = diameter (ft.)
D = depth (ft.)
T = time (min.)

-.-

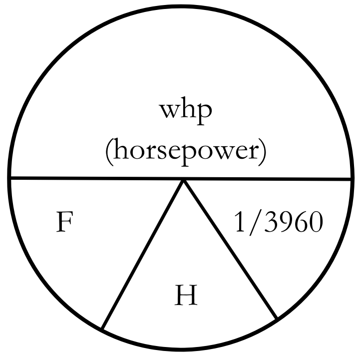
$$\text{Time to Fill} = \frac{\text{Tank volume}}{\text{Flow Rate}}$$

Where:
time to fill in min.
tank volume in gal.
flow rate in gal/min.

Horsepower, Motor & Pump Efficiency

$$whp = \frac{F \times H}{3{,}960}$$

Where:
whp = water horsepower
F = flow (gpm)
H = head (ft.)



-.-

$$bhp = \frac{F \times H}{3{,}960 \times PE}$$

Where:
bhp = brake horsepower
F = flow (gpm)
H = head (ft.)
PE = pump efficiency (%, as decimal)

-.-

$$bhp = whp/PE$$

Where:
bhp = brake horsepower
whp = water horsepower
PE = pump efficiency (%, as decimal)

-.-

$$mhp = \frac{F \times H}{3{,}960 \times PE \times ME}$$

Where:
mhp = motor horse power
F = flow (gpm)
H = head (ft.)
PE = pump efficiency (%, as decimal)
ME = motor efficiency (%, as decimal)

-.-

$$mhp = bhp/ME$$

Where:
mhp = motor horse power
Bhp = brake horsepower
ME = motor efficiency (%, as decimal)

-.-

$$ME = (bhp/mhp) \times 100\%$$

Where:
ME = motor efficiency (%)
bhp = brake horsepower
mhp = motor horse power

-.-

$$PE = (whp/bhp) \times 100\%$$

Where:
PE = pump efficiency (%)
whp = water horsepower
bhp = brake horsepower

$$\text{Efficiency} = \frac{\text{hp output}}{\text{hp supplied}} \times 100\%$$

Where: efficiency is %

-.-

Overall Efficiency = (whp/mhp) x 100%

Where: overall efficiency is %
whp = water horsepower
mhp = motor horse power

-.-

$$\text{Wire to water efficiency} = \frac{\text{whp}}{\text{Power input or mhp}}$$

Where: wire to water efficiency is %
whp = water horsepower
mhp = motor horse power
power input is hp

-.-

Wire to water efficiency = (PE x ME) x 100%

Where: wire to water efficiency is %
PE = pump efficiency (%)
ME = motor efficiency (%)

-.-

Static Head = Suction lift + Discharge Head

Where: Static Head in ft.
Suction Lift in ft.
Discharge Head in ft.

-.-

Static Head = Discharge Head – Suction Head

Where: Static Head in ft.
Discharge Head in ft.
Suction Head in ft.

-.-

Friction Loss = (0.1) x (Static Head)
** use this formula in absence of other data

Where: Friction Loss is ft.
Static Head is ft.

-.-

Total Dynamic Head = Static Head + Friction Loss

Where: Total Dynamic Head is ft.
Static Head is ft.
Friction Loss is ft.

-.-

Cost = (Motor hp) x (0.746 kW/hp) x (Cost, $/kW-hr)

Where: Cost is $/hr.

$PL = (Population)/(A)$

Where: PL = population loading (persons/acre)
Population = population served (persons)
A = pond area (acres)

-.-

$V = (A) \times (d)$

Where: V = pond volume (ac-ft.)
A = pond area (acres)
d = pond depth (ft.)

-.-

$V = [(L) \times (W) \times (d)]/(43{,}560\ ft^2/ac)$

Where: V = pond volume (ac-ft.)
L = length (ft.)
W = length (ft.)
d = pond depth (ft.)

-.-

$V (gal) = [V (ac\text{-}ft.)] \times (43{,}560\ ft^2/ac) \times (7.48\ gal/ft^3)$

Where: V = pond volume

-.-

$A = [(L) \times (W)]/(43{,}560\ ft^2/ac)$

Where: A = pond area (acre)
L = length (ft.)
W = length (ft.)

-.-

$Q (ac\text{-}ft./day) = [Q (gal/day)]/[(7.48\ gal/ft3) \times (43{,}560\ ft^2/ac)]$

Where: Q = flow

-.-

$DT = (V)/(Q)$

Where: DT = detention time (days)
V = volume (gal)
Q = flow (gal/day)

-.-

$DT = (V)/(Q)$

Where: DT = detention time (days)
V = volume (ac-ft.)
Q = flow (ac-ft/day)

$BOD\ loading = (BOD_5) \times (Q) \times (8.34\ lbs./gal)$

Where:
BOD loading = lbs./day
BOD_5 = biological oxygen demand (MGD)
Q = flow (MGD)

-.-

$OLR = (BOD)/(A)$

Where:
OLR = organic loading rate (lbs./day/acre)
BOD = influent BOD (lbs./day)
A = pond areas (acres)

-.-

$OLR = [(BOD) \times (Q) \times (8.34\ lbs./gal)]/(A)$

Where:
OLR = organic loading rate (lbs/day/acre)
BOD = influent BOD (mg/L)
Q = flow (MGD)
A = pond areas (acres)

-.-

$BOD\ removal\ efficiency, \% = [(BOD_{removed})/(BOD_{total})] \times 100\%$

Where:
$BOD_{removed}$ = BOD removed (mg/L)
BOD_{total} = total BOD (mg/L)

-.-

$HLR = [(Q)/(A)] \times 12\ in/ft.$

Where:
HLR = hydraulic loading rate (in/day)
Q = flow (ac-ft/day)
A = pond area (acres)

-.-

Loading Formulas (general)

$Loading = (Concentration) \times (Q) \times (8.34\ lbs/gal)$

Where:
Loading is TSS or BOD = lbs./day
Concentration of TSS or BOD = mg/L
Q = flow

-.-

$$\text{Hydraulic loading rate} = \frac{\text{Flow}}{A}$$

Where:
Hydraulic Loading = gpd/ft^2
Flow = gpd
A = area (ft^2)

-.-

$$\text{Surface loading rate or Surface overflow rate} = \frac{\text{Flow}}{A}$$

Where:
Surface Loading/Surface Overflow rate in gpd/ft^2
Flow = gpd
A = area (ft^2)

Temperature Conversions

$°C = (°F - 32) \times (0.566)$

$°F = (°C \times 1.8) + 32$

Where:
°C = degrees Celsius
°F = degrees Fahrenheit

Average Formulas

Average (arithmetic mean) = (sum of all terms)/(number of terms)

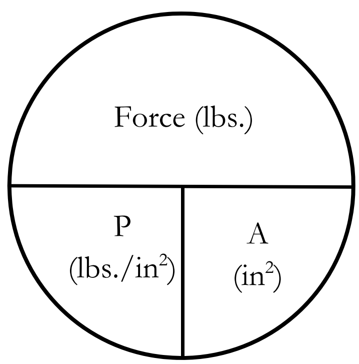
Average (geometric mean) = $\sqrt[n]{(X_1)(X_2)(X_3)(X_4)\ \ldots\ (X_n)}$

The n*th root of the product of n numbers*

FORCE

$F = (P) \times (A)$

Where:
F = force (lbs.)
P = pressure (psi or lbs./in²)
A = area (in²)



WET WELL

$$\text{Cycle time (min)} = \frac{SV}{PC - \text{Inflow}}$$

Where:
SV = storage volume (gal)
PC = pump capacity (gpm)
Inflow = wet well inflow (gpm)

COLLECTION SYSTEM

Slope, % = $\left[\frac{\text{Drop or rise}}{\text{Distance}}\right] \times 100\%$ OR Slope, % = $\left[\frac{\text{Rise}}{\text{Run}}\right] \times 100\%$

-.-

Velocity = F/A

Where:
Velocity is ft./sec
F = flow (ft^3/sec)
A = area (ft^2)

-.-

Velocity = $\frac{\text{Distance}}{\text{Time}}$

Where:
Velocity is ft./sec
D = distance (ft.)
T = time (sec)