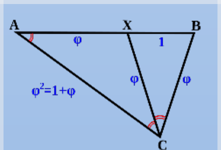
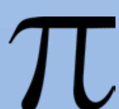
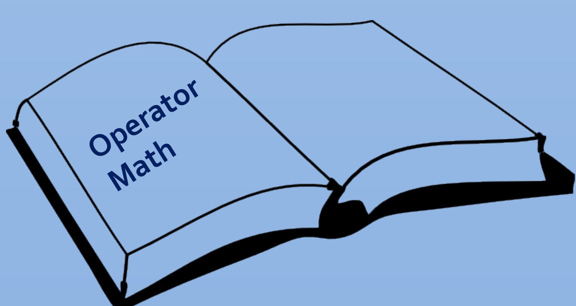
Basic Operator Math Workshop







Midwest Assistance Program

Version 9/19/18

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This training material was funded through a contract by EPA Region 8

Introductions

Let's Get Started

1. Name Cards
2. Introductions around the room
   - Where are you from?
   - What is your job/position?
   - What is your goal for this training?

Calculators

- When dividing a fraction, the top number goes first.
- Use the +/- key to make a negative (-) number.

Symbols for Operations

Math Operation	Symbol	Example
Multiplication	x	10 = 5 x 2
	•	10 = 5 • 2
	No space	10 = XY
	( ) ( )	10= (5) (2)
Division	÷	5=10 ÷2
	/	5=10/2
	____	$5=\frac{10}{2}$

Taking an Average

- Taking an average:

An **average** is the sum of a list of numbers divided by the number of numbers in the list.

- Chlorine residuals for Jan/Feb/Mar
  - 1.32, 1.91, 1.48
  - Total count of numbers = 3
  - Sum = 4.71

1.32 + 1.91 + 1.48
1st quarter residuals

$$\frac{4.71}{3}$$

= 1.57

Rounding

- First digit after the decimal is 5 or greater – round up
- First digit after the decimal 4 or less – keep the same

Five or more, add one more.
Four or less, let it rest!

Rounding

Five or more, add one more.
Four or less, let it rest!

- Round the following numbers to the nearest whole number:

45.5 = 46
45.4 = 45

101.421 = 101
101.5 = 102

Percentages

- Percent means parts of 100
  - Symbol: %
- Examples
  - Tank is 1/2 full: 50%
  - Tank is 1/4 full: 25%

$$\frac{\text{part}}{\text{whole}} \times 100\% = \_\_\%$$

To Determine Percentages

- Divide the part by the whole and multiply by 100

$$\frac{\text{part}}{\text{whole}} \times 100\% = \_\_\%$$

$$\frac{\text{4 slices of pizza}}{\text{8 slices of pizza}} \times 100\% = 50\%$$

Percentages Converted to Decimals

- Percent (%) divided by 100 will give a decimal value

SHORT CUT:
Move the decimals two places to the left.

$$50\ \% = \frac{50}{100} = 0.50$$

$$22\ \% = \frac{22}{100} = 0.22$$

$$4\ \% = \frac{4}{100} = 0.04$$

Fractions Converted to Decimals

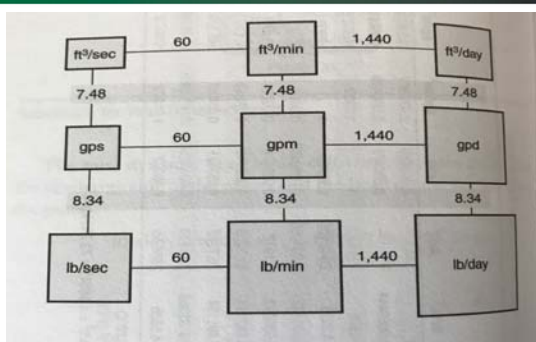
- Divide the numerator (top) by the denominator (bottom)

$\frac{1}{2} = 0.5$ $\frac{3''}{4} = 0.75''$ Put units in the answer

***REMEMBER to check the units and convert when needed.**

$\frac{6'}{12''} = \frac{72''}{12''} = 6$

CONVERT



Practice

If you read 85 meters in a day, and you have 2,100 customers, what percentage of your customers' meters did you read?

$\frac{\text{part}}{\text{whole}} \times 100\% =$ __%

How many meters would be 10% of your 2,100 customer meters?

whole x percent (decimal form) = part

<u>Remember the Decimal</u>
If you **MULTIPLY** go **RIGHT**
If you **DIVIDE** go **LEFT**

Practice

If you read 85 meters in a day, and you have 2,100 customers, what percentage of customers' meters did you read?

$$\frac{85}{2,100} \times 100\% = 4.04\%$$

How many meters would be 10% of your 2,100 customer meters?

2,100 customers x 0.10 = 210 customers

Problems

Your system has 458 valves and you replaced 142 valves this year. What percentage of your valves did you replace?

$$\frac{142}{458} \times 100\% = 31\%$$

142/458 X 100 = 31%

Exponents

- How many times a number (called the base) is multiplied by itself.
- Example: 5 raised to the power of 2
  - 5^2 is the same as 5 x 5 NOT 5 X 2 !!!!!!
  - 10^6 is the same as 10 x 10 x 10 x 10 x 10 x 10

ft x ft = ft^2

ft x ft x ft = ft^3

Different Ways to Write the Same Multiplication Problem

$$\frac{5}{7} \times \frac{9}{4} \times \frac{1}{5} = 0.32$$

$$\left(\frac{5}{7}\right)\left(\frac{9}{4}\right)\left(\frac{1}{5}\right) = 0.32$$

Order of Operations

"Please excuse my dear Aunt Sally"

» **PEMDAS**

Please	-	Parentheses ( ) [ ] { }
Excuse	-	Exponents
My	-	Multiplication
Dear	-	Division
Aunt	-	Add
Sally	-	Subtract

Order of Operations

- What do you do first when you have a complex equation?

2 - 3 x 6 =

- 3 x 6 = 18
- 2 – 18 = **-16**

Order of Operations

- "Please excuse my dear Aunt Sally"

PEMDAS

$(2 + 3)^2 + 3 \times (4 \div 2)$

$= (5)^2 + 3 \times (2)$

$= 25 + 6$

$= 31$

Order of Operations

$\frac{(5 \times 2) + 6}{8}$ = ((5 x 2) + 6) / 8

$$\frac{(5 \times 2) + 6}{8}$$

$$= \frac{10 + 6}{8}$$

$$= \frac{16}{8}$$

$$= 2$$

Practice

1. (5 x 3) + 2 (3+2) =

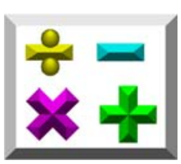
   15+10= 25

2. (4 + 3 x 2) – 4 x 2 =

   10-4 x 2 = 10-8 = 2

3. $\frac{(8 \times 3) + 6}{2}$

   $\frac{30}{2}$ **= 15**



Fractions

$$\frac{\text{Numerator}}{\text{Denominator}}$$

$$\frac{1}{2} \div \frac{1}{7} \qquad \frac{\text{gallon}}{\text{minute}} \qquad \frac{1 \times 7}{2 \times 1}$$

Gallons / minute
= gallons per minute

When dividing fractions invert and multiply

Fractions

- Any number divided by itself equals 1

$$\frac{2}{2} = 1 \qquad 2 \div 2 = 1$$

1 mile = 5280 feet $\qquad \frac{\text{1 mile}}{\text{5280 feet}} = 1$

ppm vs. mg/L

1 ppm = 1 part per million parts

1 ppm = 1 mg/L

$$\frac{\text{1 ppm}}{\text{1 mg/L}} = 1$$

Multiplying Fractions

- Multiply the numerators
- Multiply the denominators
- Divide the numerator by the denominator to convert to decimal if needed

$$\frac{1}{2} \times \frac{2}{3} = \frac{2}{6}$$

Multiplying Fractions

$$\frac{1}{2} \times \frac{2}{3} = \frac{2}{6}$$

$$\frac{1 \times 2}{2 \times 3} = \frac{2}{6}$$

$$\frac{X^2}{Y} \times \frac{X^2}{Y^3} = \frac{X^4}{Y^4}$$

Practice

$$\frac{1}{2} \times \frac{2}{3} \times \frac{2}{3} = \frac{4}{18}$$ = .2222

$$\frac{1}{2} \times \frac{2}{3} \times \frac{2}{3} = \frac{2}{9}$$ = .2222

Practice

1st Step: Multiply the numerators

$$\frac{2}{4} \times \frac{3}{9} \times \frac{5}{7} \times \frac{8}{6} = \frac{240}{}$$

Practice

2st Step: Multiply denominators

$$\frac{2}{4} \times \frac{3}{9} \times \frac{5}{7} \times \frac{8}{6} = \frac{240}{1512}$$

Practice

Provide the result in decimal form.

a. $\frac{5}{7} = .714$

b. $\frac{6}{9} = .667$

c. $\frac{5}{7} \times \frac{6}{9} = \frac{30}{63} = .476$

d. $\frac{2}{4} \times \frac{3}{2} \times \frac{4}{3} \times \frac{1}{2} = \frac{24}{48} = .5$

e. $\frac{2}{4} \times \frac{3}{9} \times \frac{5}{7} \times \frac{6}{8} = \frac{180}{2016} = .089$

Cancelling Out Units

- Units of measure can be cancelled out in order to solve a problem.
  - If your car gets 30 miles to the gallon, how far can you go on 12 gallons?
    - What unit is the answer in?
    - What information do you need?

$$\frac{30\ miles}{1\ gallon} \times \frac{12\ gallons}{1} = 360\ miles$$

★ **Units that are the same can cancel each other out!**

Solving For an Unknown

Example: If you know the **Velocity** and **Time** and are trying to find **Distance**:

1. Write down the equation

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

2. Isolate what you are solving for on one side of the equal sign. For this equation, multiply both sides of the equation by **Time**.

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

Solving For an Unknown

Important point: Do the same thing to both sides of the equation.

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

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

Word Problems

Helpful Tips:

- Highlight important information.
- Cross out useless information.
- Circle the actual question.
- Circle or underline what units the answer is needed in.
- Determine which equation is needed to solve the problem.

Word Problems

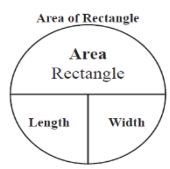
1. Make a drawing of the information.
2. Place data on the drawing.
3. Write down "What do I need to determine?"
4. Write down any equations that you are going to need.
5. Make conversions if necessary.
6. Fill in the data in the equation.
7. Make the calculation and write down the answer.
8. Ask yourself, does this make sense?

Pie Wheels

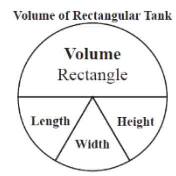
- To find the quantity **above** the horizontal line: Multiply the pie wedges below the line together.
- To solve for one of the pie wedges **below** the horizontal line: Cover that pie wedge, then divide the remaining pie wedge (s) into the quantity above the horizontal line.
- Given units must match the units shown in the pie wheel.

Setting Up Problems

Pie Wheels: Multiply bottom sections of the pie to get the solution on the top of the pie.



Area = Length x Width



Volume= Length x Width x Height

Area of a Rectangle

- L' X W' or L' X H' = square ft
- Square ft = ft^2
- 2' x 5' = 10 ft^2

Volume of a Rectangular Tank

- L' X W' X H' = ft^3
- A tank is 2 ft long x 5 ft wide x 20 ft high.
- 2' x 5' x 20'= 200 ft^3

Word Problem Steps

- Highlight important information

A blue tank at 500 feet above sea level is 10 feet high and has a diameter of 20 feet. The tank is half full. What is the volume of the tank?

Word Problem Steps

- Cross out useless information

A ~~blue tank at 500 feet above sea level~~ is 10 feet high and has a diameter of 20 feet. The tank is half full. What is the volume of the tank?

Word Problem Steps

- Circle or underline what the question is?

~~A blue tank at 500 feet above sea level~~ is 10 feet high and has a diameter of 20 feet. The tank is half full. What is the volume of the tank?

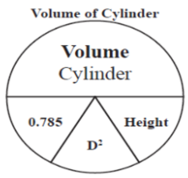
Word Problem Steps

- Circle what units the answer is needed in?
  - If not specifically mentioned, what do you assume the units are?
  - If the shape is not mentioned, look for clues.

~~A blue tank at 500 feet above sea level~~ is 10 feet high and has a diameter of 20 feet. The tank is half full. What is the volume of the tank?

Word Problem Steps

- Familiarize yourself with the Conversion Table Handout!!
- Know how to find what equation you need to solve the problem.
- Look at the pie wheels.



Word Problem Steps

- What equations can you use to find volume?
  - What shape are you finding the volume of?
- Write down the equation.
- Draw a picture if needed.
  - Label the picture
- Insert the numbers where needed in the equation chosen.
- Solve the equation, check the units.

Word Problem Steps

Once you plug your numbers in, follow the order of operations.

Volume of a cylinder = (.785)(dia^2)(height)

(.785)(20^2ft)(10ft) = (.785)(400ft^2)(10ft) =

3140 cubic feet(ft^3)

Note: Volume of a cylinder is also = $(\pi)(r^2)$ (height)

$(3.14)(10^2\text{ft})(10\text{ft}) = (3.14)(100ft^2)(10\text{ft}) = 3140ft^3$

Conversions

- What if that word problem wanted the answer in cubic inches?
  - How many inches are in a foot?
  - Cancel out units
  - Multiply the fraction

Questions / Discussion

Conversions

Midwest Assistance Program

serving rural communities since 1979

RCAP NETWORK MEMBER

Conversion Table

- Use the ABC Formula and Conversion Table handout.
  - The handout is in alphabetical order
  - (*)Asterisk means there is a pie chart for that equation.
  - Pie charts are in the back
  - Highlight important formulas

Conversions

Some conversions are subsets of larger units:

1 day = 1,440 minutes	1 day = 24 hours
1 gallon = 4 quarts	1 acre = 43,560 square feet
1 mile = 5,280 feet	1 yard = 3 feet
1 liter = 1,000 milliliters	1 gram = 1,000 milligram
1 kilo = 1,000 grams	1 metric ton = 1,000 kilos

Some conversions are weight to volume/volume to units:

1 gallon = 8.34 pounds	1 cubic foot = 7.48 gallons
1 PSI = 2.31 feet head	1 gallon = 231 cubic inches
1 foot of head = .433 psi	1 cu. ft. = 62.4 pounds
1 ppm = 1 mg/L	1 acre-feet = 325,851 gallons

Using Conversion Factors

1 hour = 60 minutes

1 acre foot = 326,000 gallons

Since both sides of the equations are equivalent :

$$\frac{1\text{ hour}}{60\text{ minutes}} = 1 \qquad \frac{1\text{ acre foot}}{326{,}000\text{ gallons}} = 1$$

If Units are Equivalent, it Doesn't Matter What is On Top

1 hour = 60 minutes

$$\frac{1\text{ hour}}{60\text{ minutes}} = \frac{60\text{ minutes}}{1\text{ hour}}$$

1 acre = 43,560 square feet

$$\frac{1\text{ acre}}{43{,}560\text{ square feet}} = \frac{43{,}560\text{ square feet}}{1\text{ acre}}$$

How Many Minutes are in 4 Hours?

Step 1 4 hours x ? = __ minutes

Step 2 $4\text{ hours} \times \frac{60\text{ minutes}}{\text{hour}} = \_\_\_\_\_\_\_\text{minutes}$

Step 3 $\frac{4\text{ hours}}{1} \times \frac{60\text{ minutes}}{\text{hour}} = 240\text{ minutes}$

Step 4 $\frac{4\text{ \sout{hours}}}{1} \times \frac{60\text{ minutes}}{\text{\sout{hour}}} = 240\text{ minutes}$

Note: Units cancel out.

Practice

- In some cases, you may need multiple conversions.
  - How many seconds are there in 1 hour?

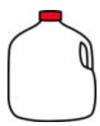
$$1 \text{ hour} \times \frac{60 \text{ minutes}}{\text{hour}} \times \frac{60 \text{ seconds}}{\text{minutes}} = \_\_\text{seconds}$$

$$1 \text{ \sout{hour}} \times \frac{60 \text{ \sout{minutes}}}{\text{\sout{hour}}} \times \frac{60 \text{ seconds}}{\text{\sout{minutes}}} = 3{,}600 \text{ seconds}$$

Practice

How much does 4 gallons of water weigh in pounds?

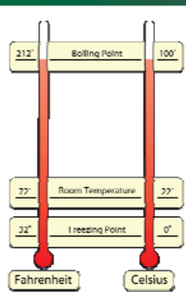
4 gallons x ? = __ pounds



$$4 \text{ gallons} \times \frac{8.34 \text{ pounds}}{1 \text{ gallon}} = \_\_\_\text{pounds}$$

$$4 \text{ \sout{gallons}} \times \frac{8.34 \text{ pounds}}{1 \text{ \sout{gallon}}} = 33.4 \text{ pounds}$$

Temperature Conversions



Source: CDPHE 2014

$°C = 5/9\ (°F - 32)$

$°F = (9/5 \times °C) + 32$

Or

$$°C = \frac{°F - 32°}{1.8}$$

$°F = (1.8 \times °C) + 32$

Temperature

1. 23°F = ______ °C
2. 10°F = _______°C
3. 34°C = _______°F
4. 7°C = _______°F

**What if the temperature is a (-) ?

5. -5°F = _______°C

Temperature

$$\frac{(°F-32)}{1.8} = °C$$

1. 23°F = $\frac{(23°F - 32)}{1.8} = \frac{-9°F}{1.8}$ = -5°C
2. 10°F = $\frac{(10°F - 32)}{1.8} = \frac{-22°F}{1.8}$ = -12.2°C

Temperature

(°C)(1.8) + 32 = °F

3. 34°C = (34°C)(1.8) + 32 = 93.2°F
4. 7°C = (7°C)(1.8) + 32 = 44.6°F

Temperature

1. 23°F = __-5__ °C
2. 10°F = _-12.2_ °C
3. 34°C = _93.2_ °F
4. 7°C = _44.6_ °F

**What if the temperature is a (-) ?

5. -5°F = ______°C

Temperature

$$\frac{(°F-32)}{1.8} = °C$$

$\frac{(-5°F-32)}{1.8}$ =°C

$\frac{-37}{1.8}$= -20.56°C

- If using a calculator, be sure to place a (-) sign with the +/- key before the 5. Then subtract 32 like you normally would.
- If not using a calculator (-5-32) is the same as adding -5 and -32. You get 37 and then place the (-) sign in front.
- When dividing keep the (-) in the answer.

Temperature

1. 23°F = __-5__ °C
2. 10°F = _-12.2_ °C
3. 34°C = _93.2_ °F
4. 7°C = _44.6_ °F

**What if the temperature is a (-) ?

5. -5°F = _-20.56_ °C

You Try

1. How many nickels are there in $2.00?
2. You have 20 pounds of water. How many gallons of water is this?
3. How many cubic feet per second (cfs) are there in 4 million gallons per day (MGD)?
4. What is 4°C in °F? What is 20°F in °C?
5. A quarter in football is 15 minutes. The maximum time between plays is 40 seconds. What would be the minimum numbers of plays that could be run in a game?

Solution

1. $\$2.00 \times \frac{20 \text{ nickels}}{\$1.00} = 40 \text{ nickels}$

**The dollar signs cancel out.

You Try

1. How many nickels are there in $2.00? 40 Nickels
2. You have 20 pounds of water. How many gallons of water is this?
3. How many cubic feet per second (cfs) are there in 4 million gallons per day (MGD)?
4. What is 4°C in °F? What is 20°F in °C?
5. A quarter in football is 15 minutes. The maximum time between plays is 40 seconds. What would be the minimum numbers of plays that could be run in a game?

Solution

2. 20 lbs of water X $\frac{1\text{ gallon}}{8.34\text{ lbs}}$ = ______gallons

**The lbs cancel out to give you gallons.

$\frac{20}{8.34}$ = 2.398 gallons

You Try

1. How many nickels are there in $2.00? 40 Nickels
2. You have 20 pounds of water. How many gallons of water is this?
   2.398 Gallons – What if you round this number to the nearest tenth?
3. How many cubic feet per second (cfs) are there in 4 million gallons per day (MGD)?
4. What is 4°C in °F? What is 20°F in °C?
5. A quarter in football is 15 minutes. The maximum time between plays is 40 seconds. What would be the minimum numbers of plays that could be run in a game?

Solution

3. 4MGD X $\frac{1.55\text{ cfs}}{1\text{MGD}}$ = _________cfs

**The MGD cancels out to give you cfs.

4 x 1.55cfs = 6.2cfs

You Try

1. How many nickels are there in $2.00? 40 Nickels
2. You have 20 pounds of water. How many gallons of water is this?
   2.398 Gallons – What if you round this number to the nearest tenth?
3. How many cubic feet per second (cfs) are there in 4 million gallons per day (MGD)? 6.2cfs
4. What is 4ºC in ºF? What is 20ºF in ºC?
5. A quarter in football is 15 minutes. The maximum time between plays is 40 seconds. What would be the minimum numbers of plays that could be run in a game?

Solution

4.

4°C = ? °F   (4°C)(1.8) + 32 = 39.2°F

20°F = ? °C $\frac{(20°F-32)}{1.8} = \frac{-12}{1.8}$ = -6.67°C

You Try

1. How many nickels are there in $2.00? 40 Nickels
2. You have 20 pounds of water. How many gallons of water is this?
   2.398 Gallons – What if you round this number to the nearest tenth?

3. How many cubic feet per second (cfs) are there in 4 million gallons per day (MGD)? 6.19cfs
4. What is 4ºC in ºF? What is 20ºF in ºC? 39.2°F, -6.67°C

5. A quarter in football is 15 minutes. The maximum time between plays is 40 seconds. What would be the minimum numbers of plays that could be run in a game?

Solution

4 x 15 minutes = 60 minutes in one game

60 minutes x $\frac{60\ seconds}{1 minute}$ = 3600 seconds in a game

3600 seconds x $\frac{number\ of\ plays}{40\ seconds\ between\ plays}$ =90 plays

You Try

1. How many nickels are there in $2.00? 40 Nickels
2. You have 20 pounds of water. How many gallons of water is this?
   2.398 Gallons – What if you round this number to the nearest tenth?
3. How many cubic feet per second (cfs) are there in 4 million gallons per day (MGD)? 6.19cfs
4. What is 4ºC in ºF? What is 20ºF in ºC? 39.2°F, -6.67°C
5. A quarter in football is 15 minutes. The maximum time between plays is 40 seconds. What would be the minimum numbers of plays that could be run in a game? 90 plays

Break into Teams

- Work together on the following problems
- Decide the fastest way to complete them
  - Work on them together or;
  - Divide problems up amongst team members or;
  - Any other strategy
- Hit your buzzer/bell when done
- Winning team must have all correct solutions

Team Work

GO!

Team Work

1. Convert 20 gpm to MGD
2. Convert 6000 cf to gallons
3. Convert 7 days to seconds
4. Convert 12°C to Fahrenheit degrees

Team Work

Let's Check the Answers

Solutions

1. Convert 20 gpm to MGD

   $\frac{1MGD}{694gpm}$ X 20 gpm = .029 MGD

2. Covert 6000 cf to gallons

   6000 cf x $\frac{7.48\ gallons}{1\ cf}$ = 44,880 gallons

3. Convert 7 days into seconds

   7 days x $\frac{24\ hours}{1day}$ x $\frac{3600\ seconds}{1hour}$ =604,800 seconds

4. Covert 12°C into Fahrenheit

   (12°C)(1.8)+ 32 = 53.6°F

Questions/Discussion?

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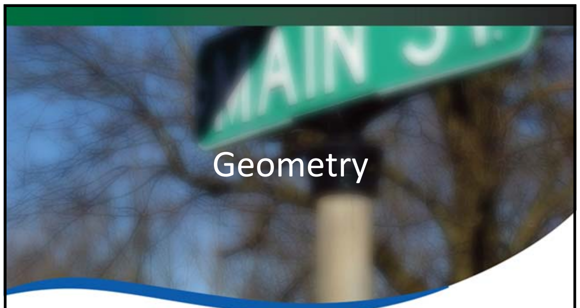
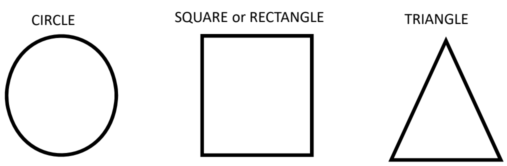


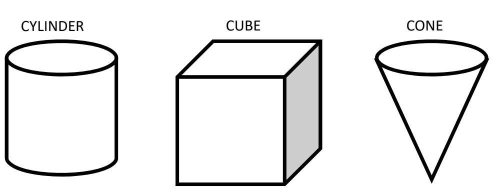
Geometry

2-Dimensional Shapes



Examples of area: square feet (ft^2), inches (in^2),and acre ft (af)

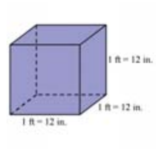
3-Dimensional Shapes



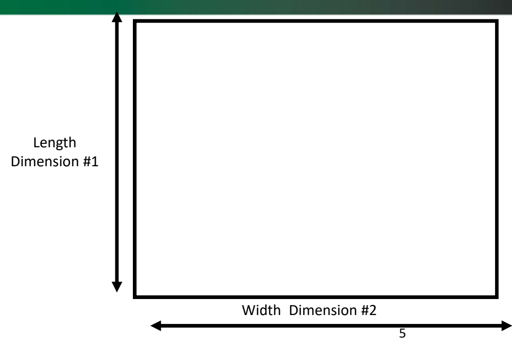
Examples of volume: cubic feet (ft^3), cubic inches (in^3), and acre feet (af)

Math Note

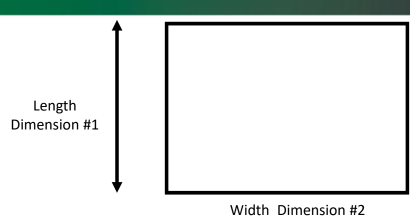
- Feet may be abbreviated ft
- ft^2 = ft x ft (area) = square feet
- ft^3 = ft x ft x ft (volume) = cubic feet



Parts of a Square or Rectangle

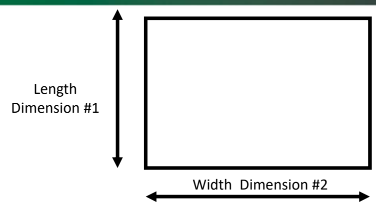


Perimeter



Perimeter = Length + Width + Length + Width
Perimeter= 2 x (Length + Width)

What Would be the Perimeter?



If the length was 10 feet and the width was 20 feet?

Perimeter = Length + Width + Length + Width

Perimeter = 2 x (Length + Width)

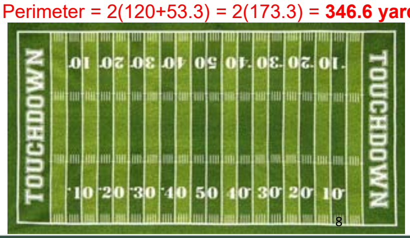
7

What is the Perimeter of a Football Field?

The length of a football field is 120 yards

The width of a football field is 53.3 yards

Perimeter = 2(120+53.3) = 2(173.3) = **346.6 yards**



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Area

- 2-Dimensional problems
  - ❖How much paint do I need to cover the outside of a tank?
  - ❖What is the surface area of a contact basin?
  - ❖What is the flow rate? (velocity times area)
    Q = VA

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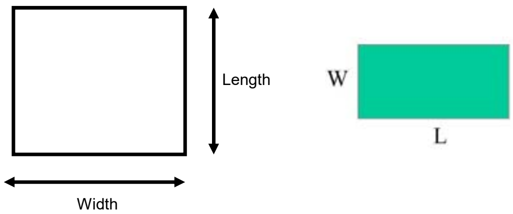
Area of Squares & Rectangles



Area = (Length)(Width)
Area = (Length)(Height)

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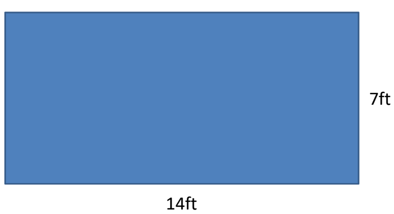
What is the Area if:

Length is 14ft and width is 7ft?



Area= 14 x 7 = **98ft²**

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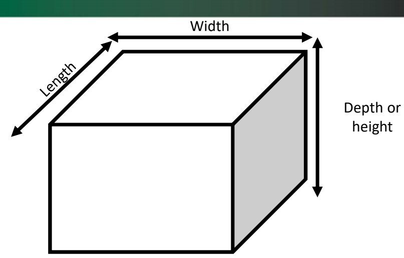
Volume



Volume of a cube = (Length)(Width)(Height)
Volume = Length x Width x Height (or Depth)

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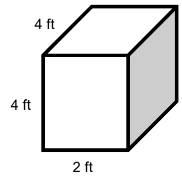
Volume

What would be the volume if:

Length = 2 feet
Width = 4 feet
Height = 4 feet



V = Length x Width x Height
V= 2 ft x 4 ft x 4 ft
V = $32\ ft^3$

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Practice

- What would be the volume of a basin that is 10 feet wide, 20 feet long, and 10 feet deep?

  Volume = (10ft)(10ft)(20ft)=$2{,}000ft^3$

- How many gallons would the basin hold if full?

  1 Cubic Foot = 7.48 gallons

  2,000cubic ft x $\frac{7.48\ gallons}{1\ cubic\ foot}$ = **14,960 gallons**

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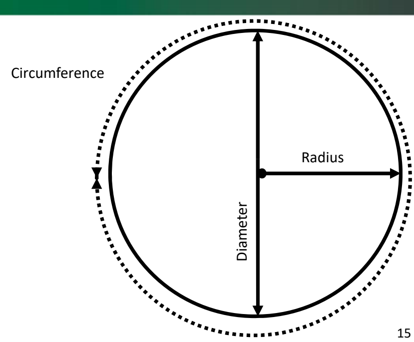
Parts of a Circle



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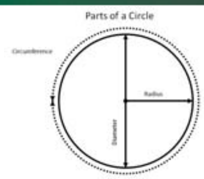
Circle



The radius is equal to half the diameter

Diameter = 2 x Radius

Radius = Diameter / 2

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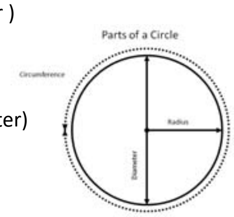
Circumference

Circumference = π (diameter)

π (pi) is equal to 3.14

Circumference = 3.14 (diameter)



Question: How would you write this equation if you had the radius measurement?

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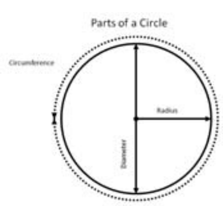
Circumference

Circumference = π x 2(radius)



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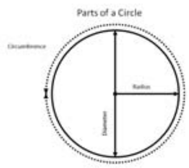
Circumference

What would be the circumference if the diameter was 10 feet?

Circumference = diameter x π



3.14 x 10ft = 31.4ft

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Circumference

What is the circumference of:

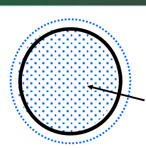
3.5 MG storage tank (20 feet tall) has a radius of 161 feet.

Circumference = 2 x π x r

2 x 3.14 x 161ft = 1,011.08ft

20

Area



Cross Section of a Pipe = Area

Area of a circle = π (radius) ^{2}

= 3.14 x radius x radius

or

Area of a circle = 0.785 (diameter)^2

= 0.785 x diameter x diameter

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Practice

- What would be the area of a circle that has a radius of 10 feet?

  $A = 3.14(10ft)^2 = 3.14(100\ ft)^2 = \mathbf{314ft^2}$

- What would be the area of a circle that has a diameter of 10 feet?

  $A = .785(10ft)^2 = .785(100ft)^2 = \mathbf{78.5ft^2}$

Area $= \pi$ (radius)^2
or
Area = 0.785 (diameter)^2

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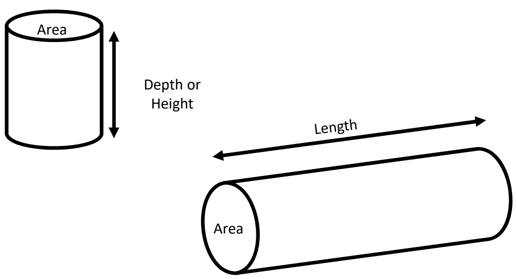
Volume of a Cylinder



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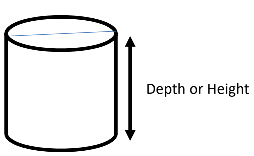
Volume of a Cylinder



- Volume = (0.785) (diameter)^2 (Height)
- Volume = (π) (radius)^2 (Height)

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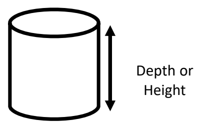
Volume

What would be the volume (in gallons) of a storage tank that has a diameter of 10 feet and a height of 5 feet?

= .785 x $(10ft)^2$ x 5ft
= .785 x 10ft x 10ft x 5ft
= 392.5cf
= 392.5cf x 7.48 gal/cf
= 2936 gal



Volume = (0.785) $(\text{diameter})^2$ (Height)

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Problem

You have a storage tank with a diameter of 100 feet and a height of 10 feet.

- How much fence would you need to go around the tank (assume the fence is 10 feet away from the tank)?
- How much paint would you need to paint the outside of the tank if one can of paint covers 100 square feet?
- How much water does the tank hold (in gallons) if completely full? If 75% full?

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Solution

- How much fence would you need to go around the tank (assume the fence is 10 feet away from the tank)?

C = 120ft x 3.14 = **376.8ft of fencing**

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Solution

- How much paint would you need to paint the outside of the tank if one can of paint covers 100 square feet?

Top= πr^2 =3.14 x (50ft)^2= 7850 ft^2 x $\frac{1\ can}{100ft^2}$ = 78.5 cans

Side= π (diameter)(height) = 3.14(100ft)(10ft) = 3140 sq ft.= 31.4cans

31.4 cans +78.5 cans = **109.9 cans (110)**

28

Solution

- How much water does the tank hold (in gallons) if completely full? If 75% full?

V=(.785)(10,000)(10)=78,500ft^3 x $\frac{7.48\ gallons}{1\ cubic\ feet}$=
587,180 gallons completely full

100% Full = 587,180 gallons x .75 =
440,385 gallons 75% Full

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Activity

- Break into teams
- 1 team at each station
- Follow the directions on the activity sheet
- Change stations when we call "time"

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Questions / Discussion

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Flow Rate

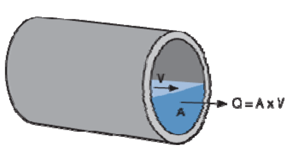
Flow Rate

- Expressed as:
  - gpm = gallons per minute
  - cfs = cubic feet per second
  - gpd = gallons per day
  - MGD = million gallons per day
- Important conversions:
  - 1 cfs = 450 gpm
  - 1MGD = 694gpm
  - 1MGD = 1.55 cfs

Flow Rate

- "**Q**" is the symbol for flow rate
- Flow rate =The **A**rea x The **V**elocity

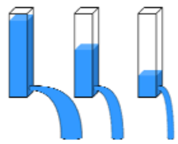
Q=AV



Flow and Velocity

Velocity (v) is the speed at which a particle of a substance is moving. It’s expressed as a distance traveled over a period of time.

- Units
  - mph – miles per hour
  - fps – feet per second



Flow-Rate

Flow rate, Q, is equal to velocity, V, times area, A

$$Q = VA = AV$$

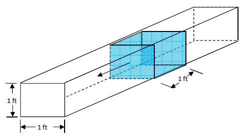
Units

If Q is in cfs, what units do you need V & A in?

Feet Per Second, Square Feet

Flow Rate, Q = VA

- Take a channel 1 ft wide x 1 ft high. A = 1 sq ft



- If the flow velocity (v) is 1 fps, 1 cu ft will pass a given reference point in one second, 1 cfs

Flow Rate

What is the flow rate (Q) if the V = 1 fps and:

- A is 1 sq ft.? Q=1cfs (cubic foot per second)
- A is 2 sq ft.? Q= 2cfs (cubic feet per second)

Flow Rate and Continuity Equation

- What is Q if the V = 1 fps and:
  - A is 1 sq. ft.? Q = 1 cfs
  - A is 2 sq. ft.? Q = 2 cfs
- What is Q if the V = 5 fps and:
  - A is 1 sq. ft.? Q = 5 cfs
  - A is 2 sq. ft.? Q = 10 cfs
- Do you see a relationship between Q, V & A?

Continuity Equation

Law of continuity states that the flow rate at each point in a pipe or channel is the same as the flow rate at any other point (provided no water is added or taken away between the two points).

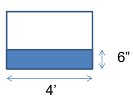
$$Q_1 = Q_2 \text{ or } A_1V_1 = A_2V_2$$

This is the continuity equation

Practice

The flow in a 4' wide channel is 502 gpm and running 6" deep. What is the average velocity in ft/sec?

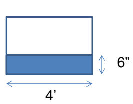
Practice



Formula Q=AV
Rearrange to solve for V

- Q=AV
- To solve for Velocity, Divide both sides by A
- Q/A = ~~A~~V/~~A~~
- V=Q/A

Solution



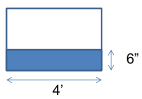
Formula V = Q/A
Known:
Q= 502 gpm
Width = 4'
Height = 6"=0.5'

1. Calculate Q (convert Q to cfs)

502 ~~gal~~/min x (1 cf/7.48 ~~gal~~) = 67.11 cf/min

67.11 cf/~~min~~ x (1~~min~~/60 sec) = 1.119 cf/sec = Q

Solution



Formula V = Q/A
Known:
Q= 502 gpm
Width = 4'
Height = 6"=0.5'

2. Calculate A (convert inches to feet)
   A= H x W = 4' x 0.5' = 2 sq ft

3. V = Q/A = (1.119 ~~c~~f/sec)/(2~~sq ft~~)

   V = 0.56 ft/sec

Flow Rate in a Pipe

What is the flow in cfs of a 6 inch pipe if the velocity is 2fps?

1. Q=VA
2. The velocity is given at 2fps
3. Find the area of the pipe (cross section)
   Area of a circle is .785 x $Diameter^2$

The first step is to convert inches to feet.

Flow Rate

- Convert the units so we can get cubic feet.
  6 in x $\frac{1ft}{12\ in}$ = .5 ft
- Now set up the equation:
  A = .785 $(Diameter)^2$
  A = .785 x .5 ft x .5 ft = .1962 ft^2
  Q = VA = .1962 ft^2 x 2 ft/sec = .39 cfs

Solution

If the flow rate is Q = .39 cfs

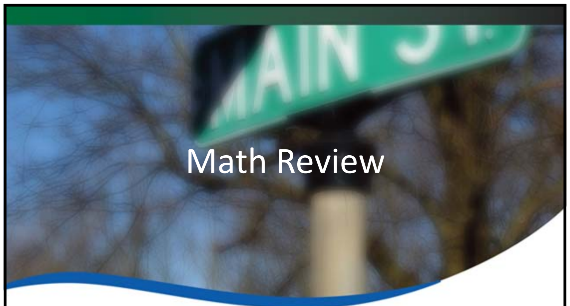
How many gpm is this?

1 cfs =7.48 gallons

60 seconds=1 minute

$\frac{.39\ ft^3}{1\ \text{second}} \times \frac{7.48\ \text{gallons}}{1\ ft^3} \times \frac{60\ \text{seconds}}{1\ \text{minute}} =$ **175 gpm**

Questions / Discussion



Math Review

Review

Yesterday we talked about:

1. Basic Math
2. Conversions
3. Geometry
4. Flow Rate

Basic Math Review

- Taking an Average
- Rounding
- Percentages
- Fractions
- Order of Operations
- Conversions

Conversion Review

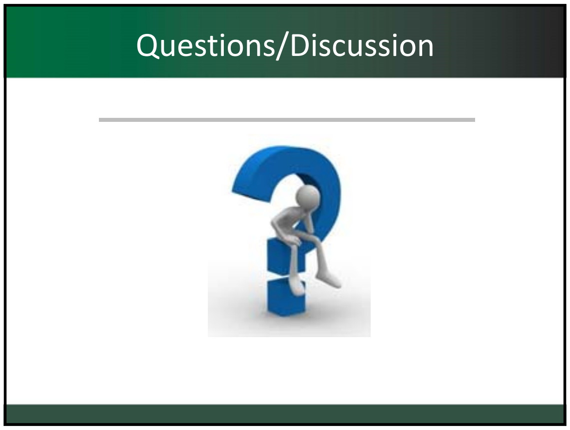
- °F to °C
- Days, Hours, Minutes, Seconds
- gpm to MGD
- cf to gallons

Geometry Review

- Perimeter
- Area
- Volume
- Diameter
- Radius
- Circumference

Flow Rate Review

- Flow Rate (Q)
  - Q = AV
  - (Q/A) = V
  - (Q/V) = A
- Velocity
- Cubic Feet per Second (cfs)
- Gallons per Minute (gpm)


Questions/Discussion

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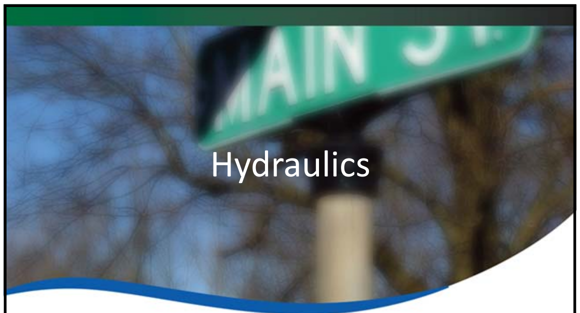


Hydraulics

Hydraulics

- Pressure
  - Pressure – general terms
  - Head pressure
- Force
- Head
- Specific yield/capacity of a well
- Horsepower
- Velocity

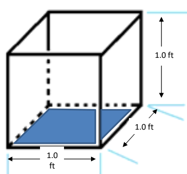
Hydraulics

- **Pressure:** Force per unit area; typically expressed as pounds per square inch (psi).
- **Force:** Push exerted by water on confined surface; force units include pounds (lbs), tons, grams (g), or kilograms (kg).
- **Head:** Vertical distance or height of water above a reference point; head is typically expressed in feet (ft).

Hydraulics

- **Specific yield:** A measure of the water available to wells.
- **Water Horsepower:** The energy or power added to water by the pump.
- **Velocity**: The measurement of the speed at which something is moving. Expressed as ft/sec or ft/min.

Pressure



One cubic foot of water weighs 62.4 lbs.

Because……

7.48 gal/1cf x 8.34 lbs/gal = 62.4 lbs/cf

Conversion Example

What is the approximate weight, in pounds, of 5,000 gallons of water?

= 5,000 gal x 8.34 lb/gal

= 41,700 lbs

Pressure Formulas

Same equation, different conversion factor:

- Pressure (psi) = depth of water (ft) x 0.433 psi/ft
- Pressure (psi) = depth of water (ft) x 2.31 ft

Pressure

What is the pressure, in psi, at the bottom of a 40-ft tall tank with a water level that is 30 feet deep?

TWO WAYS TO FIGURE THE SAME PROBLEM

$$\frac{30\ \text{ft}}{2.31\ \text{psi/ft}} = 12.99\ \text{psi} = 30\ \text{ft} \times .433\ \text{psi/ft}$$

Pressure Head

Instead of pressure, "head" is often used because of the relationship between water depth and pressure and is expressed in feet

Pressure head (ft) = Pressure (psi) x 2.31 ft/1 psi

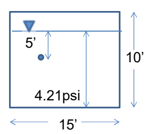
Practice Problems

- A tank is 15 feet in diameter and 10 feet deep. Find the pressure (in psi) at a point 5 feet below the water surface.
- In that same tank, a pressure gauge at the bottom of the tank reads 4.21 psi. What is the depth of the water in the tank?

Solving the practice problem

Problem 1: Known
- 5' below surface

Need to know the pressure
psi= (0.433 psi/~~ft~~)(5~~ft~~) = 2.165 psi
Round to **2 psi**



Problem 2: Known
- psi=4.21 psi

Need to know equivalent head
Head, ft = (2.31 ft/~~psi~~) x (4.21 ~~psi~~)
= 9.7251 ft - round to **9.73 ft**

Formulas:
Pressure, psi = (0.433 psi/ft) x (Head, ft)
Head, ft = (2.31 ft/psi) x (Pressure, psi)

PSI Problem

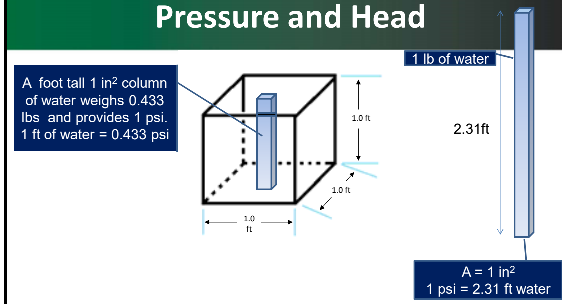
The ground elevation is 120 ft. The water elevation in an elevated tank, is 275 ft. What does the pressure gauge 10 ft. above the ground read?

1. 120 ft +10ft = **130 ft**
2. 275 ft – 130 ft = **145 ft**
3. 145 ft /2.31 ft/psi = **62.8 psi**

or

145 ft X .433 psi/ft = **62.8 psi**

Pressure and Head

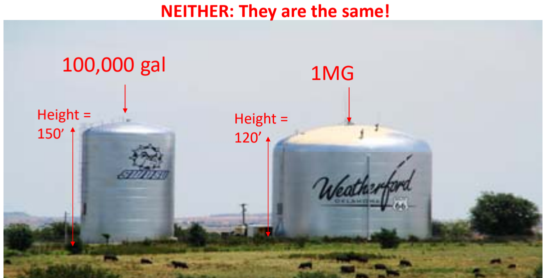


One cubic foot of water weighs 62.4 lbs. What is the force acting on the bottom of the container? **F = 62.4 lbs**
What is the area in square inches, of the bottom of the container? **A = 144 in²**
What is the pressure at the bottom of the container in psi? **P = 0.433 psi/ft**
What is the head in feet at the bottom of the container? **H = 1.0 ft**

PSI

Which has the greater pressure with 50' water?

NEITHER: They are the same!



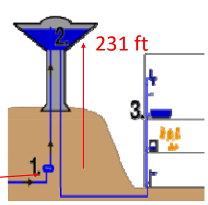
Pressure Head

A pump is rated for 100 psi. How many feet of pressure head is that?

100 psi x 2.31 ft/1psi = 231ft

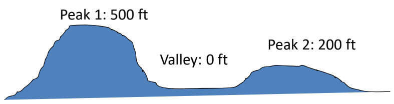
or

100 psi / 0.433psi/ft



Elevation Head

- Difference in head (feet) between 2 different elevations
- Can also be referred to as static head



What is the elevation head between Peak 1 and the valley?
Elevation head (ft) = 500 ft – 0 ft = 500 ft
What is the elevation head between Peak 1 and Peak 2?
Elevation head (ft) = 500 ft – 200 ft = 300 ft

Total Head

- Total Head is the sum of Pressure Head and Elevation Head

Formula

Total Head (ft) = Pressure Head (ft) + Elevation Head (ft)

- Total Head can also be the sum of Static Head and Head losses

Formula

Total Head (ft) = Static Head (ft) + Head Losses (ft)

* Remember – static head can also be referred to as elevation head

Total Head

What is the total head in feet if you have 42 ft static head and 4.6 ft head loss?

To solve, use the following formula:

Total Head (ft) = Static Head (ft) + Head Losses (ft)
= 42 ft (SH) + 4.6 ft (HL)
= 46.6 feet (TH)

Force

Force is pressure multiplied by the cross-sectional area

Formula

Force (lbs) = Pressure (psi) x Area (in^2)

When using this equation, area should be in square inches.

Force

The end of a main is capped for future connection. This **8-inch** main has a closed pressure of **55 psi**. What is the force on the face of the flanged cap?

Force

1. Determine the cross-sectional area of the pipe:

Cross-sectional area of pipe $= \pi r^2$

= 03.14 x 4” x 4”

= 50.24 in^2

2. Solve for force:

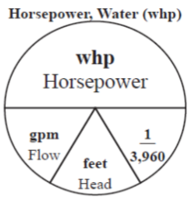
Force (lbs) = Pressure (psi) x Area (in^2)

Force(lbs) = 55 psi x 50.24 in^2 (inches cancel)

Force(lbs) = 2763 lbs

Horsepower

- Water (whp) = $\frac{\text{flow (gpm) x head (ft)}}{3960}$



Horsepower

1. Convert the flowrate from MGD to gpm:

?(gpm) = 1 MGD = (1,000,000/1 M) x (1 day/1,440 min)

= 694 gpm

2. Calculate horsepower:

hp = $\frac{\text{flowrate (gpm) x total head (ft)}}{3960}$

= $\frac{\text{694 gpm x 100 ft}}{3960}$

= 17.53 horsepower

Motor Horsepower

***NOTE:** For Motor Horsepower you will have efficiency*

3. Convert efficiencies from percentages to decimals:

Motor efficiency = 85 %/100% = 0.85

Pump efficiency = 82%/100% = 0.82

Motor Horsepower

4. Calculate Motor Horsepower:

$$hp = \frac{\text{flowrate (gpm) x total head (ft)}}{\text{3960 x. pump eff. x motor eff.}}$$

$$= \frac{\text{694 gpm x 100 ft}}{\text{3960 x .82 x .85}}$$

= 25.14 Motor Horsepower

Specific Capacity of a Well

- Also referred to as "specific yield"
- Well capacity can be limited by the water drawdown

$$\textit{Specific capacity (gpm/ft)} = \frac{\text{Pumping rate (gpm)}}{\text{Drawdown in well (ft)}}$$

Drawdown (ft) = Pumping water level (ft) – static water level (ft)

Specific Capacity

During a 20-hr pumping test of a well, drawdown of the static water level is 15 feet for a pumping rate of 200 gpm. What is the specific yield in gallons per minute per foot of the well?

$$\frac{\text{200 gpm}}{\text{15 ft}} = \text{13.4 gpm/ft}$$

Drawdown

The well has a static water level of 52 ft. With a pumping water level of 73.2 ft, what is the drawdown for the well?

Drawdown (ft) = pumping water level (ft) – static water level (ft)

= 73.2 ft - 52 ft

= 21.2 ft

Volume Pumped

- The amount of water pumped over time

Volume Pumped (gal)
= pumping rate (gpm) x time (min)

A well is pumped at a rate of 100 gpm. What volume of water in gallons is pumped in 5 hours?

Volume Pumped

1. **Convert 5 hours to minutes:**

   5 hours x 60 min/hr = **300 minutes**

2. **Determine the volume pumped when pumping 100 gpm:**

   Volume pumped (gal) = pumping rate (gpm) x time (min)

   = 100 gpm x 300 minutes

   = 30,000 gallons

Velocity

The water travels 1500 ft per hour. What is the velocity of the water in ft/min?

1. Convert the time into minutes
   1 hr x (60 min/1 hr) **= 60 min**

2. $\frac{1500\ \text{ft}}{60\ \text{min}}$ **= 25 ft/min**

Detention/Delivery Time

- Time = $\frac{\text{Volume}}{\text{Flow}}$
- Flow = $\frac{\text{Volume}}{\text{Time}}$
- Volume = Flow x Time

Detention Time

A settling basin is 120 feet long, 20 feet wide, and has a water depth of 15 feet. What is the detention time, in hours, in the basin when the flow is 9 MGD?

★ Remember units need to be compatible.

Solution

- DT(hrs) = $\frac{\text{Tank Capacity (gal)}}{\text{Flow Rate (gph)}}$
- DT(hrs) = $\frac{36{,}000\text{cf} \times 7.48 \text{ gal/cf}}{9\text{MGD} \div 24\text{hrs/d}}$
- 269,280~~gal~~
- 375,000 ~~gal~~/hr
- .72 hrs.

Questions/Discussion?

Dosage & Disinfection

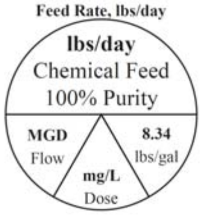
Midwest Assistance Program

serving rural communities since 1979

RCAP NETWORK MEMBER

Dosage/Disinfection

$$\text{Feed Rate, } \frac{\text{lbs}}{\text{day}} = (\text{Dosage, mg/L})(\text{Capacity, MGD})(8.34 \text{ lbs/gal})$$



Pie wheel assumes 100% purity

To find the quantity above the horizontal line, multiply the pie wedges below the line together.

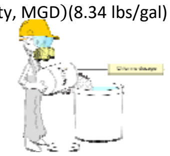
To solve for one of the pie wedges below the horizontal line, cover that pie wedge, then divide the remaining pie wedge(s) into the quantity above the horizontal line.

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

Dosing

For 100% purity only

$$\text{Feed Rate, } \frac{\text{lbs}}{\text{day}} = (\text{Dosage, mg/L})(\text{Capacity, MGD})(8.34 \text{ lbs/gal})$$



For any other % purity

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

Dosage/Disinfection

If you know feed rate and MGD and wanted to determine the dose, divide both sides of the equation by (capacity, MGD)(8.34 lbs/gal).

$$\text{Feed Rate, }\frac{\text{lbs}}{\text{day}} = (\text{Dosage, mg/L})(\text{Capacity, MGD})(8.34\text{ lbs/gal})$$

$$\frac{\text{Feed Rate, }\frac{\text{lbs}}{\text{day}}}{(\text{Capacity, MGD})(8.34\text{ lbs/gal})} = \frac{(\text{Dosage,mg/L})\cancel{(\text{Capacity, MGD})}\cancel{(8.34\text{ lbs/gal})}}{\cancel{(\text{Capacity, MGD})}\cancel{(8.34\text{lbs/gal})}}$$

$$\frac{\text{Feed Rate, }\frac{\text{lbs}}{\text{day}}}{(\text{Capacity, MGD})(8.34\text{ lbs/gal})} = \text{Dosage, mg/L}$$

Practice

A system uses 150 lb/day of alum. If the plant flow rate is 1.5 MGD, what is the dose, in mg/L, of alum being fed to the plant?

$$\text{Dosage} = \frac{\text{Feed Rate lb/day}}{(\text{Capacity MGD})(8.34\text{lbs/gal})}$$

You can also find this equation in a pie wheel!

Solution

$$\text{Dosage} = \frac{150\text{ lb/day}}{(1.5\text{ MGD})(8.34\text{ lbs/gal})} = 12\text{ mg/L}$$

Dosage

A chemical needs to be added at 15 mg/L. The plant produces water at 320 gpm. The chemical is 48% pure. How many gpd of chemical needs to be added?

Flow in MGD = $(\frac{320gal}{1min})(\frac{1440\ min}{1day})(\frac{1MG}{1{,}000{,}000gal})$ = .4608MGD

Feed rate = (.4608MGD)(15mg/L)(8.34lbs/gal)=57.64 lbs/day

BUT THIS IS FOR 100% PURE

We need to divide this by the percentage purity.

Change purity to decimal (.48) $\frac{57.64}{.48}$ = **120.1 lbs/day**

Dosage

How many lbs of sodium hypochlorite (12.5%) needs to be added to a 150,000 gallon tower to get a chlorine concentration of .5 mg/L?

1. What are they asking?...How many lb/day of chlorine?
2. Plug the numbers into the conversion formula(s)
3. Remember to factor in the % purity

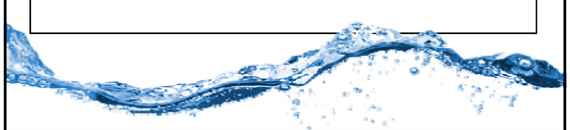
Solution Notes

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

0.5 ppm x .15 MGD x 8.34 lbs/gal

= .6255 lbs/day
.125

= 5.004 lbs/day



Practice

A 12 inch water main has to be disinfected to 50 ppm. The main is 4,000 feet long and has 1 valve installed every 500 feet for isolation. How many pounds of chlorine will be needed to disinfect the entire main?

Solution Notes

ANSWER 9.8 lbs/day

1. 3.14 x .5' x .5' x 4000' = 3,140cf
2. 3,140 cf x 7.48 gal/cf = 0.023487 MGD
3. 50 mg/l x 8.34 lbs/gal x 0.023487 MGD
4. 9.8 lbs/day

Practice

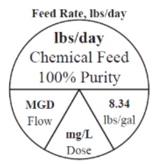
A cylindrical cistern with a radius of 5 feet and a height of 10 feet is filled with water. If 3 pounds of chemical is dissolved in the water, what will be the dosage in milligrams per liter?

a. 112 mg/L
b. 75 mg/L
c. 61 mg/L
d. 27 mg/L

Solution Notes

1. Solve for gallons (volume) of water first
   .785 x 10' x 10' x 10' x = **785 cf**
2. Convert to MGD = 785 cf x 7.48 gal/cf **.005872 MGD**
3. Solve for dosage

$$\frac{3\text{ lb}}{.005872\text{ MGD X }8.34\text{ lb/gal}} = \frac{3\text{ lb}}{.04897}$$



ANSWER **= 61.2 mg/L**

Practice

A chlorine dosage of 0.35 mg/L is applied at the pump station preceding the plant. The 36 inch force main is 23,000 feet long and the flow is 5,560 gpm.

What is the theoretical contact time for the chlorine prior to entering the plant?

a. 1 hour 48 minutes
b. 2 hours 24 minutes
c. 3 hours 38 minutes
d. 4 hours 4 minutes

Solution Notes

- Find the volume of the cylinder
  3.14 x 1.5' 1.5' x 23,000' = 162,495 cf
- Convert gpm to cfs
  162,495 cf x 7.48 gal/cf = 1.2MG
- Divide the volume by the cfs
  1.2 MG/ 5560 gpm = 219 mins

Solution Notes

- Convert the minutes into hours

$$\frac{219 \text{ mins} \times 1 \text{ hr}}{60 \text{ min/hr}} = 3.66 \text{ hrs}$$

- What do you get?

  c. 3 hours 38 minutes

Questions/Discussion?

Formula/Conversion Table

Water Treatment, Distribution, & Water Laboratory Exams

ABC Association of Boards of Certification | PO PROFESSIONAL OPERATOR

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

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

Area of Circle* = (0.785)(Diameter^2)

Area of Circle = (3.14)(Radius^2)

Area of Cone (lateral area) = $(3.14)(\text{Radius})\sqrt{\text{Radius}^2 + \text{Height}^2}$

Area of Cone (total surface area) = $(3.14)(\text{Radius})(\text{Radius} + \sqrt{\text{Radius}^2 + \text{Height}^2})$

Area of Cylinder (total exterior surface area) = [End #1 SA] + [End #2 SA] + [(3.14)(Diameter)(Height or Depth)]

Where SA = surface area

Area of Rectangle* = (Length)(Width)

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

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

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

Blending = $(V_1)(C_1) + (V_2)(C_2) = (V_3)(C_3)$ ***Where V = volume or flow, C = concentration or percent solution***

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

Chemical Feed Pump Setting, mL/min = $\frac{\text{(Flow, MGD)(Dose, mg/L)(3.785 L/gal)(1,000,000 gal/MG)}}{\text{(Feed Chemical Density, mg/mL)(1,440 min/day)}}$

Chemical Feed Pump Setting, mL/min =

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

Circumference of Circle = (3.14)(Diameter)

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

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

Degrees Celsius = $\frac{(°F - 32)}{1.8}$

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

Degrees Fahrenheit = (ºC)(1.8) + 32

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

Electromotive Force, volts* = (Current, amps)(Resistance, ohms)

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

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

Feed Rate (Fluoride), lb/day =

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

Feed Rate (Fluoride), kg/day =

$$\frac{\text{(Dosage, mg/L)(Capacity, } m^3\text{/day)}}{\text{(Available Fluoride Ion, \% expressed as a decimal)(Purity, \% expressed as a decimal)(1,000)}}$$

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

Feed Rate (Fluoride Saturator), Lpm = $\frac{\text{(Plant capacity, Lpm)(Dosage, mg/L)}}{\text{18,000 mg/L}}$

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

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

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

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

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

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

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

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

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

Flow Rate, ft^3/sec* = (Area, ft^2)(Velocity, ft/sec)

Flow Rate, m^3/sec* = (Area, m^2)(Velocity, m/sec)

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

Force, newtons* = (Pressure, pascals)(Area, m^2)

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

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

Horsepower, Motor, hp =

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

Horsepower, Motor, kW =

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

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

Horsepower, Water, kW = (9.8)(Flow, m^3/sec)(Head, m)

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

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

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

Hypochlorite Strength, % = $\frac{\text{(Chlorine Required, kg)(100)}}{\text{(Hypochlorite Solution Needed, kg)}}$

Langelier Saturation Index = pH – pHs

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

Leakage, Lpd = $\frac{\text{Volume, L}}{\text{Time, days}}$

Loading Rate, lb/day* = (Flow, MGD)(Concentration, mg/L)(8.34 lb/gal)

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

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

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

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

Milliequivalent = (mL)(Normality)

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

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

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

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

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

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

Removal, % = $\frac{\text{In} - \text{Out}}{\text{In}} \times 100\%$

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

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

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

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

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

Surface Loading Rate or **Surface Overflow Rate, gpd/ft²** = $\frac{\text{Flow, gpd}}{\text{Area, ft}^2}$

Surface Loading Rate or **Surface Overflow Rate, Lpd/m²** = $\frac{\text{Flow, Lpd}}{\text{Area, m}^2}$

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

Three Normal Equation = $(C_1 \times V_1) + (C_2 \times V_2) = (C_3 \times V_3)$ ***Where $V_1 + V_2 = V_3$; C =concentration, V = volume or flow; Concentration units must match; Volume units must match***

Threshold Odor Number = $\frac{A+B}{A}$ ***Where A = volume of odor causing sample, B = volume of odor free water***

Two Normal Equation = $(C_1 \times V_1) = (C_2 \times V_2)$ ***Where C = Concentration, V = volume or flow; Concentration units must match; Volume units must match***

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

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

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

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

Volume of Cone* = (1/3)(0.785)(Diameter^2)(Height)

Volume of Cylinder* = (0.785)(Diameter^2)(Height)

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

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

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

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

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

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

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

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

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

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

Abbreviations

C .... Celsius
cfs .... cubic feet per second
cm .... centimeters
DO .... dissolved oxygen
EMF .... electromotive force
F................. Fahrenheit
ft .... feet
ft lb .... foot-pound
g .... grams
gal .... US gallons
gfd.............. US gallons flux per day
gpcd .... US gallons per capita per day
gpd............. US gallons per day
gpg .... grains per US gallon
gpm............ US gallons per minute
hp............... horsepower
hr .... hours
in................ inches
kg............... kilograms
km.............. kilometers
kPa .... kilopascals
kW .... kilowatts
kWh........... kilowatt-hours
L .... liters
lb................ pounds
Lpcd .... liters per capita per day
Lpd .... liters per day
Lpm............liters per minute
LSI..............Langelier Saturation Index
m.................meters
MG.............million gallons
MGD ....million US gallons per day
mg/L...........milligrams per liter
min ....minutes
mL..............milliliters
ML..............million liters
MLD...........million liters per day
ORP............oxidation reduction potential
ppb ....parts per billion
ppm ....parts per million
psi ....pounds per square inch
Q.................flow
RPM...........revolutions per minute
SDI ....sludge density index
sec...............second
SS................settleable solids
TOC ....total organic carbon
TSS.............total suspended solids
TTHM........total trihalomethanes
VS...............volatile solids
W................watts
yd................yards
yr ....years

Conversion Factors

1 acre... = 43,560 ft^2
= 4,046.9 m^2
1 acre foot of water .... = 326,000 gal
1 cubic foot of water .... = 7.48 gal
= 62.4 lb
1 cubic foot per second .... = 0.646 MGD
= 448.8 gpm
1 cubic meter of water .... = 1,000 kg
= 1,000 L
= 264 gal
1 foot .... = 0.305 m
1 foot of water................................ = 0.433 psi
1 gallon (US).................................. = 3.785 L
= 8.34 lb of water
1 grain per US gallon.................... = 17.1 mg/L
1 hectare.. = 10,000 m^2
1 horsepower .... = 0.746 kW
= 746 W
= 33,000 ft lb/min
1 inch... = 2.54 cm
1 liter per second........................... = 0.0864 MLD
1 meter of water .... = 9.8 kPa
1 metric ton .... = 2,205 lb
= 1,000 kg
1 mile... = 5,280 ft
= 1.61 km
1 million US gallons per day .... = 694 gpm
= 1.55 ft^3/sec
1 pound .... = 0.454 kg
1 pound per square inch............... = 2.31 ft of water
= 6.89 kPa
1 square meter.............................. = 1.19 yd^2
1 ton .... = 2,000 lb
1% .... = 10,000 mg/L
π or pi.. = 3.14

Alkalinity Relationships

All Alkalinity expressed as mg/L as CaCO3 ● P – phenolphthalein alkalinity ● T – total alkalinity

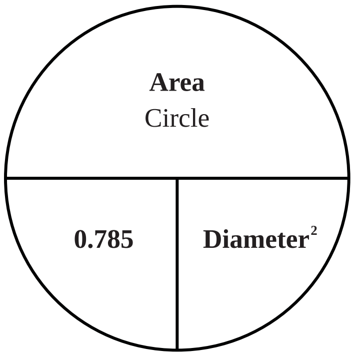
Result of Titration	Hydroxide Alkalinity	Carbonate Alkalinity	Bicarbonate Concentration
P = 0	0	0	T
P < ½T	0	2P	T – 2P
P = ½T	0	2P	0
P > ½T	2P – T	2(T – P)	0
P = T	T	0	0

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

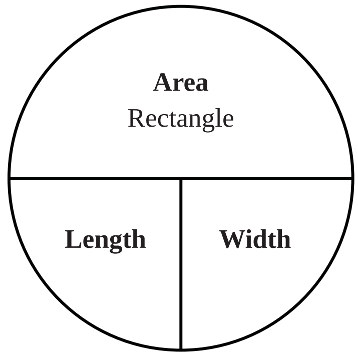
*Pie Wheels

- 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.
- When US and metric units or values differ, the metric is shown in parentheses, e.g. (m^2).

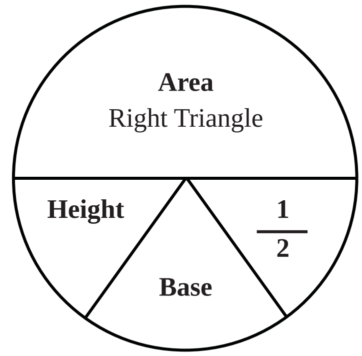
Area of Circle



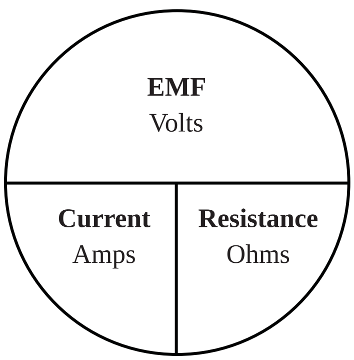
Area of Rectangle



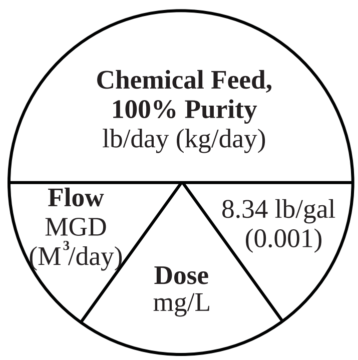
Area of Right Triangle



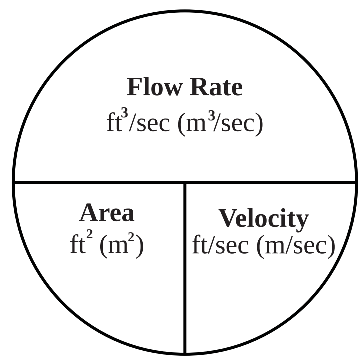
Electromotive Force (EMF), Volts



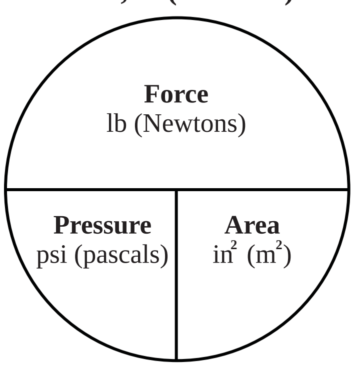
Feed Rate, lb/day (kg/day)



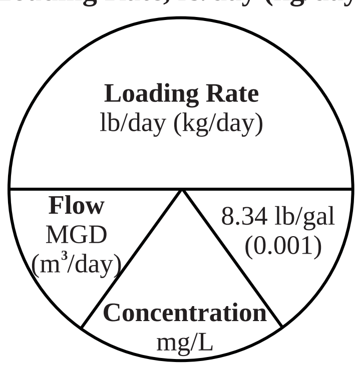
Flow Rate, ft^3/sec (m^3/sec)



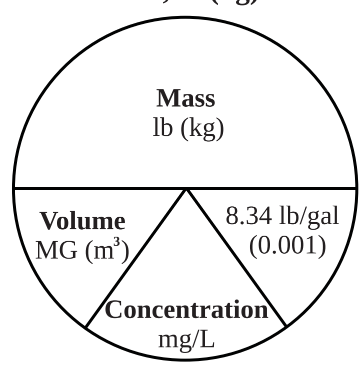
Force, lb (Newtons)



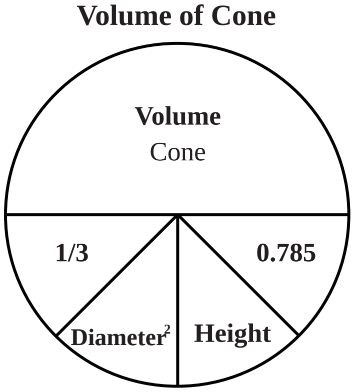
Loading Rate, lb/day (kg/day)



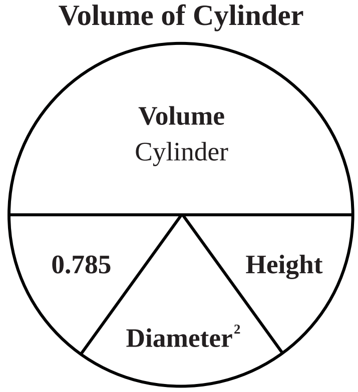
Mass, lb (kg)



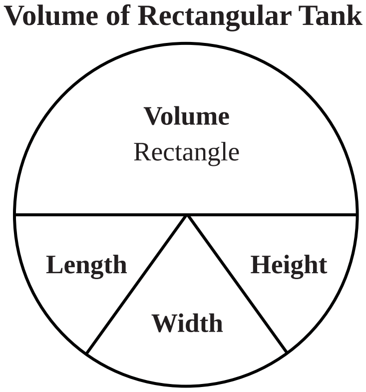
Volume of Cone



Volume of Cylinder



Volume of Rectangular Tank



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

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Formula/Conversion Table

Wastewater Treatment, Collection, Industrial Waste, & Wastewater Laboratory Exams

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

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

Area of Circle* = (0.785)(Diameter^2)

Area of Circle = (3.14)(Radius^2)

Area of Cone (lateral area) = $(3.14)(\text{Radius})\sqrt{\text{Radius}^2 + \text{Height}^2}$

Area of Cone (total surface area) = $(3.14)(\text{Radius})(\text{Radius} + \sqrt{\text{Radius}^2 + \text{Height}^2})$

Area of Cylinder (total exterior surface area) = [End #1 SA] + [End #2 SA] + [(3.14)(Diameter)(Height or Depth)]
Where SA = surface area

Area of Rectangle* = (Length)(Width)

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

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

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

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

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

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

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

Chemical Feed Pump Setting, mL/min = $\frac{\text{(Flow, MGD)(Dose, mg/L)(3.785 L/gal)(1,000,000 gal/MG)}}{\text{(Feed Chemical Density, mg/mL)(1,440 min/day)}}$

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

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

Circumference of Circle = (3.14)(Diameter)

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

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

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

Degrees Celsius = $\frac{(°F - 32)}{1.8}$

Degrees Fahrenheit = (ºC)(1.8) + 32

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

Electromotive Force, volts* = (Current, amps)(Resistance, ohms)

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

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

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

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

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

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

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

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

Flow Rate, ft^3/sec* = (Area, ft^2)(Velocity, ft/sec)

Flow Rate, m^3/sec* = (Area, m^2)(Velocity, m/sec)

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

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

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

Force, newtons* = (Pressure, pascals)(Area, m^2)

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

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

Horsepower, Motor, hp =

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

Horsepower, Motor, kW =

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

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

Horsepower, Water, kW = (9.8)(Flow, m^3/sec)(Head, m)

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

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

Loading Rate, lb/day* = (Flow, MGD)(Concentration, mg/L)(8.34 lb/gal)

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

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

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

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

Milliequivalent = (mL)(Normality)

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

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

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

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

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

Organic Loading Rate-RBC, lb $SBOD_5$/day/1,000 ft^2 = $\frac{\text{Organic Load, lb SBOD}_5\text{/day}}{\text{Surface Area of Media, 1,000 ft}^2}$

Organic Loading Rate-RBC, kg $SBOD_5/m^2$ days = $\frac{\text{Organic Load, kg SBOD}_5\text{/day}}{\text{Surface Area of Media, m}^2}$

Organic Loading Rate-Trickling Filter, lb BOD_5/day/1,000 ft^3 = $\frac{\text{Organic Load, lb BOD}_5\text{/day}}{\text{Volume, 1,000 ft}^3}$

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

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

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

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

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

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

Reduction of Volatile Solids, % = $\left(\frac{\text{VS in} - \text{VS out}}{\text{VS in} - (\text{VS in} \times \text{VS out})}\right) \times 100\%$

All information (In and Out) must be in decimal form

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

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

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

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

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

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

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

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

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

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

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

Solids Retention Time: *see Mean Cell Residence Time*

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

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

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

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

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

Three Normal Equation = $(C_1 \text{ x } V_1) + (C_2 \text{ x } V_2) = (C_3 \text{ x } V_3)$ ***Where $V_1 + V_2 = V_3$; C = concentration, V = volume or flow; Concentration units must match; Volume units must match***

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

Two Normal Equation = $(C_1 \text{ x } V_1) = (C_2 \text{ x } V_2)$ ***Where C = Concentration, V = volume or flow; Concentration units must match; Volume units must match***

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

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

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

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

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

Volume of Cone* = (1/3)(0.785)(Diameter^2)(Height)

Volume of Cylinder* = (0.785)(Diameter^2)(Height)

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

Waste Milliequivalent = (mL)(Normality)

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

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

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

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

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

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

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

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

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

Abbreviations

atm	atmospheres
BOD_5	biochemical oxygen demand
C	Celsius
$CBOD_5$	carbonaceous biochemical oxygen demand
cfs	cubic feet per second
cm	centimeters
COD	chemical oxygen demand
DO	dissolved oxygen
EMF	electromotive force
F	Fahrenheit
F/M ratio	food to microorganism ratio
ft	feet
ft lb	foot-pound
g	grams
gal	US gallons
gfd	US gallons flux per day
gpcd	US gallons per capita per day
gpd	US gallons per day
gpg	grains per US gallon
gpm	US gallons per minute
hp	horsepower
hr	hours
in	inches
kg	kilograms
km	kilometers
kPa	kilopascals
kW	kilowatts
kWh	kilowatt-hours
L	liters
lb	pounds
Lpcd	liters per capita per day
Lpd	liters per day
Lpm	liters per minute
LSI	Langelier Saturation Index
m	meters
MCRT	mean cell residence time
MG	million US gallons
MGD	million US gallons per day
mg/L	milligrams per liter
min	minutes
mL	milliliters
ML	million liters
MLD	million liters per day
MLSS	mixed liquor suspended solids
MLVSS	mixed liquor volatile suspended solids
OCR	oxygen consumption rate
ORP	oxidation reduction potential
OUR	oxygen uptake rate
PE	population equivalent
ppb	parts per billion
ppm	parts per million
psi	pounds per square inch
Q	flow
RAS	return activated sludge
RBC	rotating biological contactor
RPM	revolutions per minute
$SBOD_5$	Soluble BOD
SDI	sludge density index
sec	second
SOUR	specific oxygen uptake rate
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
VSS	volatile suspended solids
W	watts
WAS	waste activated sludge
yd	yards
yr	years

Conversion Factors

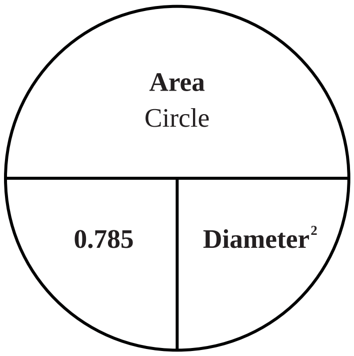
1 acre	= 43,560 ft^2
	= 4,046.9 m^2
1 acre foot of water	= 326,000 gal
1 atm	= 33.9 ft of water
	= 10.3 m of water
	= 14.7 psi
	= 101.3 kPa
1 cubic foot of water	= 7.48 gal
	= 62.4 lb
1 cubic foot per second	= 0.646 MGD
	= 448.8 gpm
1 cubic meter of water	= 1,000 kg
	= 1,000 L
	= 264 gal
1 foot	= 0.305 m
1 foot of water	= 0.433 psi
1 gallon (US)	= 3.785 L
	= 8.34 lb of water
1 grain per US gallon	= 17.1 mg/L
1 hectare	= 10,000 m^2
1 horsepower	= 0.746 kW
	= 746 W
	= 33,000 ft lb/min
1 inch	= 2.54 cm
1 liter per second	= 0.0864 MLD
1 meter of water	= 9.8 kPa
1 metric ton	= 2,205 lb
	= 1,000 kg
1 mile	= 5,280 ft
	= 1.61 km
1 million US gallons per day	= 694 gpm
	= 1.55 ft^3/sec
1 pound	= 0.454 kg
1 pound per square inch	= 2.31 ft of water
	= 6.89 kPa
1 square meter	= 1.19 yd^2
1 ton	= 2,000 lb
1%	= 10,000 mg/L
π or **pi**	= 3.14
Population Equivalent, hydraulic	= 100 gal/person/day
	= 378.5 L/person/day
Population Equivalent, organic	= 0.17 lb BOD/person/day
	= 0.077 kg BOD/person/day

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

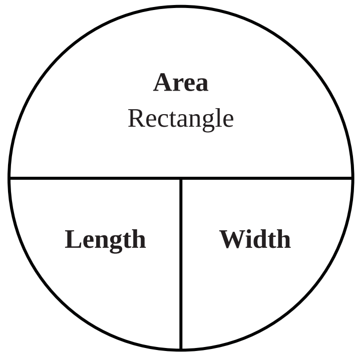
*Pie Wheels

- 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.
- When US and metric units or values differ, the metric is shown in parentheses, e.g. (m^2).

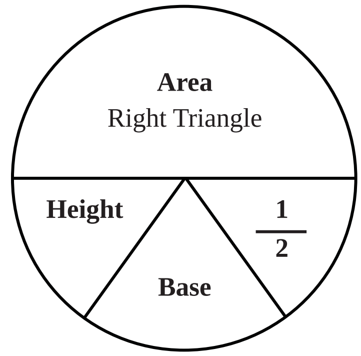
Area of Circle



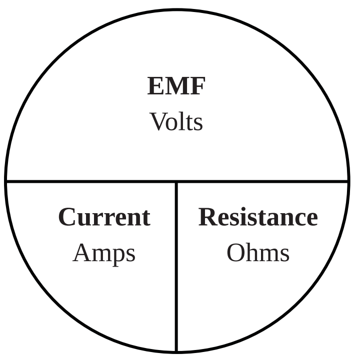
Area of Rectangle



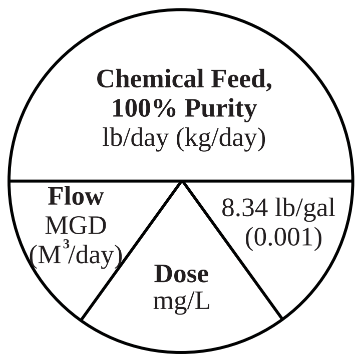
Area of Right Triangle



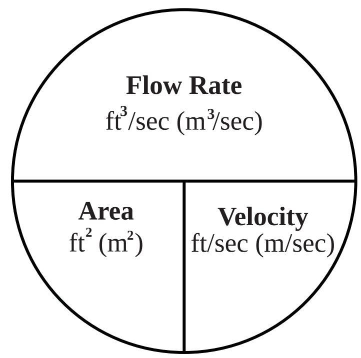
Electromotive Force (EMF), Volts



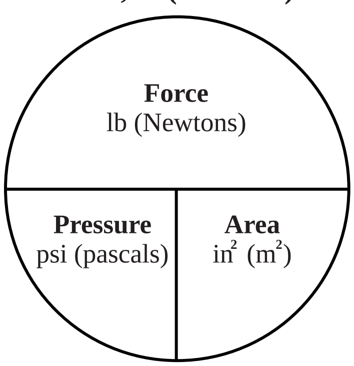
Feed Rate, lb/day (kg/day)



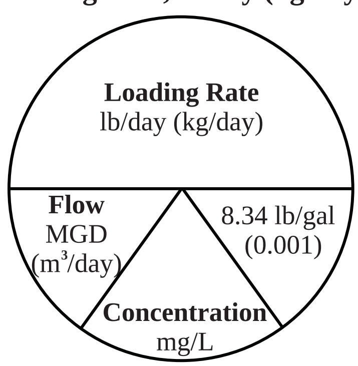
Flow Rate, ft^3/sec (m^3/sec)



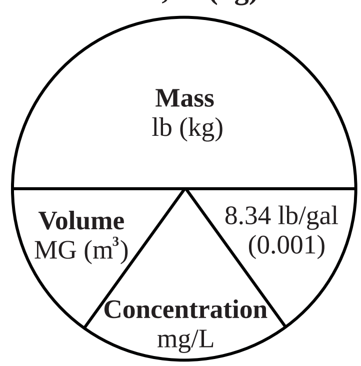
Force, lb (Newtons)



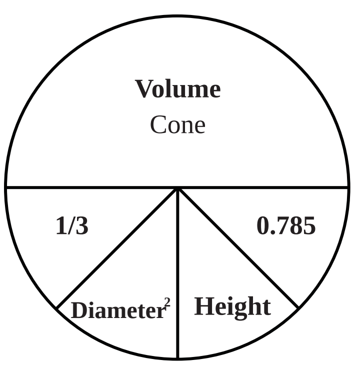
Loading Rate, lb/day (kg/day)



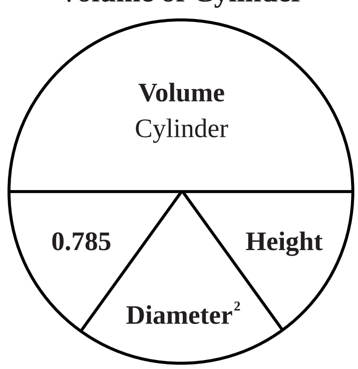
Mass, lb (kg)



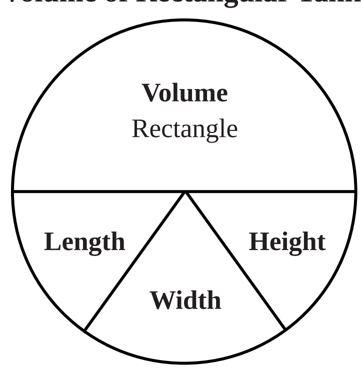
Volume of Cone



Volume of Cylinder



Volume of Rectangular Tank



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

ABC Need-to-Know Criteria for Very Small Water System Operators

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- Jess Jones (Chair), Operator Training Committee of Ohio
- Richard Bond, Colorado Springs (CO) Utilities
- Don Jackson, South Carolina Environmental Certification Board
- Ken Kerri, California State University, Sacramento, Office of Water Programs
- Thomas Rothermich, City of St. Louis (MO) – Water Division
- Russ Glaser, Clark Public Utilities, Vancouver, Washington
- Martin Nutt, Arkansas Drinking Water Advisory and Operators Licensing Committee
- Wes Haskell, Old Town Water District, Old Town, Maine
- Shawn Bradford, Aquarion Water Company
- Cindy Cook, Minnesota Department of Health, Drinking Water Protection

Introduction

As part of the development of very small water system certification exams, the Association of Boards of Certification (ABC) conducted a job analysis of very small water system operators during 1998. The definition of a very small water system used during the job analysis was a system serving a maximum population of 500 with no treatment other than disinfection. The Need-to-Know Criteria was developed from the results of ABC's 1998 very small water system operator job analysis.

In 2005, ABC's Distribution Validation and Examination (V&E) Committee revised the need-to-know criteria to reflect current terminology used in the item bank. The information in this document reflects the essential job tasks performed by operators and their requisite capabilities. This document is intended to be used by certification programs and trainers to help prepare operators for entry into the profession.

How the Need-to-Know Criteria Was Developed

In 1998, a seven-member job analysis committee was formed to provide technical assistance in the development of the very small water system operator job analysis. During their meeting, this committee developed the list of the important job tasks performed by very small water system operators. The committee also verified the technical accuracy, clarity, and comprehensiveness of the job tasks. The committee then identified the capabilities (i.e., knowledge, skills, and abilities) required to perform the identified job tasks. Identification of capabilities was done on a task by task basis, so that a link was established between each task statement and requisite capability. This process resulted in a final list of 238 job tasks and 178 capabilities.

Task Inventory

A task inventory was developed from the data collected during the committee meeting. The inventory included 8-point rating scales for frequency of performance and seriousness of inadequate or incorrect performance. These two rating scales were used because they provide useful information (i.e., how critical each task is and how frequently each task is performed) pertaining to certification. The task inventory was sent to 220 certified very small water system operators throughout the United States and Canada. Ninety-three out of the 220 inventories mailed were returned for a response rate 42%.

Analysis of Ratings

The mean, standard deviation, and the percentage of respondents performing each task statement were computed. The mean was used to determine the importance of items and the standard deviation was used to identify items with a wide variation in responses. The percentage of respondents performing each task statement was used to identify tasks and capabilities commonly performed by operators throughout the United States and Canada.

A criticality value of 2(mean seriousness rating) + mean frequency rating was calculated for each item on the inventory. This formula gives extra weight to the seriousness rating in determining critical items and was appropriate because it emphasized the purpose of certification—to provide competent operators.

Core Competencies

The criticality ratings and percentage of operators reporting that they performed the tasks were used to determine what is covered on the very small water system exam. The essential tasks and capabilities that were identified through this process are called the core competencies. The following pages list the core competencies for very small water system operators. The core competencies are clustered into the following job duties:

- Operate System
- Water Quality Parameters and Sampling
- Operate Equipment
- Install, Maintain and Evaluate Equipment
- Perform Safety Duties
- Perform Administrative and Compliance Duties

Core Competencies for Very Small Water System Operators

Operate System

System Design
- Assess system demand
- Flushing program
- System layout
- System map
- Perform pressure readings
- Read blueprints, readings, and maps
- Select materials
- Select type of pipes
- Size mains

System Inspection
- Cross connection surveys/control
- Sample site plan
- Sanitary surveys
- Well inspection

Chlorine Disinfection
- Monitor disinfection process
- Evaluate disinfection process
- Adjust disinfection process

Required capabilities:
- Ability to adjust flow patterns and system units
- Ability to communicate verbally and in writing
- Ability to diagnose/troubleshoot system units
- Ability to discriminate between normal and abnormal conditions
- Ability to evaluate system units
- Ability to inspect pumps
- Ability to maintain system in normal operating condition
- Ability to monitor and adjust equipment
- Ability to perform basic math
- Knowledge of blueprint readings
- Knowledge of cathodic protection
- Knowledge of different types of joints, restraints and thrust blocks
- Knowledge of disinfection concepts and design parameters
- Knowledge of disinfection process
- Knowledge of fireflow requirements
- Knowledge of general chemistry, biology and physical science
- Knowledge of general electrical and hydraulic principles
- Knowledge of hydrology
- Knowledge of measuring instruments
- Knowledge of monitoring requirements
- Knowledge of piping material, type and size
- Knowledge of principles of measurement
- Knowledge of regulations
- Knowledge of sampling procedures and requirements
- Knowledge of sanitary survey process
- Knowledge of standards
- Knowledge of start-up and shut-down procedures
- Knowledge of testing instruments
- Knowledge of well drilling principles
- Knowledge of well-head protection

Core Competencies (continued)

Water Quality Parameters and Sampling

- Chlorine demand/residual/dosage
- Coliforms
- pH
- Temperature
- Turbidity

Required capabilities:

- Ability to calibrate instruments
- Ability to follow written procedures
- Ability to interpret Material Safety Data Sheets
- Ability to perform basic math
- Ability to recognize normal and abnormal analytical results
- Knowledge of basic laboratory equipment
- Knowledge of chemical handling and storage
- Knowledge of general biology, chemistry and physical science
- Knowledge of normal characteristics of water
- Knowledge of principles of measurement
- Knowledge of public notification requirements
- Knowledge of quality control/quality assurance practices
- Knowledge of regulations
- Knowledge of reporting requirements
- Knowledge of safety procedures
- Knowledge of sampling procedures

Operate Equipment

- Blowers and compressors
- Centrifugal pumps
- Chemical feeders
- Chlorinators
- Hydrants
- Hydraulic equipment
- Instrumentation
- Leak detectors
- Positive-displacement pumps
- Valves

Required capabilities:

- Ability to monitor, evaluate and adjust equipment
- Knowledge of drinking water concepts
- Knowledge of function of tools
- Knowledge of general electrical and mechanical principles
- Knowledge of hydraulic and pneumatic principles
- Knowledge of regulations
- Knowledge of safety procedures
- Knowledge of start-up and shut-down procedures
- Knowledge of system operation and maintenance

Core Competencies (continued)

Install, Maintain and Evaluate Equipment

Install and maintain equipment:
- Backflow prevention devices
- Chemical feeders
- Chlorinators
- Corrosion control
- Electric motors
- Hydrants
- Meters
- Pipe repair
- Pumps
- Service connection
- Storage tanks
- Taps
- Valves
- Water mains

Evaluate operation of equipment:
- Inspect equipment for abnormal conditions
- Read charts
- Read meters
- Read pressure gauges
- Troubleshoot electrical equipment

Required capabilities:
- Ability to calibrate equipment
- Ability to diagnose/troubleshoot equipment
- Ability to differentiate between preventive and corrective maintenance
- Ability to discriminate between normal and abnormal conditions
- Ability to evaluate and adjust equipment
- Ability to follow written procedures
- Ability to order necessary spare parts
- Ability to perform general maintenance
- Ability to record information
- Knowledge of corrosion control processes
- Knowledge of dechlorination and disinfection processes
- Knowledge of different types of cross-connections and approved backflow methods and devices
- Knowledge of general electrical, mechanical, hydraulic and pneumatic principles
- Knowledge of lubricant and fluid characteristics
- Knowledge of pipe fittings and joining methods
- Knowledge of piping material, type and size
- Knowledge of regulations
- Knowledge of start-up and shut-down procedures
- Knowledge of system operation and maintenance

Core Competencies (continued)

Perform Safety Procedures

- Chemical handling
- Confined space entry
- Electrical hazards
- Fire safety
- Lock-out/tag-out
- Personal protective equipment
- Traffic/work zone

Required capabilities:

- Ability to communicate verbally and in writing
- Ability to interpret Material Safety Data Sheets
- Ability to recognize unsafe work conditions/safety hazards
- Ability to select and operate safety equipment
- Knowledge of emergency plans
- Knowledge of potential causes and impact of system disasters
- Knowledge of risk management
- Knowledge of safety procedures

Perform Administrative and Compliance Duties

Administrative and Security

- Administer compliance, emergency preparedness and safety program
- Develop budget
- Develop operation and maintenance plan
- Plan and organize work activities
- Record and evaluate data
- Respond to complaints
- Write regulatory authority reports

Comply with Drinking Water Regulations

United States Exams –

- Code of Federal Regulations, Title 40, Part 141 - National Primary Drinking Water Regulations:
  - Subpart A - General definitions
  - Subpart B - Maximum contaminant levels
  - Subpart C - Monitoring and analytical requirements
  - Subpart D - Reporting and recordkeeping
  - Subpart I - Control of lead and copper
  - Subpart Q - Public notification of drinking water violations

Canadian Exams

- Provincial and territorial regulations

Required capabilities:

- Ability to assess likelihood of disaster occurring
- Ability to communicate verbally and in writing
- Ability to coordinate emergency response with other organizations
- Ability to generate written policies and procedures
- Ability to interpret and transcribe data
- Ability to organize information and review reports
- Ability to perform basic math
- Ability to perform impact assessments
- Ability to translate technical language into common terminology
- Knowledge of emergency plans
- Knowledge of local codes and ordinances
- Knowledge of monitoring and reporting requirements
- Knowledge of potential causes and impact of system disasters
- Knowledge of principles of finance
- Knowledge of principles of management
- Knowledge of principles of public relations
- Knowledge of public notification requirements
- Knowledge of public participation process
- Knowledge of recordkeeping function and policies
- Knowledge of regulations
- Knowledge of risk management
- Knowledge of system operation and maintenance

Very Small Water System Certification Exam

The very small water system certification exam evaluates an operator's knowledge of tasks related to the operation of small water systems. The content of the exam was determined from the results of the job analysis. To successfully take an ABC exam, an operator must demonstrate knowledge of the core competencies in this document.

The very small water system exam consists of 50 multiple-choice questions. The specifications for the exams are based on a weighting of the job analysis results so that they reflect the criticality of tasks performed on the job. The specifications list the percentage of questions on the exam that fall under each job duty. For a list of tasks and capabilities associated with each job duty, please refer to the list of core competencies on the previous pages.

ABC Very Small Water System Exam Specifications

Job Duty	Percent of Exam
Operate System	22%
Water Quality Parameters and Sampling	20%
Operate Equipment	10%
Install, Maintain and Evaluate Equipment	16%
Perform Safety Duties	14%
Perform Administrative and Compliance Duties	18%

Suggested References

The following are approved as reference sources for the ABC very small water system examination. Operators should use the latest edition of these reference sources to prepare for the exam.

American Water Works Association (AWWA)
- *Water Transmission and Distribution*
- *Water Quality*
- *Basic Science Concepts and Applications*
- *Water Distribution Operator Training Handbook*
- *Water System Security, A Field Guide*

To order, contact: American Water Works Association
6666 West Quincy Ave.
Denver, CO 80235

Web site: www.awwa.org
Phone: (800) 926-7337
Fax: (303) 347-0804
E-mail: custsvc@awwa.org

California State University, Sacramento (CSUS) Foundation, Office of Water Programs
- *Water Distribution System Operation and Maintenance*
- *Small Water System Operation and Maintenance*
- *Utility Management*
- *Manage for Success*

To order, contact: Office of Water Programs
California State University, Sacramento
6000 J Street
Sacramento, CA 95819-6025

Web site: www.owp.csus.edu
Phone: (916) 278-6142
Fax: (916) 278-5959
E-mail: wateroffice@owp.csus.edu

Regulations

For United States exams:

- *Code of Federal Regulations*, Title 40, Part 141 (www.gpo.gov)
- State regulations (contact information for state certification programs is available on the Certification Contacts page of ABC's web site, www.abccert.org)

For Canadian exams:

- *Guidelines for Canadian Drinking Water Quality*. Federal-Provincial-Territorial Subcommittee on Drinking Water. Ottawa, ON: Health Canada (www.hc-sc.gc.ca/waterquality)
- Provincial and territorial regulations (contact information for provincial/territorial certification programs is available on the Certification Contacts page of ABC's web site, www.abccert.org)

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ABC
Association of
Boards of Certification

http://www.abccert.org/testing_services/need_to_know_criteria.asp

2017

Need-to-Know Criteria

Operator Certification Exams

When preparing for the ABC Operator Certification Exams the Need-to-Know Guides can be found on the ABC website listed above

- *Water Treatment*
- *Water Distribution*
- *Very Small Watery*
- *Wastewater Treatment*
- *Wastewater Collection*
- *Small Wastewater*
- *And More.......*

http://www.abccert.org/

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Sample Exam Questions and Recommended References
for ABC's Very Small Water System Exam

The following questions are provided as examples of the **types** of questions that will be covered on the ABC standardized Very Small Water System certification exam. You will not find any of these questions duplicated on a certification exam, so don't try to memorize the questions and answers. These sample questions should not be used in place of other training materials and courses. The reference material listed at the end of this document will help you better understand the topics and answer similar questions that may be on the certification exam.

1. What is the physical connection, direct or indirect, which provides the opportunity for nonpotable water to enter a conduit, pipe or receptacle containing potable water?
   A. Well testing
   B. Pump injection
   C. Bell joint clamp
   D. Cross connection

2. When bringing community water service to a home with a private well, what is the most positive method of preventing a cross connection between the two systems?
   A. Residential dual check valve
   B. Reduced pressure zone backflow preventer
   C. Complete isolation between the two systems using an air gap
   D. Pressure vacuum breaker in addition to an RPZ

3. After a new water main is installed and pressure tested it should be
   A. Flushed with clean water for 24 hours and put into service
   B. Filled with a solution of 25 ppm to 50 ppm free chlorine for at least 24 hours prior to flushing
   C. Filled with clean water and allowed to sit for 5 days at full pressure before turning the water into the system
   D. Photographed so that mapping can be avoided until the system is complete

4. Calculate the volume, in gallons, of a tank that is 75 feet long, 20 feet wide, and 10 feet deep.
   A. 15,000 gallons
   B. 112,200 gallons
   C. 150,000 gallons
   D. 224,400 gallons

5. An empty atmospheric storage tank is 8 feet in diameter and 32 feet high. How long will it take to fill 90% of the tank volume if a pump is discharging a constant 24 gallons per minute into the tank?
   A. 7 hours 31 minutes
   B. 8 hours 21 minutes
   C. 8 hours 23 minutes
   D. 9 hours 17 minutes

6. Under the requirements of the Safe Drinking Water Act, it is the duty of the water purveyor to deliver potable water of proper quantity only as far as the
   A. Entry point of the distribution system
   B. Customer's curb box and service connection
   C. Consumer's tap inside the home
   D. Furthest water main blow-off or sampling point

7. Which of the following terms refers to excessive internal pressure, which may be several times the normal operating pressure and can seriously damage hydropneumatic tanks, valves, and the piping network?
   A. Air charge
   B. Flow rate pressure
   C. Water hammer
   D. Hydraulic charge

8. What is the primary purpose of a preventive maintenance program?
   A. Increase the use of backup equipment
   B. Correct equipment breakdowns
   C. Eliminate inventory of spare parts
   D. Avoid future equipment problems

9. What are the two most important safety concerns when entering a confined space?
   A. Corrosive chemicals and falls
   B. Bad odors and claustrophobia
   C. Extreme air temperatures and slippery surfaces
   D. Oxygen deficiency and hazardous gases

10. To ensure that the water supplied by a public water system meets federal and state requirements, the water system operator must regularly collect samples and
   A. Test the water at the nearest water testing laboratory
   B. Determine a sampling schedule based on the lab's recommendations
   C. Send all analysis results to the State periodically
   D. Count the number of active wells in the system

CORRECT ANSWERS

1. Answer: D

2. Answer: C

3. Answer: B

4. Answer: B
   Solution: 75 ft x 20 ft x 10 ft = 15,000 cu ft
   15,000 cu ft x 7.48 gal/cu ft = 112,200 gal

5. Answer: A
   Solution: 8 feet x 8 feet x 32 feet x .785 = 1,607.68 cu ft
   1607.68 cu ft x 7.48 gallons per cu ft = 12,025 gallons
   12,025 gallons x 0.90 = 10,823 gallons
   10,823 gallons / 24 gpm = 451 minutes
   451 minutes = 7 hours 31 minutes

6. Answer: C

7. Answer: C

8. Answer: D

9. Answer: D

10. Answer: C

REFERENCE MATERIAL

ABC Very Small Water System exam questions are referenced to the following manuals. This list of references is recommended to help individuals prepare for an ABC Very Small Water System exam.

American Water works Association (AWWA)

- *Water Transmission and Distribution*
- *Water Quality*
- *Basic Science Concepts and Applications*
- *Water Distribution Operator Training Handbook*
- *Water System Security, A Field Guide*

To order, contact: American Water Works Association
6666 West Quincy Ave.
Denver, CO 80235

Web site: www.awwa.org
Phone: (800) 926-7337
Fax: (303) 347-0804
E-mail: custsvc@awwa.org

California State University, Sacramento (CSUS) Foundation, Office of Water Programs

- *Water Distribution System Operation and Maintenance*
- *Small Water System Operation and Maintenance*
- *Utility Management*
- *Manage for Success*

To order, contact: Office of Water Programs
California State University, Sacramento
6000 J Street
Sacramento, CA 95819-6025

Web site: www.owp.csus.edu
Phone: (916) 278-6142
Fax: (916) 278-5959
E-mail: wateroffice@owp.csus.edu

Regulations

For United States exams:

- *Code of Federal Regulations*, Title 40, Part 141 (www.gpo.gov)
- State regulations (contact information for state certification programs is available on the Certification Contacts page of ABC's web site, www.abccert.org)

For Canadian exams:

- *Guidelines for Canadian Drinking Water Quality*. Federal-Provincial-Territorial Subcommittee on Drinking Water. Ottawa, ON: Health Canada (www.hc-sc.gc.ca/waterquality)
- Provincial and territorial regulations (contact information for provincial/territorial certification programs is available on the Certification Contacts page of ABC's web site, www.abccert.org)

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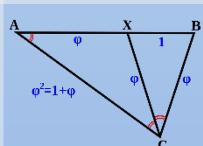
OPERATOR MATH WORKSHOP

Test & Answer Key



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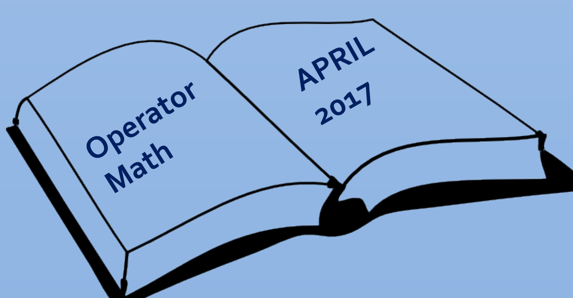

EPA REGION 8

Midwest Assistance Program

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NAME: ______________________

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Basic Water Operator Test Questions

1. Convert 6 degrees Celsius to degrees Fahrenheit
   a. 42.8 °F
   b. 34.6 °F
   c. 16.1 °F
   d. 28.4 °F

2. How many gallons per minute (gpm) are pumped if two MG are pumped per day?
   a. 13.8 gpm
   b. 381.4 gpm
   c. 1,008.1 gpm
   d. 1,388.8 gpm

3. How many gallons of water are in a pipe that is 18 inches in diameter and 1165 feet long?
   a. 18,600 gal
   b. 3,600 gal
   c. 17,800 gal
   d. 15,391 gal

4. If you need to install a perimeter fence around a water tank and it is on a lot that is 100 ft by 75 ft, how many feet of fencing do you need?
   a. 7,500 ft
   b. 400 ft
   c. 300 ft
   d. 350 ft

5. At noon, the operator started a pump to fill a standpipe; and at 3:30 PM that afternoon, he shut it down. The pump moves 320 GPM. The tank is 40 feet in diameter. How many feet of water did he put into the standpipe if there were no withdrawals during this time?
   a. 7.2 ft
   b. 40 ft
   c. 71 ft
   d. 9.4 ft

6 What does "Q" stand for in the formula Q=VA?
   a. feed rate
   b. flow rate
   c. horse power
   d. volume

7. What is the static pressure at the base of a fully elevated tank 80 feet high?
   a. 34.6 psi
   b. 64.0 psi
   c. 46.0 psi
   d. 43.6 psi

8. What is the force on the face of a capped-off 6" water main that has a closed pressure of 40 psi?

a. 1,130 lbs
b. 240 lbs
c. 4,523.9 lbs
d. 376.8 lbs

9. A water system diverts 1/3 of its total water supply to an RO treatment unit which reduces the total dissolved solids in the water. If the total water supply for the system is 36,250 gallons per hour, how many gallons per day are being treated?

a. 580,000 gal
b. 435,000 gal
c. 870,000 gal
d. 290,000 gal

10. What is the average monthly usage of sodium hypochlorite for this system?

a. 9.97 gal
b. 59.8 gal
c. 10.5 gal
d. 9 gal

January	10 gallons
February	9.5 gallons
March	9.4 gallons
April	10.25 gallons
May	10.15 gallons
June	10.5 gallons

11. How many seconds are in 12 hours?

a. 14,400 sec
b. 43,200 sec
c. 3,600 sec
d. 4,320 sec

12. What is 77 in. expressed as a decimal in feet?

a. 6.42 ft
b. 7.70 ft
c. 64.2 ft
d. 4.28 ft

13. A rectangular tank is 20' long, 8' wide, and 3' deep. The tank holds how many gallons of water?

a. 3,950 gal
b. 9,350 gal
c. 3,590 gal
d. 1,600 gal

14. The distance across the middle of a circle (from one side to the other) is the _______.

a. radius
b. diameter
c. circumference
d. area

15. A water meter in a residence records 300 cubic feet of water use in 30 days. What is the daily water use expressed in gallons per day?

a. 244 gal/day
b. 24.4 gal/day
c. 74.8 gal/day
d. 748 gal/day

16. When solving Q=VA, what units should A be in if V is in ft/second?

a. ft^2
b. seconds
c. ft^3
d. ft

17. If the pressure at the bottom of a stand pipe is 54 psi, then how many feet of water are in the stand pipe?

a. 12.47 ft
b. 24.71 ft
c. 127. 1 ft
d. 124.7 ft

18. What is the water "drawdown" when referring to a well's capacity?

a. The pumping rate
b. The pumping water level - static water level
c. The specific yield
d. The pumping water level

19. A water treatment plant uses 100 pounds per day of chlorine and treats 12 million gallons per day. What is their chlorine dose in ppm?

a. 0.87 ppm
b. 2.1 ppm
c. 9.9 ppm
d. .99 ppm

20. How many pounds of copper sulfate will be needed to dose a reservoir with 0.5 mg/L copper? The reservoir volume is 20 million gallons. The copper sulfate is 25 percent copper.

a. 36.6 lbs
b. 63.6 lbs
c. 333.6 lbs
d. 255.0 lbs

21. What is 28.7 cubic feet per second (cfs) to gallons per minute (gpm)?

a. 12,477 gpm
b. 12,700 gpm
c. 12,881 gpm
d. 12,900 gpm

22. Find the solution $\frac{3}{4} \times \frac{1}{12}$

a. $\frac{4}{48}$
b. $\frac{3}{12}$
c. $\frac{3}{48}$
d. $\frac{9}{12}$

23. How much water is in a standpipe 40 ft tall with a diameter if 22.5 ft?

a. 142,150 gal
b. 118,904 gal
c. 15,904 gal
d. 367,642 gal

24. What is the area of a pump house floor that is 20 ft wide and is 25 feet long?

a. 45 ft^2
b. 500 ft^2
c. 400 ft^2
d. 625 ft^2

25. A well pump pumps 400 gallons per minute (GPM) to the storage tank. How many million gallons per day (MGD) are pumped to the storage tank?

a. 5.76 MGD
b. 0.765 MGD
c. 0.576 MGD
d. 0.76 MGD

26. If you need to solve for V, how do you convert the formula Q=VA?

a. multiply both sides by A
b. divide both sides by A
c. divide both sides by V
d. multiply A and Q

27. If 2 feet of head is lost per 1,700 feet of water line, how many feet of head are lost in a water line that is 13,600 feet long?

a. 16 ft
b. 3400 ft
c. 68 ft
d. Depends on slope

28. The elevation of water in a tank is at 1,500 feet, the elevation of the pump is 700 feet. What is the gauge pressure at the pump?

a. 952 psi
b. 649 psi
c. 346 psi
d. 303 psi

29. How many pounds per day of calcium hypochlorite (65% chlorine by weight) would be required to treat 500,000 gallons of water at a dosage of 0.2 ppm?

a. 1.3 lbs/day
b. 8.34 lbs/day
c. 13 lbs/day
d. .65 lbs/day

30. When using a "pie wheel" to solve a Feed Rate problem, you_______.

a. add the bottom wedges to find the chemical feed in lbs/day
b. multiply the bottom wedges to find the chemical feed in lbs/day
c. don't need to match the given units with the units in the pie wheel
d. none of the above

31. How many pounds does 200 gallons of water weigh?

a. 1,668 lbs
b. 23.98 lbs
c. 12,480 lbs
d. 3.21 lbs

32. Convert -5° farenheit to degrees celsius.

a. -20.56°C
b. 15°C
c. -41°C
d. -52.6°C

33. A clarifier has a diameter of 168 inches. What is the surface area in square feet?

a. 154 ft^2
b. 386 ft^2
c. 15.4 ft^2
d. 203 ft^2

34. A wet well measures exactly six feet square. The pump turns on at a level of four feet and turns off at two feet six inches. How many gallons of water are received in the wet well between each pumping cycle?

a. 504 gal
b. 54 gal
c. 404 gal
d. 320 gal

35 If the flow rate for a well is 5.89 gpm. What is this rounded to the nearest whole number?

a. 5.9 gpm
b. 6 gpm
c. 5 gpm
d. 6.9 gpm

36. What is the flow rate if the velocity of the water is 20 ft/s and the area is 1,700 ft^2?

a. 1,720 ft^2
b. 1,720 cfs
c. 3,400 ft^2
d. 34,000 cfs

37. What line pressure in psi will a tank hold on a main when the water level is 60 feet above the main?

a. 30 psi
b. 21 psi
c. 26 psi
d. 42 psi

38. Total head in ft. is the ___________.

a. pressure head (ft) + elevation head (ft)
b. static head (ft) + head losses (ft)
c. pressure (psi) x 2.31 ft/psi
d. all of the above

39. Over a month's time, the water plant operator found he used 80 sacks of alum at 100 pounds each. He had treated 45,500,000 gallons of water. What was his average dose in ppm?

a. 2.11 ppm
b. 21.1 ppm
c. 11.2 ppm
d. 4.5 ppm

40. MGD is the acronym (label) for _______.

a. milligrams per day
b. milliliters per day
c. million gallons per minute
d. million gallons per day

41. 5^3 is the same as…

a. 5 x 3
b. 5 + 3
c. 5 x 5 x 5
d. 5 + 5 + 5

42. Convert the following fraction to a decimal: $\frac{72}{115}$

a. 1.597
b. 0.626
c. 6.26
d. 0.1597

43. What is the volume expressed in gallons of a 24 inch water main that is 600 ft long?

a. 9,200 gal
b. 4,092 gal
c. 14,092 gal
d. 19,450 gal

44. What is the circumference of a pipe that is 2 inches in diameter?

a. 6.28 in
b. 12.57 in
c. 3.14 in
d. 1.57 in

45. When solving for a flow rate, you have the following equation. Use PEMDAS, to solve:
$(4 + 2)ft^2 \times (8 - 2)ft/sec - 3 =$

a. 33 cfs
b. 18 cfs
c. 43 cfs
d. 36 cfs

46. What is the detention time, in hours, of a 25,000 ft^3 basin that has a flow of 8 MGD?

a. .55 hrs
b. .85 hrs
c. 5.8 hrs
d 8.5 hrs

47. Pressure at the bottom of a tank 40 feet tall and 100 feet in diameter will be______ the pressure at the bottom a water column that is 40 feet tall and 20 feet in diameter.

a. Greater than
b. Less than
c. Equal to
d. Cannot be determined

48. The pressure gauge in your well is set at 300 ft. It reads 55 psi. What is your static water level?

a. 127 ft
b. 23 ft
c. 173 ft
d. Not enough information

49. How much chlorine would you have to apply to a 4 million gallon tank of water to obtain a 5.0 mg/L residual if you knew the chlorine demand was 2.3 mg/L?

a. 90 lbs
b. 384 lbs
c. 432 lbs
d. 244 lbs

50. What percentage of the flouride has the water system used if the gauge shows that 12 gallons are missing from a 200 gallon tank?

a. 6%
b. 0.60%
c. 0.06%
d. 60%

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NAME: ______________________

DATE: ______________________

Basic Water Operator Test Questions

1. Convert 6 degrees Celsius to degrees Fahrenheit

a. 42.8 °F — °F = (°C)(1.8) + 32 = 1.8 x 6 + 32
b. 34.6 °F — 1.8 x 6 = 10.8
c. 16.1 °F — 10.8 + 32 = 42.8
d. 28.4 °F — = 42.8 °F

2. How many gallons per minute (gpm) are pumped if two MG are pumped per day?

a. 13.8 gpm — 2MG = 2,000,000 gal
b. 381.4 gpm — (2,000,000 gal/day)(1 day/24 hrs) = 83,333.33 gph
c. 1,008.1 gpm — (83,333.33 gal/hr)(1 hr/ 60 min) = 1,388.8 gpm
d. 1,388.8 gpm — = 1,388.8 gpm

3. How many gallons of water are in a pipe that is 18 inches in diameter and 1165 feet long?

a. 18,600 gal — (18 in)(1 ft/12 in) = 1.5 ft
b. 3,600 gal — V = (.785)(diameter^2)(height)
c. 17,800 gal — .785 x 1.5 ft x 1.5 ft x 1165 ft = 2,057.68 cf
d. 15,391 gal — 2,057.68 cf x 7.48 gal/cf = 15,391.45 gal
= 15,391 gal

4. If you need to install a perimeter fence around a water tank and it is on a lot that is 100 ft by 75 ft, how many feet of fencing do you need?

a. 7,500 ft — 100 ft + 75 ft + 100 ft + 75 ft = 350 ft
b. 400 ft
c. 300 ft
d. 350 ft

5. At noon, the operator started a pump to fill a standpipe; and at 3:30 PM that afternoon, he shut it down. The pump moves 320 GPM. The tank is 40 feet in diameter. How many feet of water did he put into the standpipe if there were no withdrawals during this time?

a. 7.2 ft — 320 gal/min x 3.5 hrs x 60 min/hr = 67,200 gal pumped
b. 40 ft — A = .785 x Diameter ^{2} = (.785) (40 ft)(40 ft) = 1,256 ft^2
c. 71 ft — (1,256 ft^2)(7.48 gal/ft^3) = 9,394 gal/ft
d. 9.4 ft — (67,200 gal)(1 ft / 9,394 gal) = 7.15 ft
round up

6 What does "Q" stand for in the formula Q=VA?

a. feed rate
b. flow rate
c. horse power
d. volume

7. What is the static pressure at the base of a fully elevated tank 80 feet high?

a. 34.6 psi — 1 ft water = .433 psi (80)(.433 psi) = 34.6 psi
b. 64.0 psi
c. 46.0 psi
d. 43.6 psi

8. What is the force on the face of a capped-off 6" water main that has a closed pressure of 40 psi?

a. 1,130 lbs
b. 240 lbs
c. 4,523.9 lbs
d. 376.8 lbs

Force = Pressure x Area
Area = (.785)(diameter^2)
(.785)(6 in)(6 in) = 28.26 in^2
(40 psi)(28.26 in^2) = 1,130.4 lbs

9. A water system diverts 1/3 of its total water supply to an RO treatment unit which reduces the total dissolved solids in the water. If the total water supply for the system is 36,250 gallons per hour, how many gallons per day are being treated?

a. 580,000 gal
b. 435,000 gal
c. 870,000 gal
d. 290,000 gal

(36,250 gal/hr)(24 hr/day) = 870,000 gal/day
(870,000 gal/day)(1/3 day) = 290,000 gal

10. What is the average monthly usage of sodium hypochlorite for this system?

a. 9.97 gal
b. 59.8 gal
c. 10.5 gal
d. 9 gal

January	10 gallons
February	9.5 gallons
March	9.4 gallons
April	10.25 gallons
May	10.15 gallons
June	10.5 gallons

(10+9.5+9.4+10.25+10.15+10.5) gal ÷ 6 = 9.97 gal

11. How many seconds are in 12 hours?

a. 14,400 sec
b. 43,200 sec
c. 3,600 sec
d. 4,320 sec

(12 hrs)(60 min/hr)(60 sec/min) = 43,200 sec

12. What is 77 in. expressed as a decimal in feet?

a. 6.42 ft
b. 7.70 ft
c. 64.2 ft
d. 4.28 ft

(77 in)(1 ft/12 in) = 77 ÷ 12 = 6.42 ft

13. A rectangular tank is 20' long, 8' wide, and 3' deep. The tank holds how many gallons of water?

a. 3,950 gal
b. 9,350 gal
c. 3,590 gal
d. 1,600 gal

V = L x W x H
(20 ft)(8 ft)(3 ft) = 480 ft^3
(480 gal/ft^3)(7.48) = 3,590.4 gal

14. The distance across the middle of a circle (from one side to the other) is the _______.

a. radius
b. diameter
c. circumference
d. area

15. A water meter in a residence records 300 cubic feet of water use in 30 days. What is the daily water use expressed in gallons per day?

a. 244 gal/day
b. 24.4 gal/day
c. 74.8 gal/day
d. 748 gal/day

(300 ft^3)(7.48 gal/ft^3) = 2,244 gal
2,244 gal ÷ 30 days = 74.8 gal/day

16. When solving Q=VA, what units should A be in if V is in ft/second?

a. ft^2
b. seconds
c. ft^3
d. ft

17. If the pressure at the bottom of a stand pipe is 54 psi, then how many feet of water are in the stand pipe?

a. 12.47 ft
b. 24.71 ft
c. 127. 1 ft
d. 124.7 ft

1 pound per square inch (psi) = 2.31 feet of wter
(54 psi)(2.31 ft/1 psi) = 124.74 ft

18. What is the water "drawdown" when referring to a well's capacity?

a. The pumping rate
b. The pumping water level - static water level
c. The specific yield
d. The pumping water level

19. A water treatment plant uses 100 pounds per day of chlorine and treats 12 million gallons per day. What is their chlorine dose in ppm?

a. 0.87 ppm
b. 2.1 ppm
c. 9.9 ppm
d. .99 ppm

Feed Rate lbs/day = (MGD)(Cl dose mg/L)(8.34 lbs/gal)
100lbs/day = (12 MGD)(Cl dose mg/L)(8.34 lbs/gal)
100 lbs/day = 100.08 lbs/day (Cl dose mg/L) =
Cl dosage mg/L = 100lbs/day ÷ 100.08 lbs/day Cl = .99 ppm
* 1ppm = 1mg/L

20. How many pounds of copper sulfate will be needed to dose a reservoir with 0.5 mg/L copper? The reservoir volume is 20 million gallons. The copper sulfate is 25 percent copper.

a. 36.6 lbs
b. 63.6 lbs
c. 333.6 lbs
d. 255.0 lbs

Feed Rate lbs/day = (mg/L)(MGD)(8.34 lbs/gal) ÷ Copper %
Day can be eliminated from formula. No time frame is given.
Feed Rate = (.5 mg/L)(20MG)(8.34lbs) ÷ 0.25 = 333.6 lbs

21. What is 28.7 cubic feet per second (cfs) to gallons per minute (gpm)?

a. 12,477 gpm
b. 12,700 gpm
c. 12,881 gpm
d. 12,900 gpm

(28.7 ft^3/sec)(60 sec/min)(7.48 gal/ft^3) = 12,880.56 gal/min
Round up

22. Find the solution $\frac{3}{4} \times \frac{1}{12}$

a. $\frac{4}{48}$
b. $\frac{3}{12}$
c. $\frac{3}{48}$
d. $\frac{9}{12}$

mulitply the top numbers (3)(1) = 3
multiply the bottom numbers (4)(12) = 48

23. How much water is in a standpipe 40 ft tall with a diameter if 22.5 ft?

a. 142,150 gal
b. 118,904 gal
c. 15,904 gal
d. 367,642 gal

Volume = .785 (diameter²)(Height) = (.785)(22.5 ft)(22.5 ft)(40 ft) = 15,896.25 ft^3
(15,896.25 ft^3)(7.48 gal/ft^3) = 118,903.95 gal

24. What is the area of a pump house floor that is 20 ft wide and is 25 feet long?

a. 45 ft^2
b. 500 ft^2
c. 400 ft^2
d. 625 ft^2

(20 ft)(25 ft) = 500 ft^2

25. A well pump pumps 400 gallons per minute (GPM) to the storage tank. How many million gallons per day (MGD) are pumped to the storage tank?

a. 5.76 MGD
b. 0.765 MGD
c. 0.576 MGD
d. 0.76 MGD

(400 gpm)(60 min/hr)(24 hrs/day) = 576,000 gal/day
576,000 gal/day ÷ 1,000,000 = .576 MGD

26. If you need to solve for V, how do you convert the formula Q=VA?

a. multiply both sides by A
b. divide both sides by A
c. divide both sides by V
d. multiply A and Q

27. If 2 feet of head is lost per 1,700 feet of water line, how many feet of head are lost in a water line that is 13,600 feet long?

a. 16 ft
b. 3400 ft
c. 68 ft
d. Depends on slope

13,600 ft ÷ 1,700 ft = 8
(8)(2 ft of head) = 16 ft of head

28. The elevation of water in a tank is at 1,500 feet, the elevation of the pump is 700 feet. What is the gauge pressure at the pump?

a. 952 psi
b. 649 psi
c. 346 psi
d. 303 psi

1,500 ft - 700 ft = 800 ft 1 ft water = .433 psi
(800 ft)(.433 psi/ft) = 346.4 psi

29. How many pounds per day of calcium hypochlorite (65% chlorine by weight) would be required to treat 500,000 gallons of water at a dosage of 0.2 ppm?

a. 1.3 lbs/day
b. 8.34 lbs/day
c. 13 lbs/day
d. .65 lbs/day

100% pure lbs/day = (MGD)(mg/L)(8.34lbs/gal) 65% = .65
.65 lbs/day = (.5MG)(0.2 ppm)(8.34lbs/gal) *500,000 = .5 million
.65 lbs/day = .835
lbs/day = .835 ÷ .65 = 1.28 lbs/day Round up
1.3 lbs/day

30. When using a "pie wheel" to solve a Feed Rate problem, you________.

a. add the bottom wedges to find the chemical feed in lbs/day
b. multiply the bottom wedges to find the chemical feed in lbs/day
c. don't need to match the given units with the units in the pie wheel
d. none of the above

31. How many pounds does 200 gallons of water weigh?

a. 1,668 lbs
b. 23.98 lbs
c. 12,480 lbs
d. 3.21 lbs

(200 gal)(8.34 lbs/gal) = 1,668 lbs

32. Convert -5° farenheit to degrees celsius.

a. -20.56°C
b. 15°C
c. -41°C
d. -52.6°C

°C = (°F - 32) ÷ 1.8 = (-5-32) ÷ 1.8
°C = -37 ÷ 1.8 = -20.56

33. A clarifier has a diameter of 168 inches. What is the surface area in square feet?

a. 154 ft^2
b. 386 ft^2
c. 15.4 ft^2
d. 203 ft^2

(168 in)(1ft/12 in) = 14 ft *same as ÷ by 12
A = .785 ($diameter^2$)
(.785)(14ft)(14ft) = 153.87 ft^2
Round up

34. A wet well measures exactly six feet square. The pump turns on at a level of four feet and turns off at two feet six inches. How many gallons of water are received in the wet well between each pumping cycle?

a. 504 gal
b. 54 gal
c. 404 gal
d. 320 gal

4ft - 2.6ft = 1.5ft
(6 ft)(6 ft)(1.5 ft) = 54 ft^3 of sewage
(54 ft^3)(7.48 gal/ft^3) = 403.92 gal
Round up

35 If the flow rate for a well is 5.89 gpm. What is this rounded to the nearest whole number?

a. 5.9 gpm
b. 6 gpm
c. 5 gpm
d. 6.9 gpm

A whole number does not have a decimal
5 or more, add one more

36. What is the flow rate if the velocity of the water is 20 ft/s and the area is 1,700 ft^2?

a. 1,720 ft^2
b. 1,720 cfs
c. 3,400 ft^2
d. 34,000 cfs

(20 ft/sec)(1,700 ft^2) = 34,000 cfs   cfs = ft^3/sec

37. What line pressure in psi will a tank hold on a main when the water level is 60 feet above the main?

a. 30 psi
b. 21 psi
c. 26 psi
d. 42 psi

.433 psi = 1 ft of water
(60 ft)(.433 psi/ft) = 25.98 psi
Round up

38. Total head in ft. is the ___________.

a. pressure head (ft) + elevation head (ft)
b. static head (ft) + head losses (ft)
c. pressure (psi) x 2.31 ft/psi
d. all of the above

39. Over a month's time, the water plant operator found he used 80 sacks of alum at 100 pounds each. He had treated 45,500,000 gallons of water. What was his average dose in ppm?

a. 2.11 ppm
b. 21.1 ppm
c. 11.2 ppm
d. 4.5 ppm

80 sacks x 100 lbs each = 8,000 lbs   *1 ppm = 1 mg/L
Dose = Feed rate ÷ (MGD)(8.34 lbs/gal)   45,500,000 gal ÷ 1,000,000 = 45.5MG
ppm = 8000 lbs/day ÷ (45.5 MGD)(8.34 lbs/gal)
ppm = 8000 lbs/day ÷ 379.7 lbs/day
ppm = 21.08   round up to 21.1 ppm

40. MGD is the acronym (label) for _______.

a. milligrams per day
b. milliliters per day
c. million gallons per minute
d. million gallons per day

41. 5^3 is the same as…

a. 5 x 3
b. 5 + 3
c. 5 x 5 x 5
d. 5 + 5 + 5

42. Convert the following fraction to a decimal: $\frac{72}{115}$

a. 1.597
b. 0.626
c. 6.26
d. 0.1597

Divide the top by the bottom
72 ÷ 115 = .626

43. What is the volume expressed in gallons of a 24 inch water main that is 600 ft long?

a. 9,200 gal
b. 4,092 gal
c. 14,092 gal
d. 19,450 gal

Volume = (.785)(diameter^2)(height)   24 in = 2 ft
(.785)(2 ft)(2 ft)(600 ft) = 1884 cubic ft^3
(1884 ft^3)(7.48 gal/ft^3) = 14,092 gal

44. What is the circumference of a pipe that is 2 inches in diameter?

a. 6.28 in
b. 12.57 in
c. 3.14 in
d. 1.57 in

Circumference = (π)(diameter)
(3.14)(2 in) = 6.28 in

45. When solving for a flow rate, you have the following equation. Use PEMDAS, to solve:
(4 + 2)ft^2 x (8 - 2)ft/sec - 3 =

a. 33 cfs
b. 18 cfs
c. 43 cfs
d. 36 cfs

Parenthesis first   6 ft^2 x 6 ft/sec -3
Mulitply next   36 ft^3/s - 3
Subtract last   33 ft^3/s
33 cfs

46. What is the detention time, in hours, of a 25,000 ft^3 basin that has a flow of 8 MGD?

a. .55 hrs
b. .85 hrs
c. 5.8 hrs
d 8.5 hrs

Detention Time = Volume ÷ Flow
25,000 ft^3 x 7.48 gal/ft^3 = 187,000 gal
187,000 gal ÷ 1,000,000 = .187 MG
.187MG/8MGD = 0.023days
(.023 days)(24 hrs/day) = .55 hours

47. Pressure at the bottom of a tank 40 feet tall and 100 feet in diameter will be______ the pressure at the bottom a water column that is 40 feet tall and 20 feet in diameter.

a. Greater than
b. Less than
c. Equal to
d. Cannot be determined

48. The pressure gauge in your well is set at 300 ft. It reads 55 psi. What is your static water level?

a. 127 ft
b. 23 ft
c. 173 ft
d. Not enough information

1 psi = 2.31 ft of water
(55 psi)(2.31 ft/1 psi) = 127.05 ft

49. How much chlorine would you have to apply to a 4 million gallon tank of water to obtain a 5.0 mg/L residual if you knew the chlorine demand was 2.3 mg/L?

a. 90 lbs
b. 384 lbs
c. 432 lbs
d. 244 lbs

dosage = 2.3 mg/L + 5.0 mg/L
dosage = 7.3 mg/L
Feed rate (lbs) = (dose mg/l)(MGD)(8.34 lbs/gal)
lbs = (7.3mg/L)(4 MGD)(8.34 lbs/gal)
Feed rate = 243.528 lbs

50. What percentage of the flouride has the water system used if the gauge shows that 12 gallons are missing from a 200 gallon tank?

a. 6%
b. 0.60%
c. 0.06%
d. 60%

12 gal ÷ 200 gal = .06 gal
(.06)(100 %) = 6 %