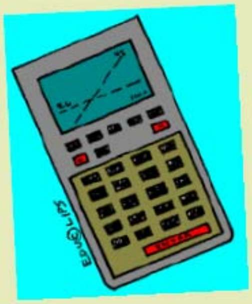
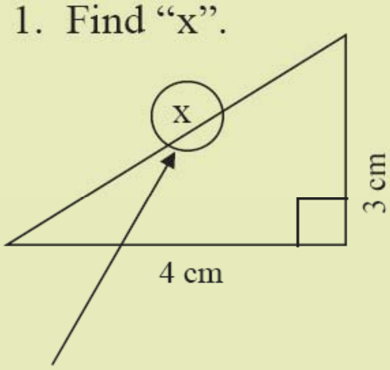
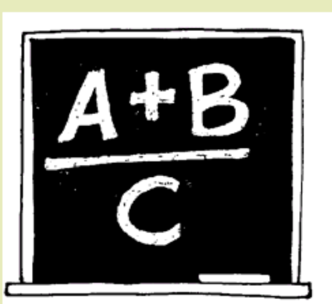
DISTRIBUTION MATH REVIEW



1. Find "x".



Here it is.



Kentucky Water Distribution System Operators

COMMONWEALTH OF KENTUCKY
ENERGY AND ENVIRONMENT CABINET
DIVISION OF COMPLIANCE ASSISTANCE
CERTIFICATION AND LICENSING BRANCH
OPERATOR CERTIFICATION PROGRAM

Kentucky Board of Certification of
Water Treatment and Distribution System Operators

certifying **Professionals**

This booklet is intended to provide a basic mathematical guide to be used in conjunction with the formula sheet given to the student in both certification class as well as the day of the test. The answers to the problems are provided in the back of this booklet.

The solving of math problems is one of most frequent sources of apprehension for operators. This booklet is an attempt to assuage these fears. The ability to comprehend and use these mathematical principles can greatly increase the operator's knowledge of how and why events occur in the system which will result in cleaner water and a more viable, better run system.

Solving math problems are really not different than solving any other type of problem. Determining where to start and following through on the necessary steps to complete the task are similar to any type of problem solving. A viable approach would be to approach any problem as follows:

1) Determine what the problem is asking.
2) Determine if there is an applicable formula needed.
3) Perform any necessary conversions to fulfill the requirements of the formula.
4) Plug the numbers into the formula.
5) Make sure the answer is in the units necessary to satisfy the question.

$$\frac{\text{numerator}}{\text{denominator}}$$

EXAMPLE:

$$\frac{12 \text{ X } 12}{6} =$$

$$\frac{144}{6} =$$

$$24$$

INCORRECT:

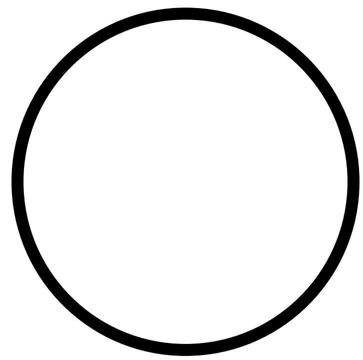
$$\frac{12 \times 12}{6} = \frac{2 \times 2}{1} = \frac{4}{1} = 4$$

MATHMATICAL "RULES"

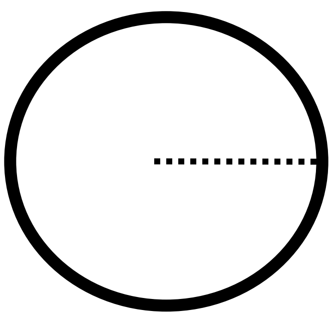
1) Complete the calculations in the numerator before completing the calculations in the denominator.
2) Do the calculations in the parenthesis first.
3) Multiplication operations can be indicated by several symbols. EXAMPLES:
   a) 5 feet • 4 feet = 20 ft²
   b) [5 feet] [4 feet] = 20 ft²
   c) (5 feet) (4feet) = 20 ft²
   d) 5 feet X 4 feet = 20 ft²
4) The order by which numbers are multiplied has NO impact on the final answer.
5) Division is the reverse operation of multiplication.
6) Division problems can be written several ways. EXAMPLES:
   a) $\frac{41.7 \text{ lbs.}}{8.34 \text{ lbs.}}$ = 5 gallons
   b) 41.7 lbs/8.34 lbs. = 5 gallons
   c) (41.7 lbs.)/(8.34 lbs) = 5 gallons
   d) 41.7 lbs. ÷ 8.34 lbs. = 5 gallons
7) The order by which numbers are divided DOES have an impact on the final answer. The correct order must be maintained to derive the correct answer.
8) To turn a percentage into a decimal equivalent, divide by 100.
9) To turn a decimal into a percentage equivalent, multiply by 100.

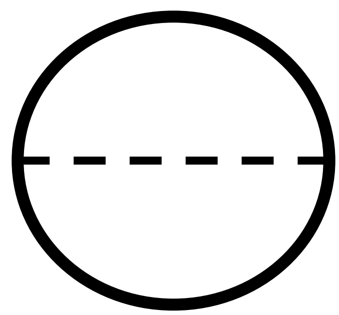
BASIC GEOMETRIC SHAPES and DEFINITIONS

Rectangle – a two – dimensional geometric figure formed of four sides in which each angle is a right angle.



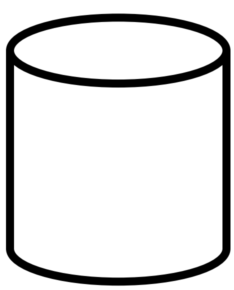
Circle – a two – dimensional geometric figure formed of a curved line surrounding a center point, every point of the line being an equal distance from the center point



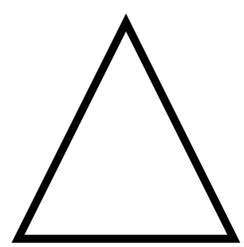


Radius – a straight line extending from the center of a circle to its edge.

Diameter – a straight line running from one side of a circle through the center to the other side. The width or thickness something circular or cylindrical.



Cylinder – a three-dimensional geometric form bounded by two equal parallel circles to a fixed straight line forming a hollow tube shape.



Triangle – a two-dimensional geometric figure formed of three sides and three angles.

CONVERSIONS

We use conversions every day. Four quarters is equivalent to a dollar. Thirty - six inches is equivalent to three feet.

1 psi	=	2.31 ft. of head
1 ft of head	=	.433 psi
1 cuft of water	=	7.48 gallons
1 cuft of water	=	62.4 lbs.
1 gallon	=	8.34 lbs.
1 gallon	=	3,785 ml (milliliters)
1 Liter	=	1,000 ml
1 mg/L	=	8.34 lbs/MG
1 ppm	=	1 mg/L
1 pound	=	453.6 grams
1 pound	=	7,000 grains
1 kilogram	=	1,000 grams
1 cuft/sec	=	448.8 gpm
1 MGD	=	1.55 cuft/sec (ft^3/sec)
1 MGD	=	694.5 gpm
1 horsepower	=	33,000 ft.lbs./min
1 horsepower	=	.746 kilowatt
1 mile	=	5,280 feet

You will notice that every entity in the left hand column has a numeric value of one and everything in the right hand column (except for 1 mg/L) does not.

If you know the quantity of the heading in the left hand column and need to determine the equivalent in the right hand column, you would multiply.

EXAMPLES:

Five miles is equivalent to ___________ feet.

We know the quantity in the left hand column, 5 miles, so all we need to do is multiply by X 5280 feet.

Five miles = 26,400 feet.

The quantity known is on the left hand column, the unknown quantity is on the right hand column. We are moving from left to right so we would multiply.

5.5 MGD = _________?

On the conversion sheet we see:

1 MGD = 694.5 gpm
5.5 MGD X 694.5 gpm
5.5 MGD = 3819.75 gpm

If the quantity given in the problem is on the right hand column and we need to determine the equivalent quantity on the left hand side we would divide.

EXAMPLES:

7.75 ft^3/sec is equivalent or = _____________ MGD?

On the conversion sheet we see:

1MGD = 1.55 cuft/sec
7.75 ft^3 ÷ 1.55 ft^3/sec = 5 MGD.

249.6 lbs. of water is equivalent to or equals _______ ft^3 of water?

On the conversion sheet we see:

1 cuft/water = 62.4 lbs.
249.6 lbs ÷ 62.4 lbs = 4 ft^3/water

THERE WILL BE ONLY <u>ONE</u> LINE ON THE FORMULA SHEET THAT HAS THE UNITS NEEDED FOR YOUR PROBLEM.

PROBLEMS:

1) 10 psi	=	___?___	ft. of head
2) 5 gallons	=	___?___	ml
3) 41.7 lbs	=	___?___	gallons
4) 2268 grams	=	___?___	pounds
5) 5 cuft/sec	=	___?___	gpm
6) 42240 ft	=	___?___	miles
7) 4167 gpm	=	___?___	MGD
8) 15 cuft of water	=	___?___	gallons
9) 8 MGD	=	___?___	cuft/sec
10) 80 ft. of head	=	___?___	psi
11) 11 MGD	=	___?___	gpm

OBJECT	**AREA (ft^2)**	**VOLUME (ft^3)**
Rectangle	**Length' X Width'**	**Length' X Width' X Height'**
Circle	**.785 X D' X D'**	
Triangle	**½ (Base' X Altitude')**	
Cylinder		**.785 X D' X D' X Length'**
Sphere		**.5236 X D' X D' X D'**

Diameter (D) = 2 X radius

Circumference = 3.14 X D'

Perimeter = Sum of the sides

AREA

Area is a two - dimensional measurement usually notated (for our purposes) in inches, feet, yards, or miles. For instance, if you needed to cover up the maintenance shop's roof after it was blown off you would measure the size of the opening in order to get a tarp large enough to cover the hole. If the opening in the roof was 10 feet by 12 feet then we would multiply;

$$10 \text{ ft} \times 12 \text{ ft} = 120 \text{ square feet}$$

You would need a tarp that covers 120 ft^2 to cover the opening in the roof. When we multiply feet X feet our answer will always be in square feet (ft^2).

If we need to know the cross-sectional area of a pipe to obtain velocity or flow we would use the formula:

$$.785 \times D' \times D'$$

Please notice that the formula calls for the diameter in feet. If the pipe isn't 12 inches we can derive the equivalent in feet by dividing the number by 12.

EXAMPLE:

4 inch pipe would be .33 feet (4" ÷ 12")
6 inch pipe would be .50 feet (6" ÷ 12")
10 inch pipe would be .83 feet (8" ÷ 12")

The cross sectional area of an 8 inch pipe would be _______?

Area = .785 X D' X D'
Area = .785 X (8" ÷ 12") X (8" ÷ 12")
Area = .785 X .66' X .66'
Area = .342 ft^2

The question always arises, “How many decimals should I carry out on my answer?” It DOES NOT matter. The answers on the test are far enough apart that the correct answer will be evident.

VOLUME

OBJECT	AREA (ft^2)	VOLUME (ft^3)
Rectangle	Length’ X Width’	Length’ X Width’ X Height’
Circle	.785 X D’ X D’	
Triangle	½ (Base’ X Altitude’)	
Cylinder		.785 X D’ X D’ X Length’
Sphere		.5236 X D’ X D’ X D’

Diameter (D) = 2 X radius **Circumference = 3.14 X D’**

Perimeter = Sum of the sides

When we compute volume we are adding a third dimension. Now we are figuring in the height or depth of whatever object we are working with. Volume notates the amount of something that can be put into a particular object.

EXAMPLE:

If a trench measured 3 feet in width, eight feet in length and 2 feet. How many cubic feet of dirt has been removed?

Cuft (ft^3) of a rectangle = Length’ X Width’ X Height’
Cuft (ft^3) = 3’ X 8’ X 2’
ft^3 = 48

A standpipe that measures 30 feet in diameter and is 80 feet tall would contain __________ cubic feet?

ft^3 = .785 X 30 ft X 30 ft X 80 ft
ft^3 = 56,520

Anytime you multiply feet X feet X feet your answer will be in cubic feet. (ft^3)

I don't know about you but I seldom referred to a volume of water as so many cubic feet. So, if we want to convert these cubic feet into some notation we are much more familiar with, we can convert these cubic feet to gallons.

Our formula sheet, under conversions, tells us that:

1 cuft of water	**=**	**7.48 gallons**

In the previous problem we could convert the 56,520 ft^3 to gallons by multiplying them by 7.48 gallons.

gallons = 56,520 ft^3 X 7.48 gallons
gallons = 422,769.6 or 422,770 gallons

A pipeline that is one mile long and is 10 inches in diameter would hold how many gallons? Our formula sheet shows that to figure the volume of a cylinder, we need to:

gallons = .785 X D' X D' X Length' X 7.48 gallons
gallons = .785 X .83' X .83' X 5280' X 7.48 gallons
gallons = 21,358

PROBLEMS:

12) The mayor wants to buy new carpet for your break room. The room measures 10 feet by 12 feet. How many square feet of carpet should you tell the mayor he needs. Be nice!

13) The water plant needs you to build a cover or flat roof over an excavation that has a radius of 14 ft 6 inches. How many square feet of 1" plywood will you need?

14) A standpipe that measures 100 feet in height and 40 feet in diameter could contain ___________ cubic feet?

15) a. An 18" pipeline that is 3000 feet long could contain __________ gallons?

b. How many MG?

º F = (º C X 1.8) + 32	$$^{\circ}C = \frac{(^{\circ}F - 32)}{1.8}$$

CONVERSION of TEMPERATURES

We measure temperatures by two different notations. The first, Fahrenheit is what we commonly use and the other is Celsius or Centigrade. On the right hand side of the formula sheet are the temperature formulas.

16) If the thermometer at your house reads 85º Fahrenheit, what would the equivalent reading in Celsius be?

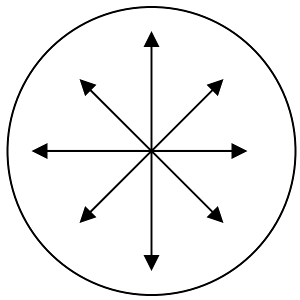
17) If a thermometer read 34º Celsius, what would be the equivalent temperature in Fahrenheit?

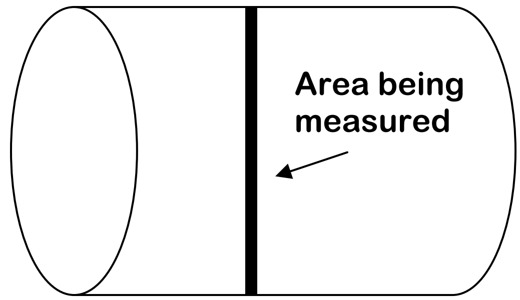
FLOW & VELOCITY

Flow is a measurement of volume over time. In our business we frequently use gallons per minute (gpm), million gallons a day (MGD), cubic feet per second (ft^3/sec), etc. It can be expressed anyway we want, teaspoons per millennium, as long as it holds true to a measurement of volume over time.

Velocity is the speed of something. In the water business we express it as feet per second (fps). State troopers express it on my tickets as miles per hour.

Area is expressed in square feet (ft^2). This measurement is only concerned with the cross-sectional, two dimensional portion of whatever is being measured. Both flow and velocity are measured as the water passes a certain point in a pipe or ditch or whatever is being measured. In a pipe we are only concerned with the area that encompasses one "slice" of pipe.





In this measurement we are not concerned with the length of the object being measured.

FLOW AND VELOCITY

"Q" = FLOW expressed in cubic ft per second (cfs) (ft^3/sec)

"V" = VELOCITY expressed in feet per second (fps)

"A" = AREA expressed in square feet (sqft) (ft^2)

$Q = A \times V$

$V = Q \div A$

$A = Q \div V$

EXAMPLES:

Water is traveling in an eight inch pipe at a velocity of 1.2 fps. What is the flow?

$Q = A \times V$

$Q = (.785 \times (8" \div 12") \times (8" \div 12")) \times 1.2$ fps

$Q = (.785 \times .66' \times .66') \times 1.2$ fps

$Q = .342\ ft^2 \times 1.2$ fps

$Q = .41\ ft^3/sec$

The flow through an 18" pipe is 550 gpm. What is the velocity?

$V = Q \div A$
$V = (550 \text{ gpm} \div 448.8^*) \div (.785 \times (18" \div 12") \times (18" \div 12"))$
$V = 1.2 \text{ ft}^3/\text{sec} \div (.785 \times 1.5' \times 1.5')$
$V = 1.2 \text{ ft}^3/\text{sec} \div 1.8 \text{ ft}^2$
$V = .66 \text{ fps}$

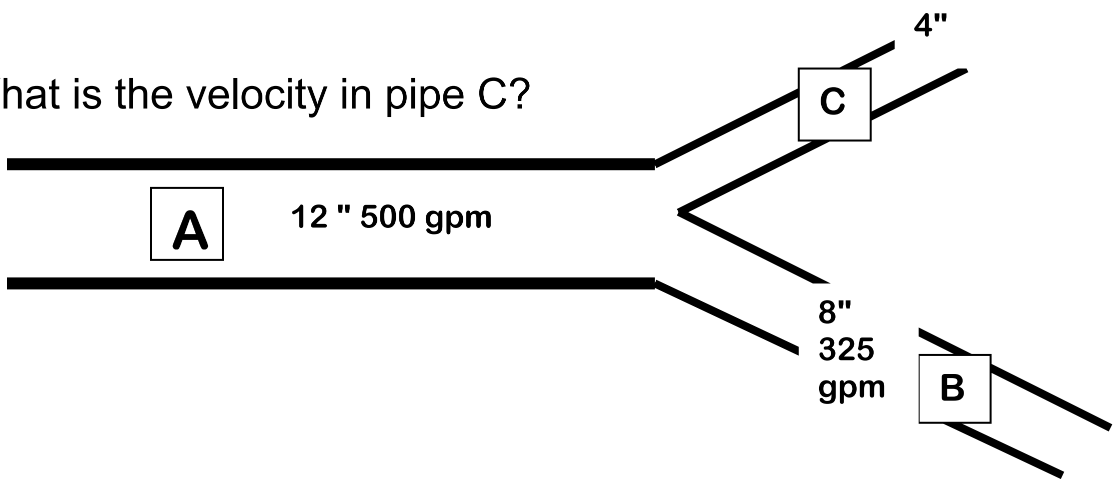
* On our formula sheet, one conversion is 1 cuft/sec = 448.8 gpm

18) Flow through an open channel that measures 10 feet long by 2 feet deep by 3 feet wide is 800 gpm. What is the velocity?

19) The velocity in a 2 inch pipe in 0.75 fps. What is the flow?

20) Flow through a 3 foot pipe is 3 ft³/sec. What is the velocity?

21) What is the velocity in pipe C?



WATER – BRAKE – MOTOR HORSEPOWER

$$WHP = \frac{GPM \times Total\ Head\ (ft)}{3960}$$

$$BHP = \frac{GPM \times Total\ Head\ (ft)}{3960 \times Ep}$$

$$MHP = \frac{GPM \times Total\ Head\ (ft)}{3960 \times Ep \times Em}$$

Ep = Pump Efficiency (%)
Em = Motor Efficiency (%)

EXAMPLES:

Water is being pumped at a rate of 400 gpm and must overcome 15 feet of head. What would be the necessary water horsepower?

$$WHP = \frac{GPM \times Total\ Head}{3960}$$

$$WHP = \frac{400\ gpm \times 15\ ft/head}{3960}$$

$$WHP = \frac{6000}{3960}$$

$$WHP = 1.5$$

Water is needed at a rate of 700 gpm and has to be pumped up a 60 ft incline. The pump efficiency is 89% and the motor efficiency is 84%. What is the motor horse power?

$$MHP = \frac{GPM \text{ X Total Head}}{3960 \text{ X Ep X Em}}$$

$$MHP = \frac{700 \text{ gpm X } 60 \text{ ft/head}}{3960 \text{ X } .89 \text{ X } .84}$$

$$MHP = \frac{42{,}000}{2960.5}$$

$$MHP = 14.19$$

PROBLEMS:

22) What is the motor horsepower (MHP) for a pump with the following parameters?

Motor Efficiency 89%
Pump Efficiency 81%
Total Head 117 feet
Flow 3.5 MGD

23) What is the brake horsepower (BHP) for a pump with the following parameters?

Motor Efficiency 82%
Pump Efficiency 74%
Total Head 194 feet
Flow 1.75 MGD

Lbs. of chemical = $\frac{\text{ppm X 8.34 X MG}}{\text{\% purity}}$	**Specific Gravity = $\frac{\text{wt of a particular liquid}}{\text{equivalent wt. of water}}$**
Cl_2 Dosage = Demand + Residual	
ppm = $\frac{\text{lbs. of chemical X \% purity}}{\text{8.34 X MG}}$	**Strength of Solution = $\frac{\text{wt. of chemical}}{\text{wt. of solution}}$**

When we need to disinfect a new pipeline or a storage tank we have regulatory standards we must meet. (50 ppm held for 24 hours with a 25 ppm residual.) In order to satisfy these regulations we need a way to determine how much disinfectant we need to add to stay in compliance.

$$\text{lbs. of chemical} = \frac{\text{ppm X 8.34 X MG}}{\text{\% purity}}$$

$$\text{ppm} = \frac{\text{lbs. of chemical X \% purity}}{\text{8.34 X MG}}$$

We frequently use forms of chlorine that are not 100%. We use calcium hypochlorite that is 65 -75% available chlorine or sodium hypochlorite (bleach) that is usually from 5 - 15% available chlorine. To make correct dosages we have to allow for the differences in purity or strength. If the chlorine used is 100% available then we can ignore the % purity portion of the formula.

EXAMPLE:

How many pounds of chlorine* would be needed to obtain a 50 ppm dosage in a storage tank holding 500,000 gallons?

lbs of chemical = ppm X 8.34 X MG
lbs of chemical = 50 ppm X 8.34 X .5 MG (500,000/1,000,000)
lbs of chemical = 208.5 *

* 100 % available chlorine

Let's try the same problem, but instead of 100% chlorine we will use 65% available calcium hypochlorite.

$$\text{lbs of chemical} = \frac{\text{ppm X 8.34 X MG}}{\text{\% purity}}$$

$$\text{lbs of chemical} = \frac{\text{50 ppm X 8.34 X 0.5 MG}}{.65\ *}$$

$$\text{lbs of chemical} = \frac{208.5}{.65}$$

lbs of chemical = 320.8

* When using a percentage % in an equation, convert the percentage into a decimal equivalent. i.e. 25 % = .25 by dividing the percentage number by 100.

Same problem but with 5.25 % available bleach (sodium hypochlorite). We know we needed 208.5 lbs of 100% chlorine so all we need to do is divide the 208.5 lbs by the percent purity.

$$\text{lbs. of chemical} = \frac{\text{208.5 lbs}}{.0525}\text{ of 100\% chlorine}$$

lbs. of chemical = 3971.4

Did you notice that we need to use larger amounts of the weaker disinfectant? Not allowing for this difference will mean incorrect dosages and potentially compromised water quality.

Under Kentucky Administrative Regulations the minimum disinfectant residual allowable in the distribution system is 0.2 ppm for chlorinated systems, 0.5 ppm for chloraminated systems.

Residual means “left over”. In our business residual is what is left over after the chlorine has reacted with everything (demand) it can. We can determine the residual, dosage and demand with this simple formula.

$$Cl_2 \text{ Dosage} = \text{Demand} + \text{Residual}$$

Like many equations or formulas we can change the order of the formula to determine any of the three variables.

Demand = dosage – residual
Residual = dosage – demand
Dosage = demand + residual

An easy way to remember these terms is to use a checkbook as an analogy.

Dosage is the amount of money you deposit in your checking account.
Demand is the amount of money you have leaving your account because of the checks you have written.
Residual is the miniscule, at least in my case, amount of money left in your account after the checks have cleared.

If you deposit $500 (dosage), write $400 worth of checks (demand), you would have $100 left in your account (residual).

EXAMPLES:

If the treatment plant is adding 2 ppm to the water and the chlorine demand is determined to be 1.2 ppm, what would the residual be?

2 ppm (*dosage*) – 1.2 ppm (*demand*) = 0.8 ppm (*residual*)

If demand is determined to be 0.9 mg/L and the residual is measured at 0.2 mg/L, what would the dosage be?

0.9 mg/L (*demand*) + 0.2 mg/L (*residual*) = 1.1 ppm (*dosage*)

If the water plant is dosing the water with 3.2 ppm chlorine and the residual is determined to be 1.9 ppm, what would the demand be?

3.2 ppm (*dosage*) – 1.9 ppm (*residual*) = 1.3 ppm (*demand*)

SPECIFIC GRAVITY

Water weighs 8.34 lbs. a gallon. Not everything weighs 8.34 lbs. a gallon. For instance kerosene weighs 6.67 lbs. a gallon. Some polymers we use weigh 10.00 lbs. a gallon. Kerosene's "specific gravity" is .8 so to determine its weight we would multiply 8.34 lbs X 0.8 which equals 6.67 lbs. The polymer in question has a specific gravity of 1.2 so to determine its weight we would multiply 8.34 lbs. X 1.2 which equals 10.00 lbs.

$$\text{Specific gravity} = \frac{\text{weight of a particular liquid}}{\text{equivalent weight of water}}$$

EXAMPLES:

What is the specific gravity for a solution that weighs 10.27 lbs/gal?

10.27 lbs ÷ 8.34 lbs. = 1.23 SG

If the solution we are adding has a specific gravity of 1.8 how much would a gallon of this solution weigh?

8.34 lbs. /gal X 1.8 SG = 15.01 lbs.

STRENGTH of SOLUTION

Strength of solution is nothing more than the weight of a chemical we are adding to the water in relation to the weight of the chemical and the weight of the water to which it was added.

$$\text{Strength of Solution} = \frac{\text{wt. of chemical}}{\text{wt. of solution}}$$

EXAMPLES:

What would the strength of solution (SOS) be if we added 30 lbs. of caustic to 350 lbs. of water?

$$SOS = \frac{30 \text{ lbs.}}{350 \text{ lbs.}}$$

SOS = 0.0857 (decimally)

SOS = 0.0857 X 100

SOS = 8.57%

If we added 10 gallons of a solution that had a specific gravity of 1.45 to 125 gallons of water, what would the % of the strength of solution.

$$SOS = \frac{10 \text{ gallons X (8.34 lbs. X 1.45 SG)}}{125 \text{ gallons X 8.34 lbs.}}$$

$$SOS = \frac{120.93 \text{ lbs.}}{1042.5 \text{ lbs.}}$$

SOS = 0.116 (decimally)

SOS = 11.6 %

PROBLEMS:

24) If the chlorine dose is 3.25 mg/L and the chlorine residual is 1.14 mg/L, what is the chlorine demand?

25) How many lbs. /day of liquid alum would be added to the water if the dosage was 9 mg/L and the purity of the alum is 45%?
The flow is 4.5 MGD.

26) You need to disinfect a new 10" line that is 2 miles long. How many lbs. of 11% bleach will be needed to complete this task?

27) What is the chlorine dosage in ppm if 12.3 MGD is treated with 266 lbs. of chlorine?

28) A small 300 gallon day tank at a booster station needs to disinfected and put back into service. If the dosage is 50 mg/L, how many pounds of 10.5 % available sodium hypochlorite are required?

29) A 36 inch pipe that is 2.2 miles long is disinfected with 71 pounds of 70% available chlorine. Calculate the dosage in milligrams per liter.

30) An operator mixes 110 lbs of HTH (65.5% available) to 300 gallons of water. What percent is the calcium hypochlorite solution?

31) A hypochlorite solution is being pumped from a tank that is 3 feet in diameter. The level of the tank drops 3.5 feet in 3 hours. How many gallons per minute of hypochlorite solution were pumped?

32) Records indicate that Podunk pumped 17,324,949 gallons during the month of May. Determine the average pumped per day.

33) Convert 49 ft^3/sec to gpm.

34) The pressure head at a fire hydrant is 162 feet. Determine the pounds per square inch.

35) What is the area for a rectangular trench that is 600 feet long, 10 feet wide and 4 feet deep?

36) The velocity of water through a channel is 1.75 fps. If the channel is 4.5 feet wide and has a water depth of 2.3 feet, what is the flow in gpm?

37) A 6 inch line must be flushed. The pipeline is 600 feet long. How many minutes will it take to flush the line at a rate of 35 gpm?

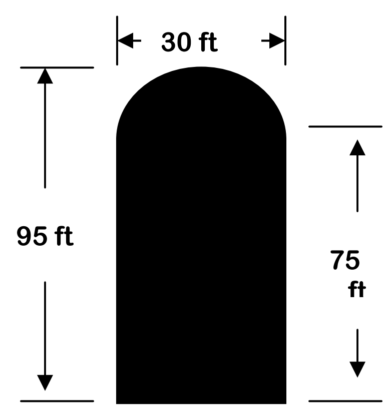
38) A pump with 91% efficiency must overcome 140 feet of head while delivering 3.1 MGD. Determine the brake horsepower.

39) Find the total head for a pump with a static head of 24 feet and a head loss of 4.1 feet.

40) A pump discharges 750 gpm. How many gallons will it pump in 14 hours?

41) Monkey Eyebrow's standpipe measures 75 feet in height and has a radius of 15 feet. If a pressure gauge was mounted 5 feet above grade, what would it read?

42) Calculate the capacity, in gallons, of this tank.



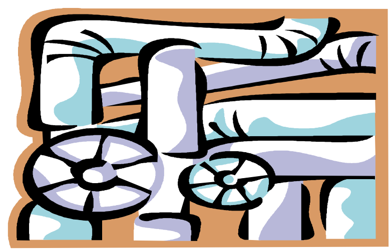
43) Water is flowing in a 48 inch pipe at 600 gpm. What is the velocity?

44) Statesboro has a population of 35,000 people that use 4.2MGD of water. What is the average daily usage per person?

45) A trench is 120 feet long, 4 feet wide and 4.5 feet deep. How many cubic yards of soil has been excavated from this ditch?

46) Convert 55 MGD to ft^3/sec.

47) Your distribution system consists of 10 miles of 6 inch PVC pipe, 1.4 miles of 12 inch DI pipe, 0.4 miles of 4 inch pipe, one standpipe that measures 80 feet in height and 25 feet in diameter and another above ground storage tank that is 40 feet tall and has a radius of 17 feet. What is the capacity, in gallons, of your distribution system?



48) Sorrowful treats 4.5 MGD while operating 22 hours a day and doses its water with 5 ppm cationic polymer, 2.5 ppm chlorine, and 1.2 ppm caustic soda. The plant employs five operators, three male and two female. At the furthest reaches of their distribution system it is determined that the chlorine residual is 0.6 mg/L. What is the chlorine demand?

49) If you are unidirectionally flushing your hydrant through the 6 inch steamer opening at a rate of 5.5 fps and the line supplying the hydrant is supplying 450 gpm, could a backflow situation occur?

50) What is the diameter of a storage tank with a circumference of 596.6 feet?

51) The liquid polymer used in the treatment plant has a specific gravity of 1.6. How much would 50 gallons of this polymer weigh?

52) Beaver Falls treated 52,493,186 gallons during June of 2009. It billed 46,093,548 gallons. What is the percentage of water loss or unaccounted water during June 2009?

53) A positive displacement pump is used to deliver a chemical solution into the water supply. The pump speed can be adjusted accurately between 10 and 50 strokes per minute. At 25 strokes per minute the pump delivers 45 gallons per minute. How many gallons per minute does the pump deliver at 12 strokes and 40 strokes a minute?

54) You have disinfected a new 24 inch HDPE pipe that is 1.5 miles long with 110 tablets of 65% available HTH, each weighing one pound. Have you satisfied the regulatory requirements for disinfecting a new line?

55) If a pump discharges 27,239 gallons in 2 and ½ hours, what is the flow rate in gallons per minute?

56) A hypochlorite solution is being pumped from your day tank that has a diameter of 3 feet. The level in the tank drops 1.75 feet in 4 hours. How many gallons per minute of solution were used?

57) What should your chlorinator be set on in pounds per day if you require a dosage of 2.8 mg/L and the pumping rate from the well is 750 gpm?

58) Your new 500,000 gallon storage tank is being filled at a rate of 650 gpm. How many hours will it take to fill this tank?

59) Podunk has 3762 service connections and they average 752,400 gallons a day from the treatment plant. What is the average per day consumption of water by the citizens of Podunk?

60) You have discovered that water age in one of your storage facilities is a major cause of Haloacetic Acid concentrations to increase. In order to reduce water age you must turn over 85% of the water from the tank each day. If the tank holds 1.45 million gallons and you are pumping water from this tank at a rate of 1500 gpm for twelve hours a day, are you turning over 85% of the water from this tank?

ANSWERS:

1) 10 psi = 23.1 ft of head (10 psi X 2.31 ft of head)
2) 5 gallons = 18925 ml (5 gal X 3785 ml)
3) 41.7 lbs. = 5 gallons (41.7 lbs. ÷ 8.34 lbs.)
4) 2268 grams = 5 lbs. (2268 grams ÷ 453.6 grams)
5) 5 ft^3/sec = 2244 gpm (5 cuft/sec X 448.8 gpm)
6) 42240 ft = 8 miles (42240 ft ÷ 5280 feet)
7) 4167 gpm = 6 MGD (4167 gpm ÷ 694.5 gpm)
8) 15 cuft of water = 112.2 gallons (15 cuft/water X 7.48 gallons)
9) MGD = 12.4 ft^3/sec (8 X 1.55 ft^3/sec)
10) 80 ft of head = 34.64 psi (80 ft/head X .433 psi)
11) 11 MGD = 7639.5 gpm (11 MGD X 694.5 gpm)
12) 120 ft^2 (10 ft X 12 ft)
13) 660.19 ft^2

    Area of a circle = .785 X D' X D'
    Area = .785 X (14.5' X 2) X (14.5' X 2)
    Area = .785 X 29' X 29'
    Area = 660.185 ft^2

14) 125,600 ft^3

    Volume of a cylinder = .785 X D' X D' X L'
    Volume = .785 X 40' X 40' X 100'
    Volume = 125,600 ft^3

15) a. 39634.7 gallons

    Volume of a cylinder in gallons
    Gallons = .785 X D' X D' X L' X 7.48 gallons
    Gallons = .785 X (18" ÷ 12") X (18" ÷ 12") X 3000' X 7.48 gallons
    Gallons = .785 X 1.5' X 1.5' X 3000' X 7.48 gallons
    Gallons = 39,634.65

15) b. .039 MG

MG = 39,634.65 ÷ 1,000,000
MG = .039

16) 29.4º C

$$ºC = \frac{(85º\ F - 32)}{1.8}$$

17) 93.2 º F

ºF = (34º C X 1.8) + 32

18) Looking for velocity

V = Q ÷ A
V = (800 gpm ÷ 448.8 gpm) ÷ (10' X 3')
V = 1.78 ft^3/sec ÷ 30 ft^2
V = .059 or .06 fps

We don't need the depth of the trench only length and width.

19) Looking for flow

= A X V
= (.785 X (2" ÷ 12") X (2" ÷ 12")) X 0.75 fps
= .02 ft^2 X 0.75 fps
= .015 ft^3/sec

20) Looking for velocity

$= Q \div A$
$= 3\ ft^3/sec \div (.785 \times 3' \times 3')$
$= 3\ ft^3/sec \div 7.1$ (actually 7.065, rounded to 7.1)
$= .42$ fps

21) Looking for velocity

We can figure out the flow in pipe "C" by subtracting the flow in pipe B" (325 gpm) from the flow in pipe "A" (500 gpm)

Now we know the flow in pipe "C" is 175 gpm. Since we know the flow and the diameter, we can plug those two variables into our formula.

$V = Q \div A$
$V = (175\ gpm \div 448.8\ gpm) \div (.785 \times (4" \div 12") \times (4" \div 12"))$
$V = .3899$ rounded up to $.39\ ft^3/sec \div (.785 \times .33' \times .33')$
$V = .39\ ft^3/sec \div .085\ ft^2$
$V = 4.6$ fps

22) Looking for motor horsepower (MHP)

$$MHP = \frac{\text{GPM X Total Head (ft)}}{3960 \times E_p \times E_m}$$

$$MHP = \frac{(3.5\ MGD \times 694.5\ gpm) \times 117'}{3960 \times .81 \times .89}$$

$$MHP = \frac{2430.75\ gpm \times 117'}{2854.76}$$

$$MHP = \frac{284397.75}{2854.76}$$

$MHP = 99.62$

23) Looking for brake horsepower (BHP)

$$BHP = \frac{\text{GPM X Total Head (ft)}}{3960 \text{ X } E_p}$$

$$BHP = \frac{\text{(1.75 MGD X 694.5 gpm) X 194'}}{\text{3960 X .74}}$$

$$BHP = \frac{\text{1215.38 X 194'}}{2930.4}$$

$$BHP = \frac{235783.72}{2930.4}$$

BHP = 80.46 or 80.5

24) Looking for demand

Demand = Dosage – Residual
Demand = 3.25 mg/L – 1.14 mg/L
Demand = 2.11 mg/L

25) Looking for pounds

Lbs. of chemical = ppm X 8.34 X MG
Lbs. of chemical = 9 ppm X 8.34 X 4.5 MG
Lbs. of chemical = 337.77
Now we have to account for the % purity

$$\text{Lbs. of 45\% available chemical} = \frac{337.7}{.45}$$

Lbs. of chemical = 750.44

26) ANYTIME on the test you see the word "new" or "put back into service", the ppm will be 50.

Lbs. of chemical = ppm X 8.34 X MG
Lbs. = 50 ppm X 8.34 X (.785 X (10" ÷ 12") X (10" ÷ 12") X 2 X 5280')
X 7.48
Lbs = 50 ppm X 8.34 X (.785 X .833' X .833' X 10560') X 7.48
Lbs = 50 ppm X 8.34 X .043 MG
Lbs = 17.9 of 100 % chlorine which we are NOT using

$$\text{Lbs} = \frac{17.9 \text{ lbs.}}{.11 \text{ purity}}$$

Lbs = 162.7

27) Looking for dosage in ppm

$$\text{ppm} = \frac{\text{lbs. of chemical}}{8.34 \text{ X MG}}$$

$$\text{ppm} = \frac{266 \text{ lbs.}}{8.34 \text{ X } 12.3\text{MG}}$$

$$\text{ppm} = \frac{266 \text{ lbs.}}{102.58}$$

ppm = 2.6 (actually 2.593)

28) Looking for pounds

Lbs = ppm X 8.34 X MG
Lbs = 50 ppm X 8.34 X (300 ÷ 1,000,000)
Lbs = 50 ppm X 8.34 X .0003 MG
Lbs = 0.125 of 100 % chlorine. We are using 10.5%

$$\text{Lbs} = \frac{0.125}{.105}$$

Lbs = 1.2 (actually 1.19)

29) Looking for mg/L or ppm

$$\text{ppm} = \frac{\text{lbs. of chemicals X \% purity}}{\text{8.34 X MG}}$$

$$\text{ppm} = \frac{\text{71 lbs. X .70}}{\text{8.34 X (.785 X 3' X 3' X (2.2 X 5280')) X 7.48 gallons}}$$

$$\text{ppm} = \frac{\text{49.7 lbs.}}{\text{8.34 X (.785 X 3' X 3' X 11616' X 7.48 gallons/ 1,000,000)}}$$

$$\text{ppm} = \frac{\text{49.7 lbs}}{\text{8.34 X .61MG}}$$

$$\text{ppm} = \frac{49.7}{5.1}$$

ppm = 9.74

30) Looking for strength of solution

$$\text{Strength of solution} = \frac{\text{weight of chemical}}{\text{weight of solution}}$$

$$\text{SOS} = \frac{\text{110 lbs}}{\text{(300 gallons X 8.34 lbs) + 110 lbs}}$$

$$\text{SOS} = \frac{\text{110 lbs}}{\text{2612 lbs}}$$

SOS = .042 x 100 (for percentage)

SOS = 4.2%

31) First, we need to determine the gallons that were pumped.

Gallons pumped = .785 X 3' X 3' X 3.5' X 7.48 gallons
Gallons pumped = 185 (actually 184.96)
Now, determine the number of minutes in 3 hours
3 hrs X 60 min/hr = 180 minutes
185 gallons pumped in 180 minutes
185 gallons ÷ 180 minutes
gpm = 1.03 (actually 1.0277777)

32) Looking for average per day

31 days in May

$$\text{Average} = \frac{17{,}324{,}949 \text{ gallons}}{31 \text{ days}}$$

Average = 558,869.3 gallons per day

33) Converting from ft^3/sec to gpm

gpm = 1 ft^3/sec = 448.8 gpm
gpm = 49 ft^3/sec X 448.8 gpm
gpm = 21991.2

34) Converting from head to psi

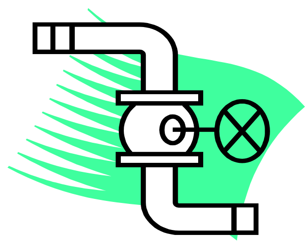
1 foot of head = .433 psi
psi = ?
psi = 162 feet of head X .433 psi
psi = 70.1

35) Looking for area in ft^2

Area of a rectangle = Length' X Width'
Area = 10' X 600'
Area = 6000 ft^2

36) Looking for flow in gpm

Flow in gpm = A X V
Flow/gpm = (4.5' X 2.3') X 1.75 fps
Flow/gpm = 10.35 ft^2 X 1.75 fps
Flow = 18.11 ft^3/sec
Converting to gpm (1 ft^3/sec = 448.8 gpm)
Flow/gpm = 18.11 ft^3/sec X 448.8 gpm
Flow/gpm = 8127.8 gpm (actually 8127.768)



37) We need to determine how many gallons of water are in the pipe.

Volume of a cylinder = .785 X D' X D' X L' X 7.48 gallons
Volume = .785 X (12" ÷ 6") X (12" ÷ 6") X 600' X 7.48 gallons
Volume = .785 X .5' X .5' X 600' X 7.48 gallons
Volume = 880.77 gallons
Pumping rate is 35 gpm
880.77 gallons ÷ 35 gpm
Minutes = 25.16

38) Brake Horsepower = $\frac{\text{GPM X Total Head (ft)}}{\text{3960 X } E_p}$

BHP = $\frac{\text{(3.1 MGD X 694.5 MGD) X 140'}}{\text{3960 X .91}}$

BHP = $\frac{301413}{3603.6}$

BHP = 83.6

39) Total Head

TH = 24 ft + 4.1 ft
TH = 28.1 ft of head

40) Gallons /14 hrs

750 gpm X (60 minutes X 14 hrs)
750 gpm X 840 minutes
Gallons/14 hrs = 630,000

41) Looking for psi

We start out with elevational head of 75 feet but lose 5 feet of it because the gauge is 5 feet above ground.
psi = 70 feet of head X .433 psi
psi = 30.31

42) Looking for volume of a cylinder and a sphere.

$$\text{Gallons} = (.785 \times D' \times D' \times L') + \frac{(.5236 \times D' \times D' \times D')}{2}$$

$$\text{Gallons} = (.785 \times 30' \times 30' \times 75') + \frac{(.5236 \times 30' \times 30' \times 30')}{2}$$

Gallons = 52987.5 ft^3 + 7068.6 ft^3

Converting ft^3 to gallons (52987.5 + 7068.6) X 7.48 gallons

Gallons = 449219.6

On the sphere, the total is divided in half because the volume in the bottom half of the sphere was accounted for in the volume of the standpipe.

43) Looking for velocity

$$V = \frac{Q}{A}$$

$$V = \frac{(600 \text{ gpm} \div 448.8 \text{ gpm})}{.785 \times 4' \times 4'}$$

$$V = \frac{1.3 \text{ ft}^3\text{/sec}}{12.56 \text{ ft}^2}$$

V = .10 fps

44) 35,000 people use 4.2 MG of water

$$\frac{4{,}200{,}000 \text{ gallons of water}}{35{,}000 \quad \text{people}}$$

120 gallons per day/per person

45) Looking for volume relative to cubic feet

Volume = length' X width' X depth'
Volume = 120' X 4' X 4.5'
Volume = 2160 ft^3
27 ft^3 in 1 cubic yard
2160 ft^3 ÷ 27 ft^3
80 cubic yards

46) Convert 55 MGD to ft^3/sec

1 MGD = 1.55 ft^3/sec
55 MGD X 1.55 ft^3/sec
ft^3/sec = 85.25

47) Yea, I know you hate this one. It is just a bunch of volumes added together.

6" line = .785 X.5' X.5' X 52800' X 7.48 gallons
12" DI line = .785 X 1' X 1' X 7392' X 7.48 gallons
4" pipe = .785 X .33' X .33' X 2112' X 7.48 gallons
Standpipe = .785 X 25' X 25' X 80' X 7.48 gallons
Above ground = .785 X 34' X 34' X 40' X 7.48 gallons

6" line =	77507.76 gallons
12" line =	43404.35 gallons
4" line =	1350.50 gallons
SP =	293590.00 gallons
AG =	271512.03 gallons

Added all together you get
687,364.64 gallons

48) Read the question!
Demand = Dosage – Residual
Demand = 2.5 mg/L – 0.6 mg/L
Demand = 1.9 mg/L

49) Flow = A X V
Flow = (.785 X .5' X.5') X 5.5 fps
Flow = 0.196 ft^2 X 5.5 fps
Flow = 1.078 or 1.1 ft^3/sec 1 ft^3/sec = 448.8 gpm
So, if the line is delivering 450 gpm and the hydrant is flowing at 493.68 gpm (1.1 X 448.8 gpm) then I would be VERY careful. You will have a backflow situation.

50) Circumference = 3.14 (π) X Diameter in feet

So if we are given circumference we can divide by 3.14 to get the diameter.

$$\text{Circumference} = \frac{596.6 \text{ ft}}{3.14}$$

Diameter = 190 feet.

51) 50 gallons of polymer with a specific gravity of 1.6.

50 gallons of water weighs - 50 gallons X 8.34 lbs = 417 lbs.
417 lbs. X 1.6 SG = 667.2 lbs.

52) You treated 52,493,186 gallons

You billed - 46,093,548 gallons
Difference = 6,399,638 gallons
Divide the 6,399,638 unaccounted for gallons by the 52,493,186 gallons and you get the decimal equivalent of the percentage and multiply by 100 for the percentage.
6,399,638 gallons ÷ 52,493,186 gallons = 0.1219
Multiply 0.1219 by 100 = 12.19% water loss

53) 25 strokes per minute delivers 45 gpm

12 strokes per minute = ? gpm
12 strokes per minute ÷ 25 strokes per minute = .48
.48 X 45 gpm = 21.6 gpm
40 strokes per minute = ? gpm
40 strokes per minute ÷ 25 strokes per minute = 1.6
1.6 X 45 gpm = 72 gpm

54) Looking for pounds

$$\text{lbs.} = \frac{\text{ppm X 8.34 X MG}}{\text{\% purity}}$$

$$\text{lbs.} = \frac{\text{50 ppm (new pipe) X 8.34 X (.785 X 2' X 2' X (1.5 X 5280')) X 7.48 gal}}{\text{\% purity}}$$

$$\text{lbs.} = \frac{\text{50 X 8.34 X 0.186 MG}}{\text{\% purity}}$$

$$\text{lbs} = \frac{77.56}{.65}$$

lbs = 119

You have dosed the pipe with 110, 1 lb tablets so you have not satisfied the regulation.

ANOTHER WAY TO FIGURE THIS

$$\text{ppm} = \frac{\text{lbs. of chemical X \% purity}}{\text{8.34 X MG}}$$

$$\text{ppm} = \frac{\text{110 lbs X .65}}{\text{8.34 X ((.785 X 2' X 2' X 7920' X 7.48 gallons)} \div \text{1,000,000)}}$$

$$\text{ppm} = \frac{\text{71.5 lbs}}{\text{8.34 X 0.186 MG}}$$

$$\text{ppm} = \frac{\text{71.5 lbs}}{1.55}$$

ppm = 46.12 No, you haven't satisfied the regulation.

55) Pump discharging 27,239 gallons in 2 and ½ hours

Pump discharging 27,239 gallons in 150 minutes
27,239 gallons ÷ 150 minutes
gpm = 181.59 rounded to 181.6

56) Looking for volume

Volume of a cylinder = .785 X D' X D' X L' X 7.48 gallons
Volume of a cylinder = .785 X 3' X 3' X 1.75' X 7.48 gallons
Volume of a cylinder = 92.48 gallons rounded up to 92.5

Now we figure gpm

gpm = 92.5 gallons ÷ 240 minutes (4 hours)
gpm = .38

57) Looking for pounds

lbs = ppm (mg/L) X 8.34 X MG
lbs = 2.8 ppm X 8.34 X (750 gpm ÷ 694.5 gpm)
OR

$$\text{lbs} = 2.8 \text{ ppm} \times 8.34 \times \frac{(750 \text{ gpm} \times 1440 \text{ minutes})}{1{,}000{,}000}$$

Either way you get:

lbs. = 2.8 ppm X 8.34 X 1.08MG
lbs. = 25.2
lbs. = 1.05/hour

58) 500,000 gallons being filled at 650 gpm

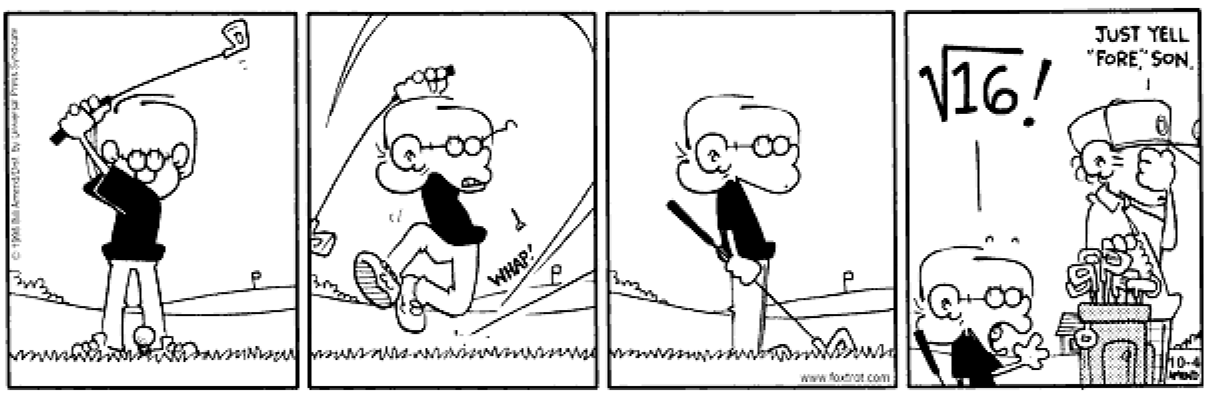
500,000 gallons ÷ 650 gpm =
769.23 minutes
To determine hours just divide 769.23 minutes by 60 minutes
Hours to fill = 12.8

59) 752,400 gallons ÷ 3762 service connections

Average daily consumption = 200 gallons

60) 85% of 1,450,000 gallons =

.85 X 1,450,000 =
1,232,500 gallons
1500 gpm for 720 minutes =
1,080,000 gallons
No, you are NOT turning over 85% of the tank volume daily.



USEFUL EQUATIONS and FORMULAS in DISTRIBUTION SYSTEMS

$$\text{Slope} = \frac{\text{headloss, ft}}{\text{distance, ft}}$$

$$\text{Slope} = \frac{\text{energy loss, ft}}{\text{distance, ft}}$$

$$\text{Flow from hydrant, gpm} = \frac{(2.83 \text{ X diameter, in}^2 \text{ X length, in}}{\sqrt{\textit{height}}}$$

$$\text{Pressure, lbs/ft}^2 = (62.4 \text{ lbs/ft}^3 \text{ X height, ft})$$

Wire – to – water Efficiency % = (% pump efficiency) (% motor Efficiency) (100) %'s entered as decimals

1 Horsepower = 746 Watts or 0.746 kilowatts

Power (watts) = volts X amps

$$\text{Horsepower} = \frac{(\text{volts X amps})}{746}$$

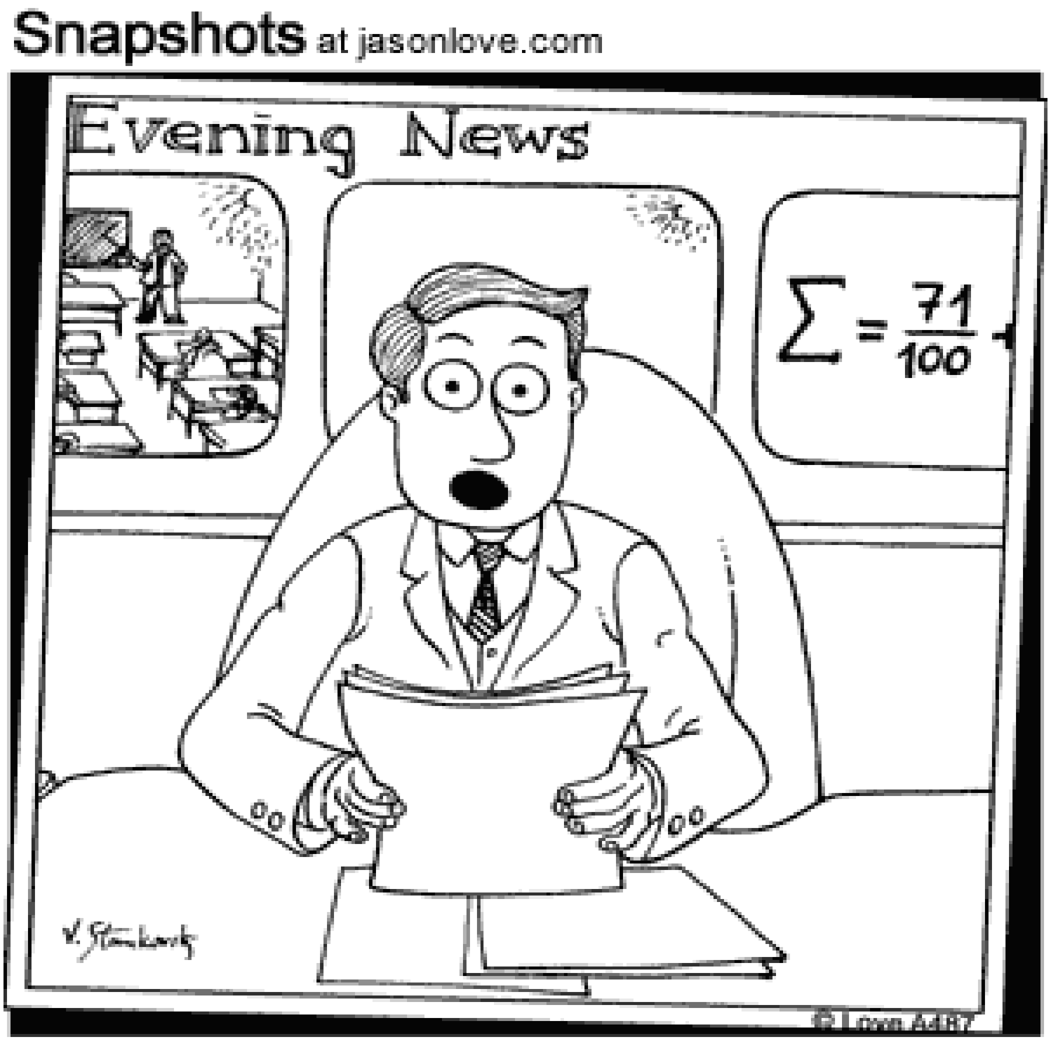
$$\text{Kilowatts, single phase} = \frac{(\text{volts X amps X power factor})}{1000}$$

$$\text{Kilowatts, three phase} = \frac{(\text{volts X amps X power factor X 1.732})}{1000}$$

Cost, \$/hour = motor HP X 0.746 kW/hp X cost, \$kW-hr

$$\text{Dosage} = \frac{(\text{grams} \div \text{minutes})\ (1{,}000\text{mg} \div \text{grams})}{\text{Flow (MGD) X 8.34 lbs/gal}}$$

$$\text{Meter accuracy \%} = \frac{(\text{volume of water registered, gal) X (100)}}{\text{Actual volume, gal}}$$



"Of students surveyed, 64% prefer English and 32% prefer math. The fact that these numbers do not add up to 100 may help explain why."

PRINTED WITH AGENCY FUNDS
ON RECYCLED PAPER

Why do utilities, excavators, contractors and the public have to call Kentucky811 prior to disturbing the earth?

The Kentucky Dig Law (KRS 367.4901 to KRS 367.4917) has been in affect since 1994. The law requires all persons excavating to call at least two full business days before digging, and no more than 10 business days prior to digging. The act in its entirety can be viewed at the following Web site: www.kentucky811.org.