

WATER MATH: CONVERSIONS and FORMULAE

**2009 ANNUAL CONFERENCE
-BASIC WATER TREATMENT-**



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References

- ❖ Basic Math Concepts for Water and Wastewater Plant Operators, Joanne Kirkpatrick Price, Technomic Publishing Co., Inc., 1991.
- ❖ Applied Math for Water/Wastewater Plant Operators & Workbook, Texts and Workbooks, Joanne Kirkpatrick Price, Technomic Publishing Co., Inc., 1991.
- ❖ Wastewater Math The Basics, Skeet Arasmith, ACR Publications, Inc., 1995.
- ❖ The Math Text for Water and Wastewater Technology, 2nd ed., Grover Wright, Wright's Training, 1994.
- ❖ Simplified Math for Waterworks Operators, George Mason, ACR Publications, Inc., 1992.

Acronyms and Abbreviations

A = area

V = velocity

t = time

Vol = volume

= pounds

W = width

D = depth

L = length

Q = flow

r = radius

dia = diameter

cir = circumference

π = 3.14

Hp = horse power

psi = pounds per inch

ft = feet

sq = square

cu = cubic

yd = yard

DT = detention time

mg/L = milligrams per litre

ppm = parts per million

MGD = million gallons per day

gpm = gallons per minute

Cl₂ = chlorine

Math Equivalents

- 12 inches = 1 foot
- 36 inches = 3 feet or 1 yard
- 144 square inches = 1 sq. ft.
- 9 square feet = 1 sq. yd.
- 43,560 sq. ft. = 1 acre
- 325,828 gallons = 1 acre foot
- 1 cubic foot = 1,728 cu. in.
- 1 cu.ft. of water contains 7.48 gals. & weighs 62.4 lbs.
- 1 gal. of water weighs 8.34 lbs.
- 1 liter = 1,000 milliliters
- 1 gram = 1,000 milligrams
- 1 mg/L = 1 ppm
- 1 kilogram = 1,000 grams
- 1 pound = 453.6 grams
- 1 gal. of water = 3.785 liter or 3,785 milliliters

Math Equivalents

1 grain per gal. = 17.1 ppm

1 cubic yard = 27 cubic feet

1% = 10,000 mg/L

1 psi = 2.31 feet of water

1 atmosphere = 14.7 psi

1 day = 24 hours = 1,440 min. = 86,400 sec.

1 MGD = 694 gals./min = 1,545 ft³/sec.

1 Hp = .746 kw = 550 ft. lbs/sec = 33,000ft.lbs./min.

Words and Symbols

Hierarchy of Operations

MATH OPERATION	SYMBOL	EXAMPLE
Multiplication	X	$Q = V \times A$
Multiplication	.	$Q = V \cdot A$
Multiplication	No space	$Q = VA$
Multiplication	() ()	$Q = (V) (A)$
Division		$r = D \quad 2$
Division	—	$r = \frac{D}{2}$
Division	/	$r = D/2$

Word Problems

- Word problems are a series of expressions that fits into an equation. An equation is a combination of math expressions. Suggestions:
- **Read the problem entirely**
Get a feel for the whole problem
- **Draw a diagram to describe the problem statement**
- **List information** and the **variables** you identify
Attach units of measure to the variables (gallons, miles, inches, etc.)
- **Define what answer you need**,
as well as its units of measure
- **Set up equation(s), solve for variable, populate with data**
- **Work in an organized manner**
Working clearly will help you think clearly
 - Draw and label all graphs and pictures clearly
 - Note or explain each step of your process;
this will help you track variables and remember their meanings
- **Look for the "key" words (above)**
Certain words indicate certain mathematical operations.

Common Conversions

1. Linear Measurements

- 1 inch = 2.54 cm
- 1 foot = 30.5 cm
- 1 meter = 100 cm = 3.281 = 39.4 inches
- 1 acre = 43,560 sq. ft.
- 1 yard = 3 feet

2. Volume

- 1 gal. = 3.78 liters
- 1 cubic foot (ft³) = 7.48 gals.
- 1 liter = 1000 mL
- 1 acre foot = 43,560 cubic feet
- 1 gal = 16 oz. dry wt.

3. Weight

- 1 ft³ of water = 62.4 lbs.
- 1 gal. = 8.34 lbs.
- 1 lb. = 453.6 grams
- 1 kg = 1000 g = 2,2 lbs.
- 1 % = 10,000 mg/L

4. Pressure

- 1 ft. of head = 0.433 psi
- 1 psi = 2.31 ft. of head

5. Flow

- 1 cfs = 448 gpm
- 1 gpm = 1440 gpd

Example # 1

- Question: How many feet are in 18 inches
- Known: 1 foot = 12 inches
- Solution?

- Example # 2
 1. Question: How many gallons are in 3291 cubic feet (cu.ft.)?
 2. Known: 1 cubic feet = 7.48 gallons.
 3. Solution: ?

- Example # 3
 1. Question: how many feet are in $\frac{1}{4}$ mile?
 2. Known: 1 mile = 5280 ft.
 3. Solution: ?

- Example # 4
- Question: convert 3,920 cu.ft. to cubic yards (cu.yds.)
- Known: 1 cu.yds. = 27 cu.ft.
- Solution: ?

- Example # 5
- Gallons Per Day (GPD)
- Million Gallons Per Day (MGD)
- Question: convert 3,211,000 GPD to MGD
- Known: 1 MGD = 1,000,000 GPD
- Solution: ?

The Ohm's Law Pie Chart

P = Watts

$$\text{Watts} = \frac{\text{Volts}^2}{\text{Ohms}}$$

$$\text{Watts} = \text{Amperes}^2 \times \text{Ohms}$$

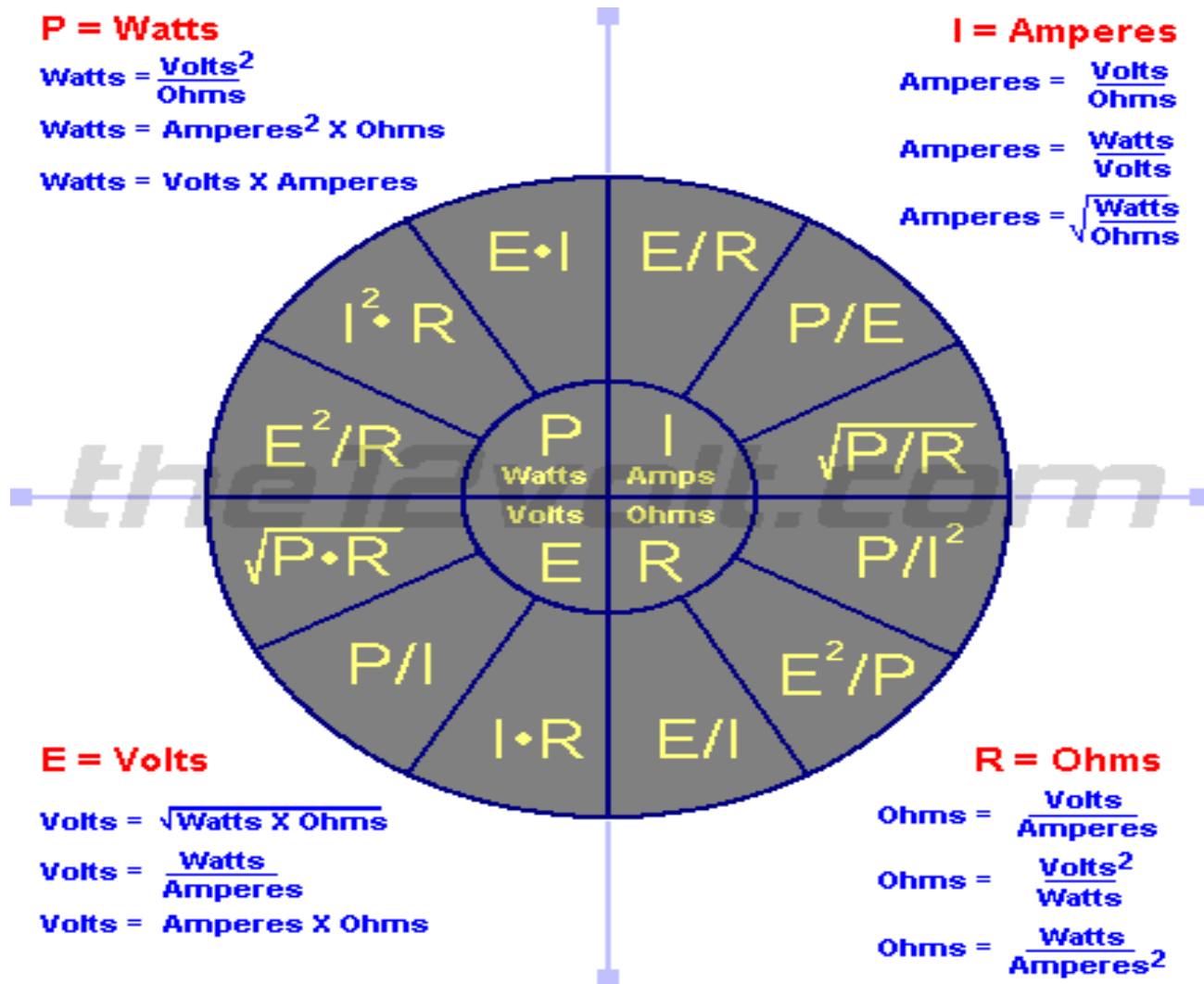
$$\text{Watts} = \text{Volts} \times \text{Amperes}$$

I = Amperes

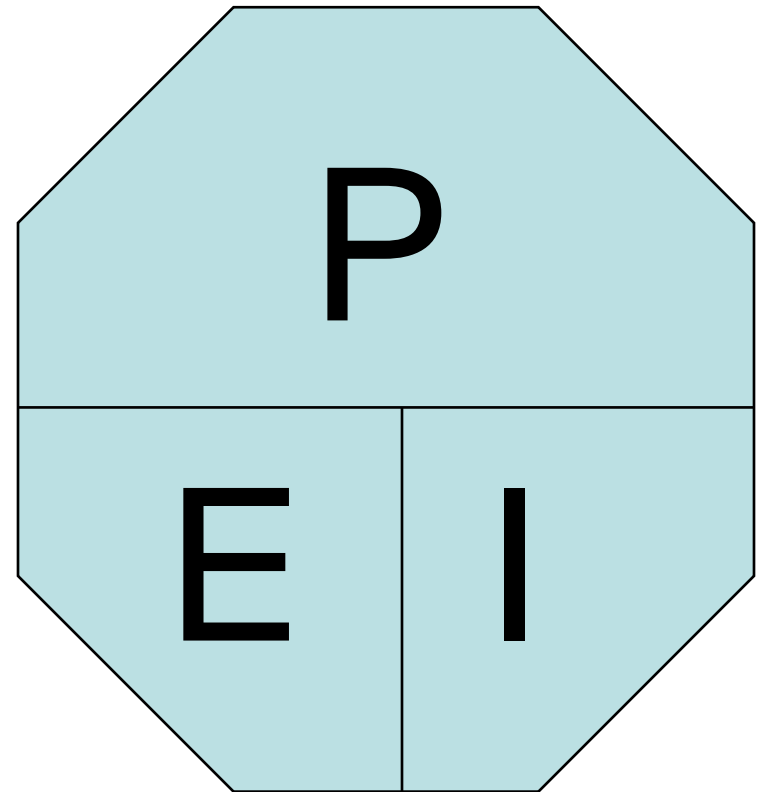
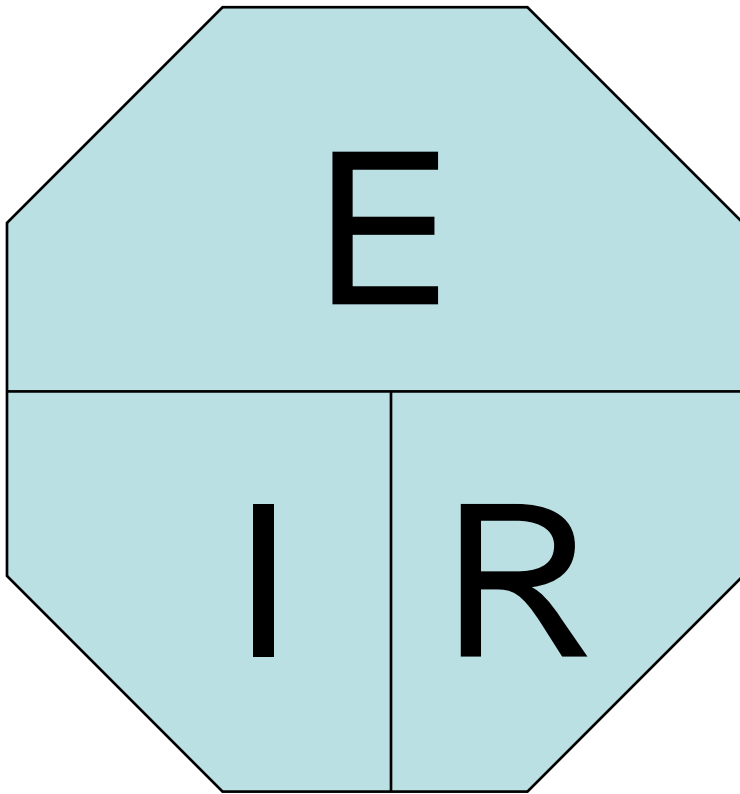
$$\text{Amperes} = \frac{\text{Volts}}{\text{Ohms}}$$

$$\text{Amperes} = \frac{\text{Watts}}{\text{Volts}}$$

$$\text{Amperes} = \sqrt{\frac{\text{Watts}}{\text{Ohms}}}$$

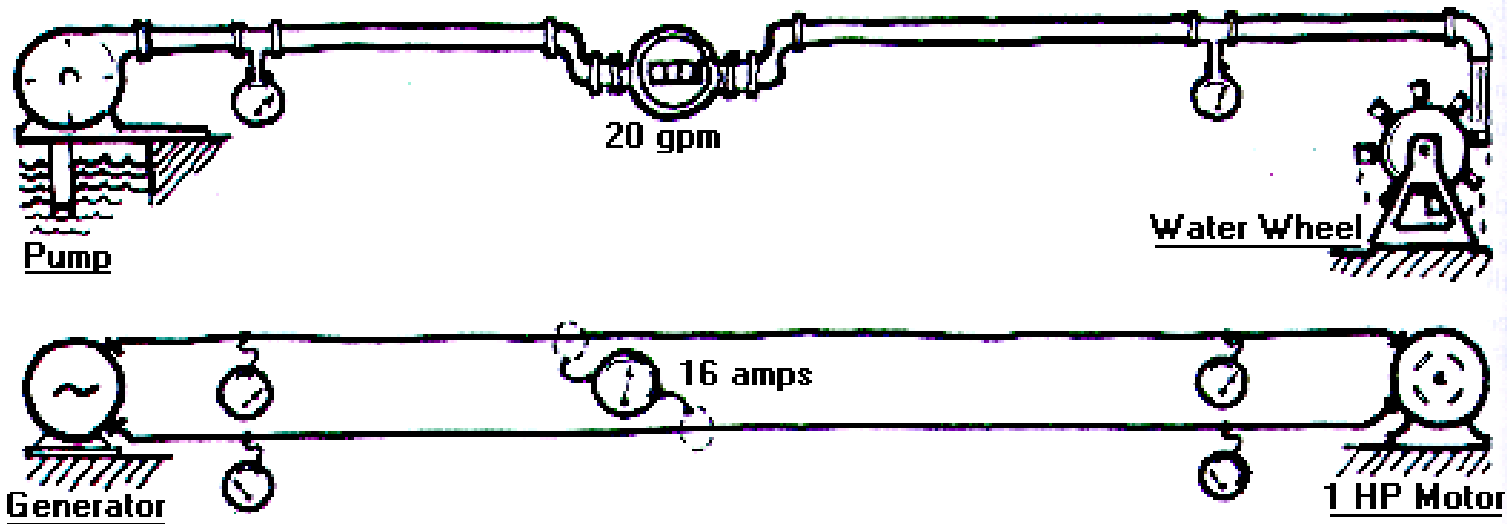


The Ohm's Law Pie Chart Shortcut Calculations



Current, I (Amps)

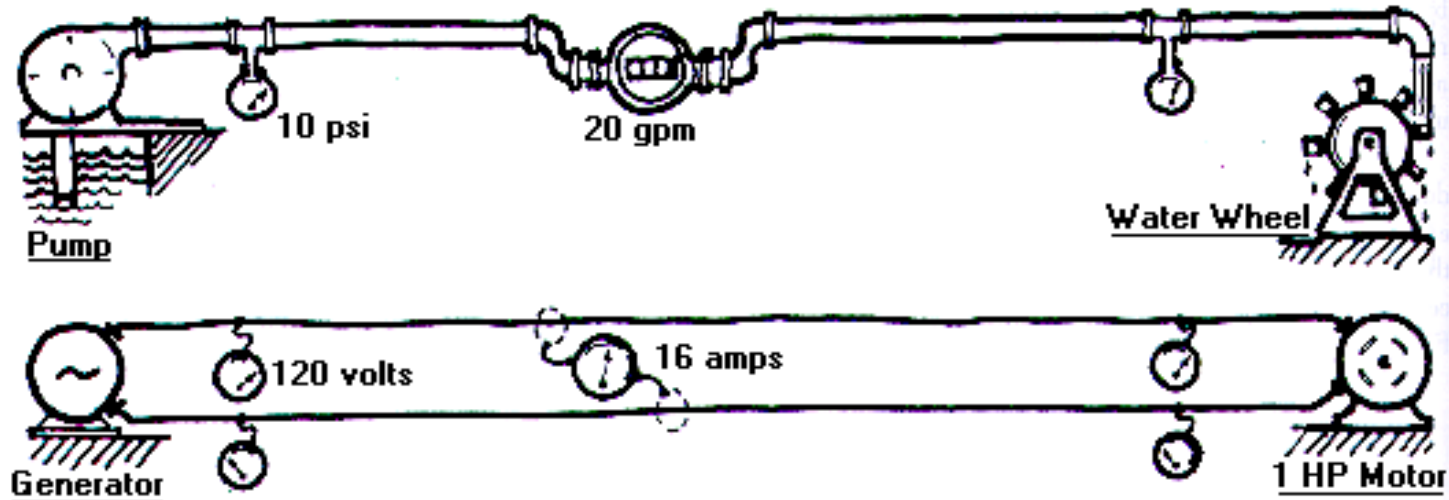
“Flow” of electricity defined as
one Coulomb per second



Voltage, V (Volts)

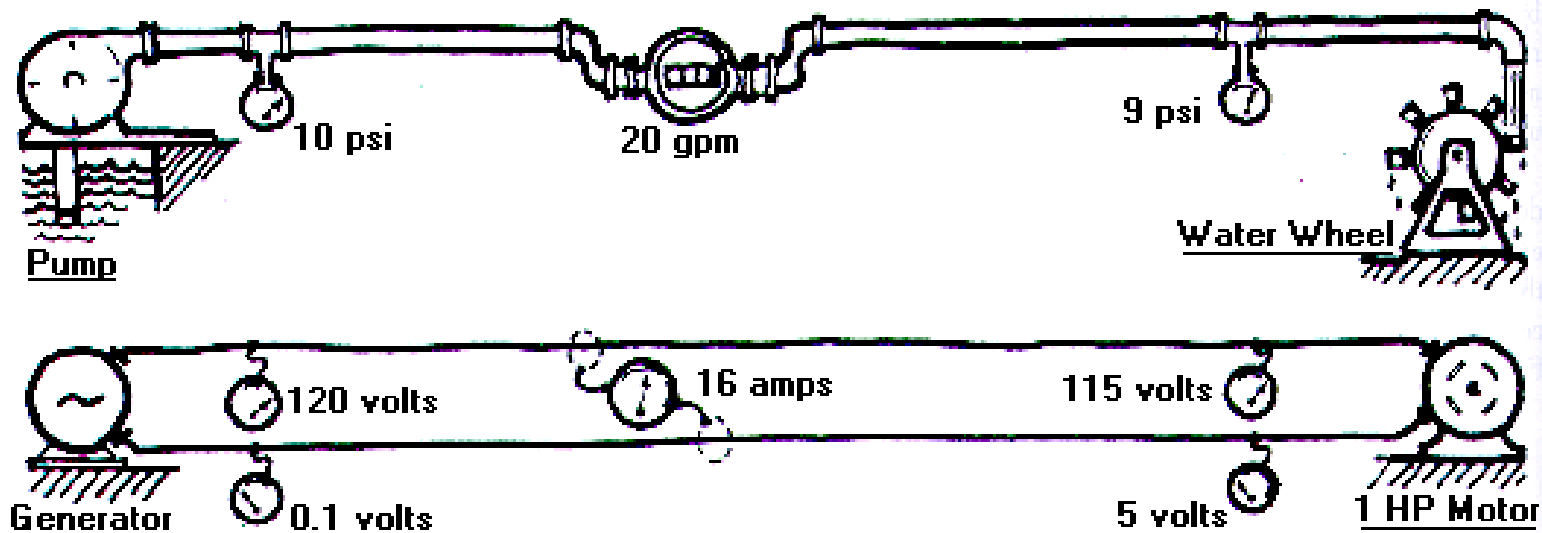
❖ Defined as Electromotive Force, or EMF

❖ Similar to pressure in a water system



Resistance, R (Ohms)

- ❖ The unit of resistance to current flow – similar to headloss in a water system
- ❖ An ohm is the amount of resistance that allows 1 amp of current to flow when the applied voltage is 1 volt



Power, P (Watts or HP)

- A function of both voltage and amps:
 - ❖ Volts X Amps = Watts
- Wattage is a measure of work
- 1000 watts = 1 KW = 1.34 HP, or
- 1 HP = 746 watts = 0.746 KW

Temperature Conversion

- There are two scales used to report temperature;
- Fahrenheit (F) = English scale
- Celsius (C) = metric scale
- $C = 5/9 (F - 32)$ or
- $C = 0.55 (F - 32)$ or
- $C = (F - 32) \div 1.8$
- $F = (9/5 \times C) + 32$ or
- $F = (1.8 \times C) + 32$

Temperature Scales

Fahrenheit	Celsius	Kelvin	
212	100	373	Boiling point of water at sea-level
194	90	363	
176	80	353	
158	70	343	
140	60	333	
122	50	323	
104	40	313	
86	30	303	
68	20	293	Average room temperature
50	10	283	
32	0	273	Melting (freezing) point of ice (water) at sea-level
14	-10	263	
-4	-20	253	
-22	-30	243	
-40	-40	233	
-58	-50	223	
-76	-60	213	
-94	-70	203	
-112	-80	193	-89°C (-129°F) Lowest recorded temperature. Vostok, Antarctica July, 1983
-130	-90	183	
-148	-100	173	

Reference: Ahrens (1994)

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