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Syracuse University
College of Engineering & Computer Science
Environmental Finance Center

Great Lakes Environmental Infrastructure Center
Environmental Finance Center for EPA Region 5

Basic Drinking Water Math for Operators

Thursday, Nov 13, 2025 | 1:00 - 2:00 PM EST
Instructor: Daryl Gotham PE

This program is made possible under a cooperative agreement with US EPA.

Certificate of Completion

This session has **NOT** been submitted for pre-approval of Continuing Education Credits, but eligible attendees will receive a certificate of attendance for their personal record.

To receive a certificate:

- You must attend the entire session
- You must register and attend using your real name and unique email address - group viewing credit will not be acceptable
- You must participate in all polling questions
- Certificates will be sent via email within 30 days

If you have questions or need assistance, please contact smallsystems@syr.edu.

EFCN
environmental finance center network

About Us

The **Environmental Finance Center Network (EFCN)** is a university- and non-profit-based organization creating innovative solutions to the difficult how-to-pay issues of environmental protection and water infrastructure.

The EFCN works collectively and as individual centers to address these issues across the entire U.S, including the 5 territories and the Navajo Nation. The EFCN aims to assist public and private sectors through training, direct professional assistance, production of durable resources, and innovative policy ideas.

EFCN
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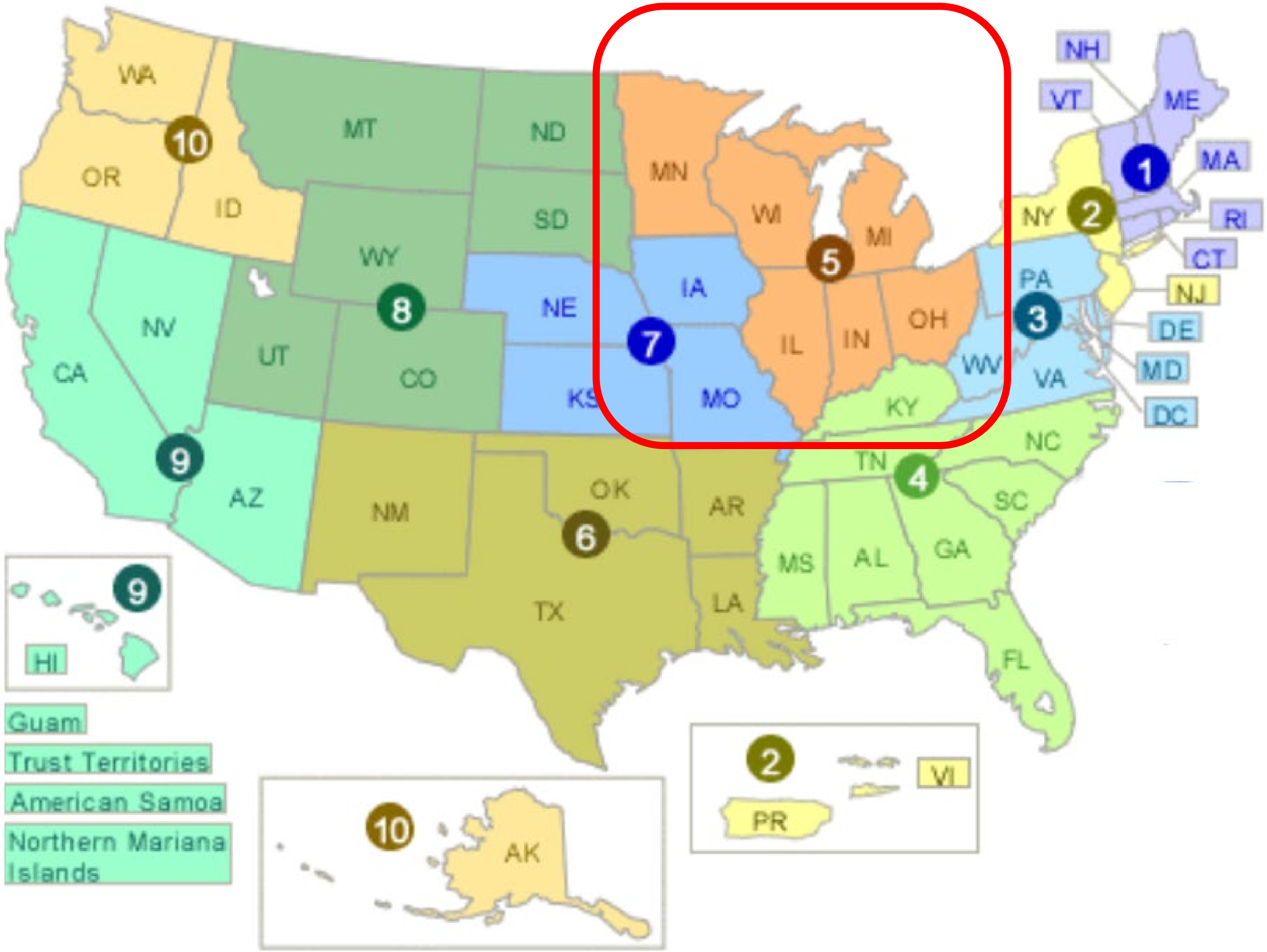
Nationwide reach of EFC Network



Great Lakes Environmental Infrastructure Center

Environmental Finance Center for EPA Region 5

Serve small communities (population of less than 10,000) throughout EPA Region 5: Indiana, Illinois, Michigan, Minnesota, Ohio, Wisconsin, and 35 federally recognized American Indian governments.

Training, Research, and Technical Assistance with a mission to help water and wastewater utilities increase technical, managerial, and financial capacity (TMF).

Contact Information
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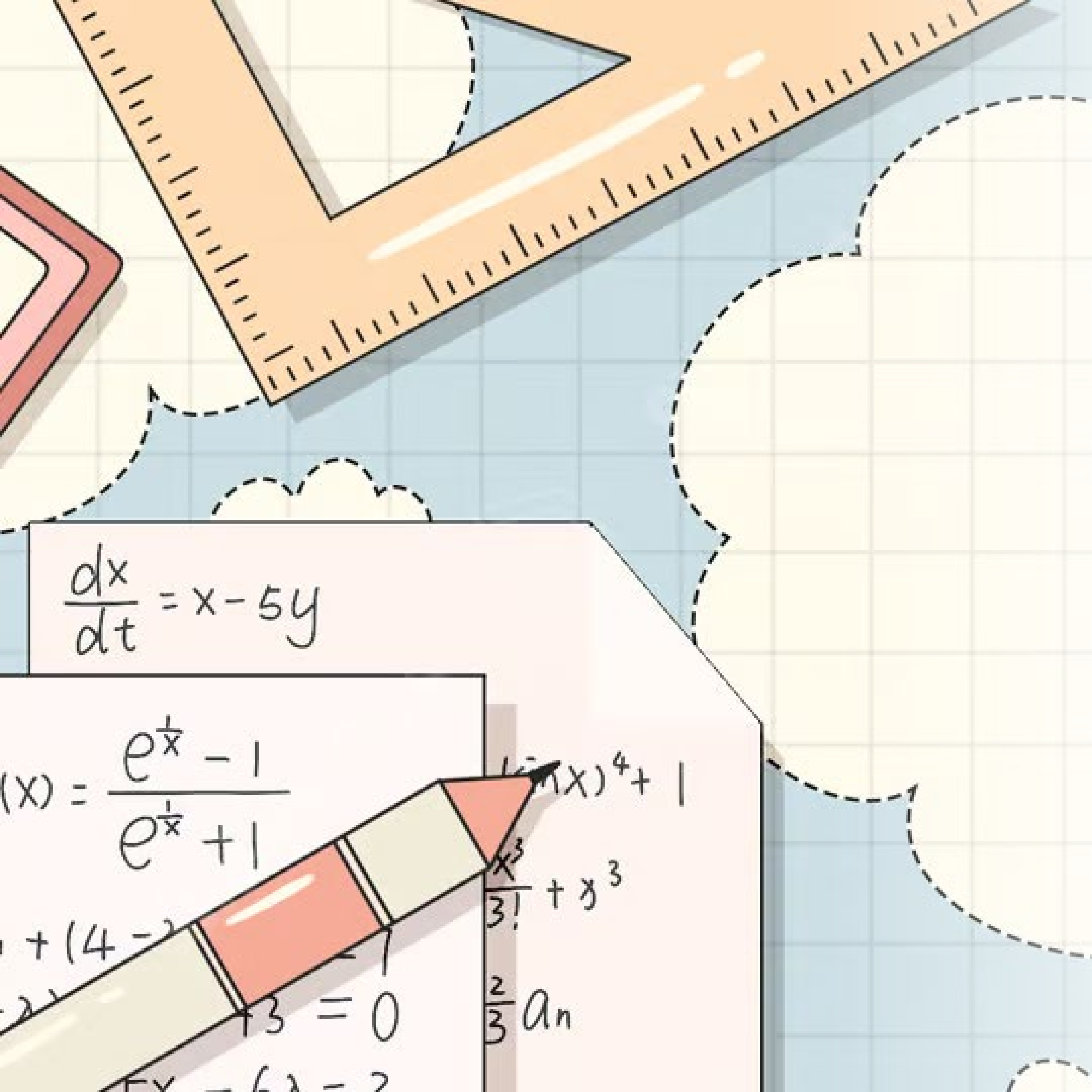
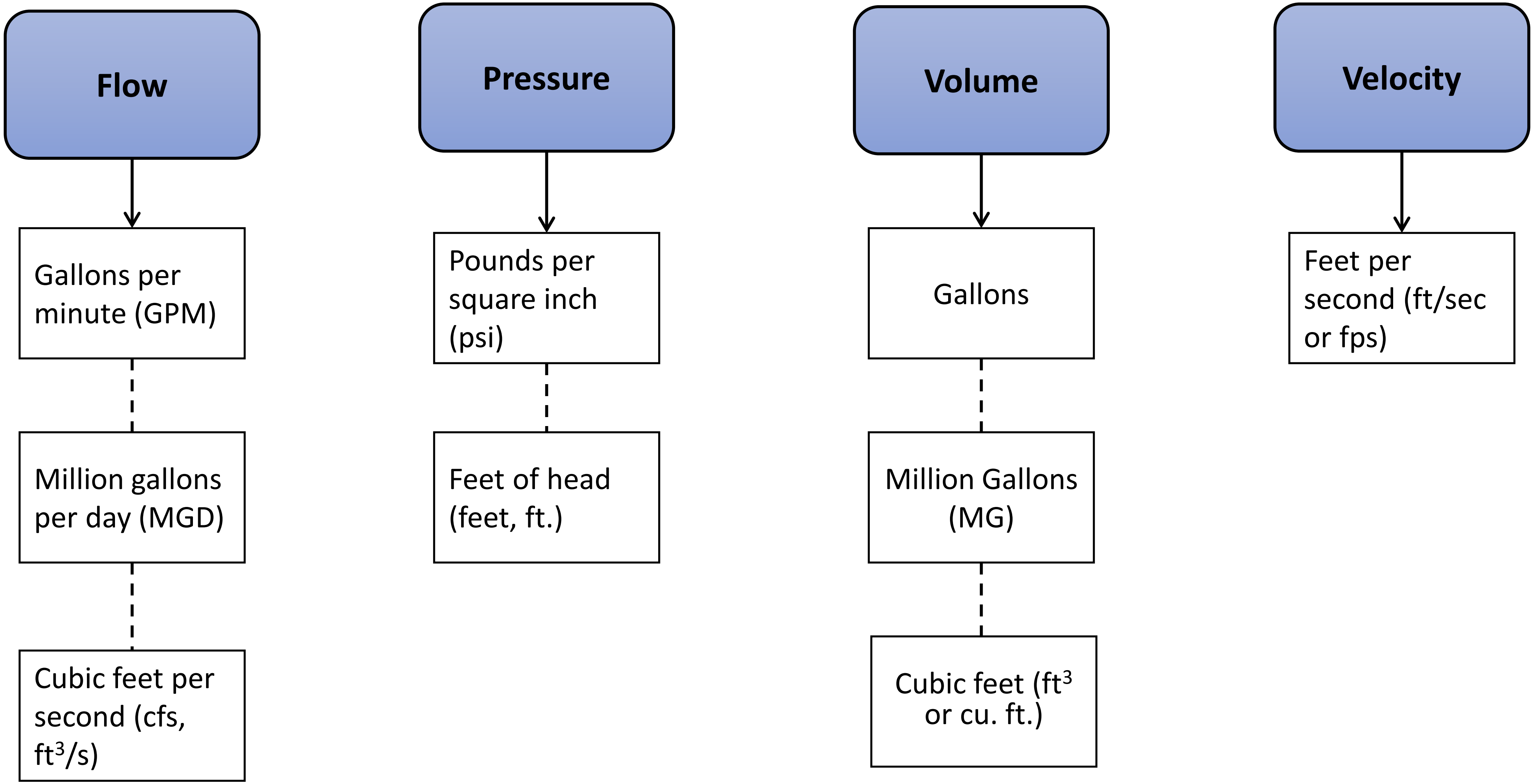


Basic Drinking Water Math

- Calculating Areas and Volumes
- Conversions
- Flow Rates
- Pressure
- Pounds Formula and Feed rates

Units of Measure



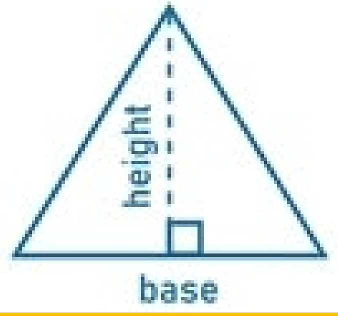
Areas used in pipe and tank calculations

- **Rectangle:** A = L x W

- **Square:** A = L^2

- **Circle:** A = π x r^2 = 0.785 x d^2

- **Triangle:** A = ½ x b x h



Rectangular Area

Rectangular area is used for filtration and sedimentation calculations.

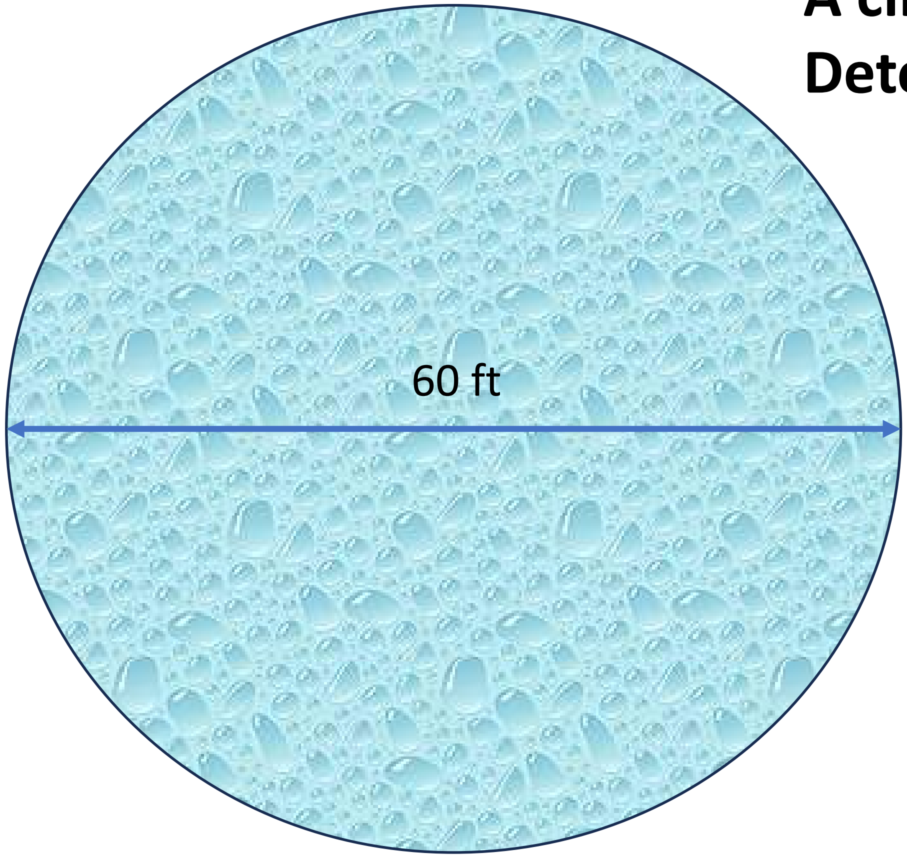
A rapid sand filter has a width of 10 feet and a length of 20 feet. What is the area of the filter in square feet (ft^2)?

Area = Length x Width

20ft x 10ft = **200 ft^2**

Circular area

Circular area is used for filtration and sedimentation calculations and flow rates in pipes.



A circular sedimentation basin has a diameter of 60 feet. Determine the surface area in square feet (ft^2).

Area = πr^2

Area = $3.14 \times 30ft \times 30ft = 2{,}826\ ft^2$

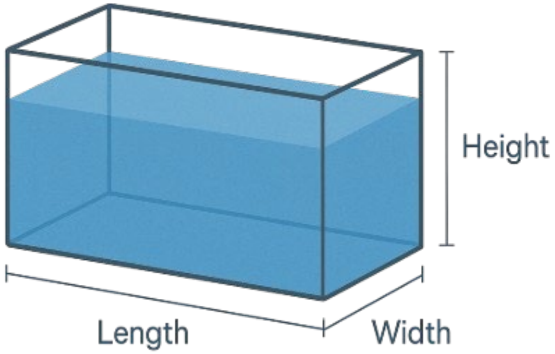
Area = $0.785 \times D^2$

Area = $0.785 \times 60ft \times 60ft = 2{,}826\ ft^2$

0.785 is one quarter of Pi

$\pi r^2 = 3.14 \times D/2 \times D/2 = 3.14 \times ¼ \times D^2 = 0.785 \times D^2$

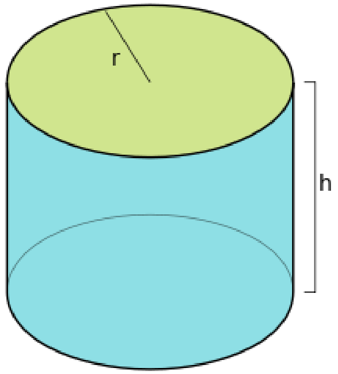
Volumes used in tank/pipe calculations



Rectangular Tank: $V = L \times W \times H$

Cylindrical Tank: $V = \pi \times r^2 \times h$ or $V = 0.785 \times d^2 \times h$

Cylindrical Pipe: $V = \pi \times r^2 \times l$ or $V = 0.785 \times d^2 \times l$



Lesser used volumes:

Cone: $V = 1/3\ (\pi r^2 h)$

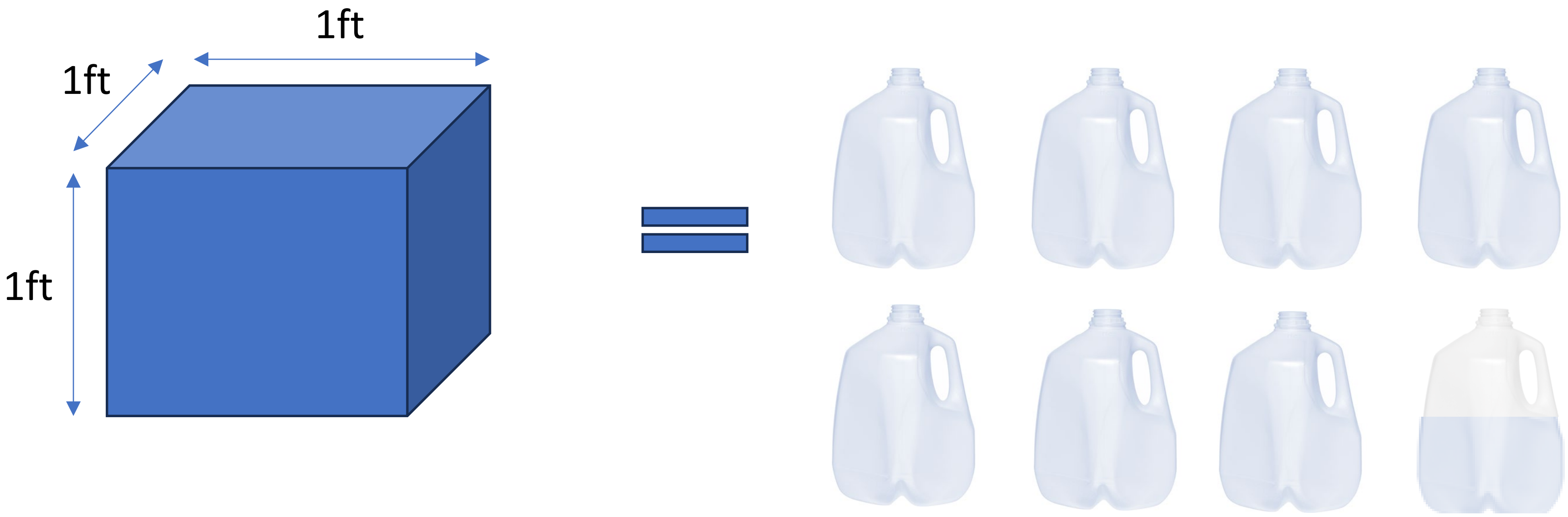
Pyramid: $V = L \times W \times (1/3)H$

Sphere: $V = 4/3\ (\pi r^3)$

Volume conversion from cubic foot to gallons

Rectangular volume is L x W x H

1 cubic foot = 7.48 gallons



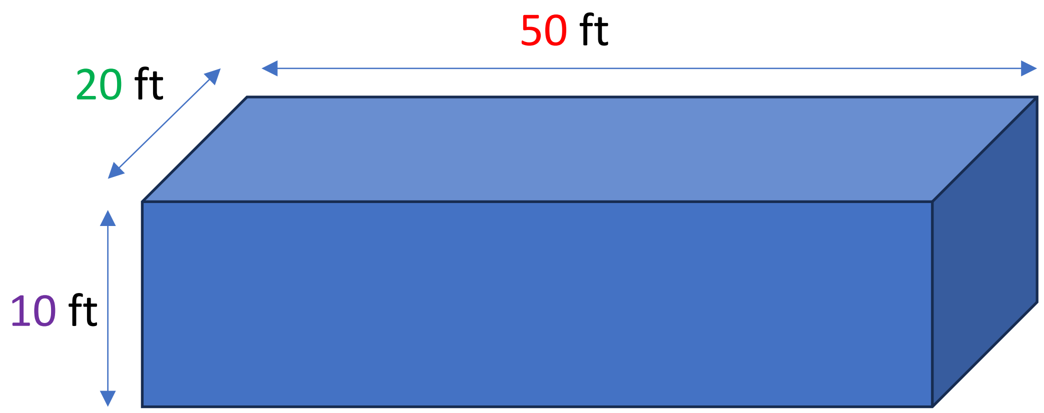
How many gallons can a 24 cubic foot tank hold?

24 ft^3 x 7.48 gal/ft^3 = **179.5 gallons**

Note: The ft^3 units cancel

Rectangular Volume

Volume = L x W x H



A rectangular sedimentation basin has a depth of 10 feet, a length of 50 feet and a width of 20 feet. Determine the volume in cubic feet and in gallons.

Volume = **50**ft x **20**ft x **10**ft = **10,000 ft³**

10,000 ft³ x 7.48 gal/ft³ = **74,800 gallons**

Cylindrical Volume

A cylindrical tank has a radius of 10 ft and a height of 20 ft. How many gallons can it hold?

Formula:

Volume = 0.785 x Diameter x Diameter x Height

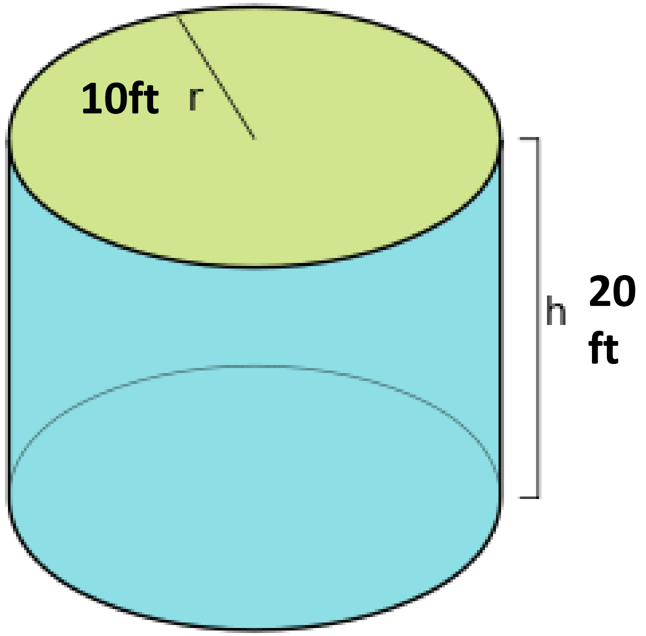
$V = 0.785 \times D^2 \times H$ or $V = \pi \times r^2 \times H$

We first determine the volume of the tank in cubic feet:

$V = \pi \times (10 \text{ feet})^2 \times 20 \text{ feet} = 6{,}283 \text{ ft}^3$

Next, we convert from cubic feet to gallons:

$6{,}283 \text{ ft}^3 \times 7.48 \text{ gallon/ft}^3 = 47{,}000 \text{ gallons}$



Poll 1

A new, 800-foot section of 8-inch diameter watermain was recently installed. The watermain needs to be filled for testing. How many gallons of water will be required to fill the watermain?

a. 300,636 gallons
b. 2,351 gallons
c. 2,109 gallons
d. 10,569 gallons

Poll 1 Solution

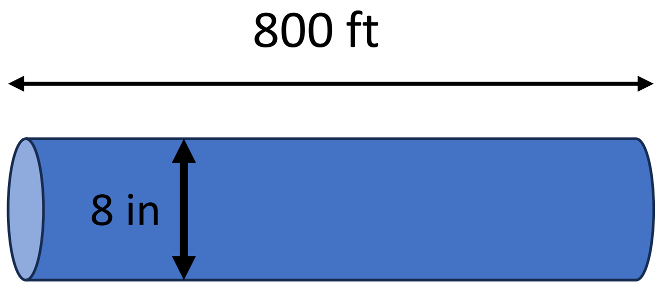
A new, 800-foot section of 8-inch diameter watermain was recently installed. The watermain needs to be filled for testing. How many gallons of water will be required to fill the watermain?

0.785 x Diam x Diam x Length x 7.48 gal/ft^3

(Diameter = 8 in x 1 ft/12 in = 0.67 ft)

0.785 x 0.67ft x 0.67ft x 800ft x 7.48 gal/ ft^3

= 2,109 gallons (Answer C)



Conversion Table

Multiply	By	**To Obtain**
Cubic Feet (ft^3 or cu. ft.)	7.48	Gallons of Water (gal)
Cubic Feet (ft^3 or cu. ft.)	62.4	Pounds (lbs) of Water
Gallons of Water (gal)	8.34	Pounds (lbs) of Water
Feet of Water (ft)	0.433	Pounds/Square Inch (psi)
Pounds/Square Inch (psi)	2.31	Feet of Water (ft)

Conversion Example

We have 16,456 gallons of water that needs to be transferred to a basin. What is the minimum number of cubic feet that the basin must be in order to adequately hold this much water? How much would the water weigh, in pounds?

Convert gallons to cubic feet.

Do we use 7.48 gallons/1 cubic foot or 1 cubic foot/7.48 gallons?

16,456 gallons x 1 cubic foot/7.48 gallons = 2,200 cubic feet

Convert cubic feet to pounds.

2,200 cubic feet x 62.4 pounds/1 cubic foot = 137,280 pounds

Rate of Flow

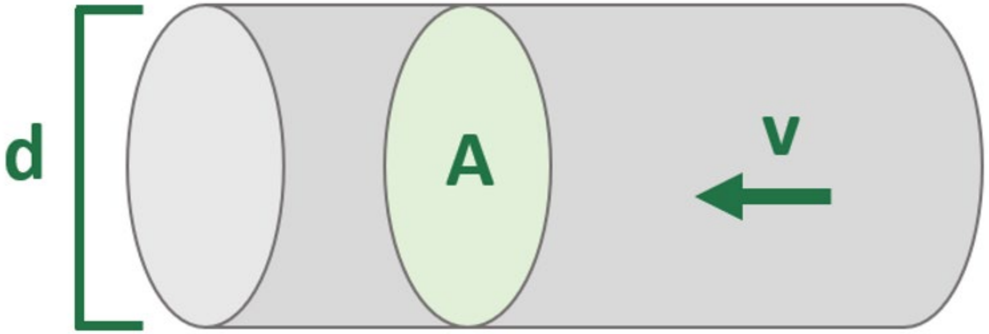
An indication of how much water (a volume) is moving past a spot in a unit of time.

Flow rates are typically referred to as discharge (Q) and expressed in volumes per units of time.

Gallons per minute (gpm)

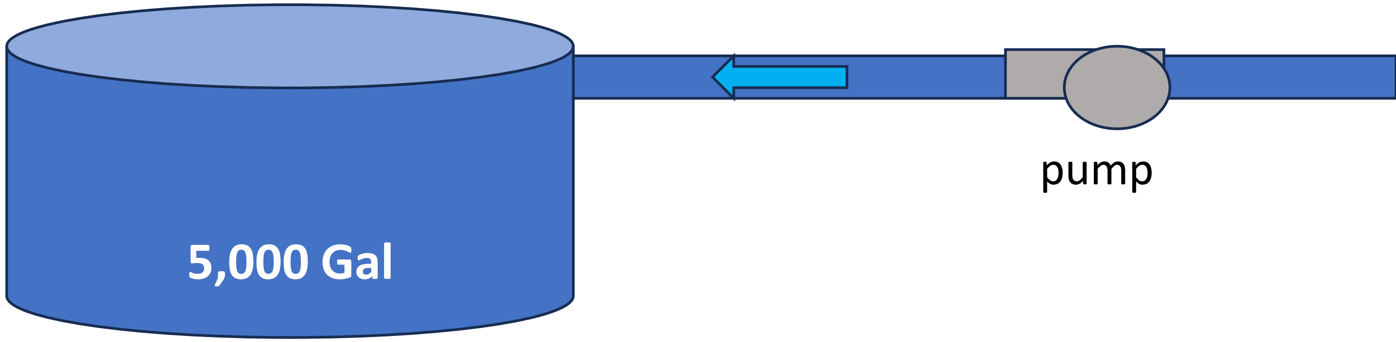
Millions of Gallons per day (MGD)

Cubic feet per second (cfs)



$$Q = A \times v$$

Flow rate (GPM)



$$\frac{\text{Gallons}}{\text{Minutes}} = \text{GPM}$$

A pump fills a 5,000-gallon tank in 12 minutes. What is the pump output in GPM?

$$\frac{\text{5,000 gallons}}{\text{12 minutes}} = \text{416.7 GPM}$$

If this same pump ran for a full day, how much water would it pump?

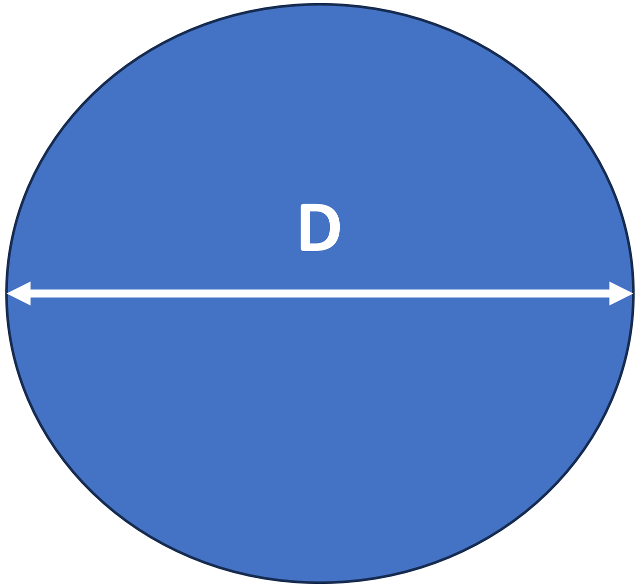
416.7 gal/min x 60 min/hour x 24 hrs/day = 600,048 gallons/day

Minutes in a day: 24 hours/day x 60 minutes/hour = 1,440 min/day

Flow: Q = A x v

Cross-sectional area of pipe flow is circular

Flow (Q) = Area x velocity



<u>Units</u>

- Flow = ft^3/sec (or cfs)
- Area = ft^2
- Velocity = ft/sec

$Q = A \times v$

Water is moving through a six-inch pipe at a velocity of 2 feet per second. What is the flow in cfs?

Step 1: **Convert inches to feet**

6 in x 1 ft/12in = **0.5 ft**

Step 2: **Calculate Area**

Area = 0.785 x 0.5ft x 0.5 ft = **0.19625 ft^2**

Step 3: **Use the flow formula** *(Area x velocity)*

Q = 0.19625 ft^2 x 2 ft/sec = **0.3925 ft^3/sec** (or cfs)

Flow rate conversions between CFS and GPM

CFS to GPM: cf/sec x 60 sec/1 min x 7.48 gal/cf = GPM

GPM to CFS: gal/min x 1min/60 sec x 1 cf/7.48 gal = CFS

A pipe has a flow of 0.5 cubic feet per second. What is this flow in GPM?

0.5 ft^3/sec x 60 sec/min x 7.48 gal/ft^3 = **224.4 GPM**

A pipe has a flow of 500 gpm. What is this flow in CFS?

500 gal/min x 1min/60 sec x 1 ft^3/7.48 gal = **1.11 CFS**

Solving for velocity in Q = A x v

$Q = A \times v$

Divide both sides by A

$$\frac{Q}{A} = \frac{\cancel{A} \times v}{\cancel{A}}$$

Area cancels out on the right side of the formula

$$\text{Velocity} = \frac{\text{Flow (Q)}}{\text{Area}}$$

A pipe with a cross-sectional area of 0.23 ft² has a flow of 0.75 cubic feet per second. What is the velocity in the pipe?

$$V = \frac{0.75\ ft^3/sec}{0.23 ft^2} = \mathbf{3.26\ ft/sec}$$

Flow velocity with conversion

A pipe has a diameter of 18 inches and has a flow of 800 gallons per minute. What is the velocity of flow in the pipe?

Step 1: Convert inches to feet, 18in x 1ft/12in = **1.5 feet**

Step 2: Area = 0.785 x 1.5ft x 1.5ft = **1.766 ft^2**

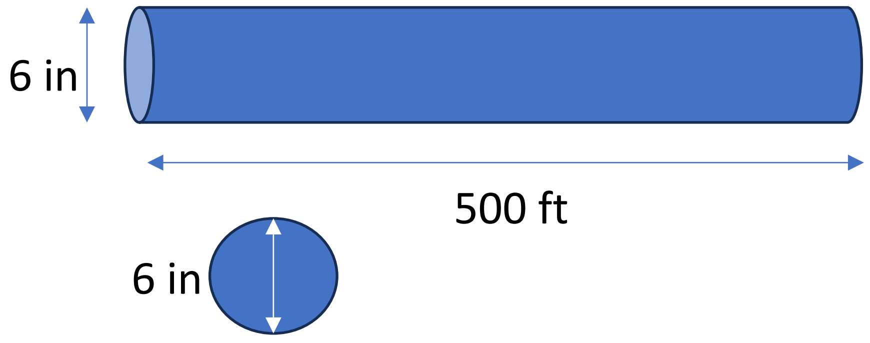
Step 3: Q = 800 gal/min x 1 min/60 sec x 1 ft^3/7.48 gal = **1.783** ft^3/sec

Step 4: $V = \frac{Q}{A} = \frac{1.783\ ft^3/sec}{1.766\ ft^2}$ = **1.010 ft/second**

Poll 2

What flow in GPM is needed to flush a 500-foot section of 6-inch water main at a velocity of 5 feet per second?

a. 733.9 GPM
b. 440.4 GPM
c. 98.1 GPM
d. 23.4 GPM



Poll 2 solution

What flow in GPM is needed to flush a 500-foot section of 6-inch water main at a velocity of 5 feet per second?

Flow necessary to attain 5ft/sec velocity

We will use Area (ft^2) x velocity (ft/sec) = flow (ft^3/sec)

Step 1

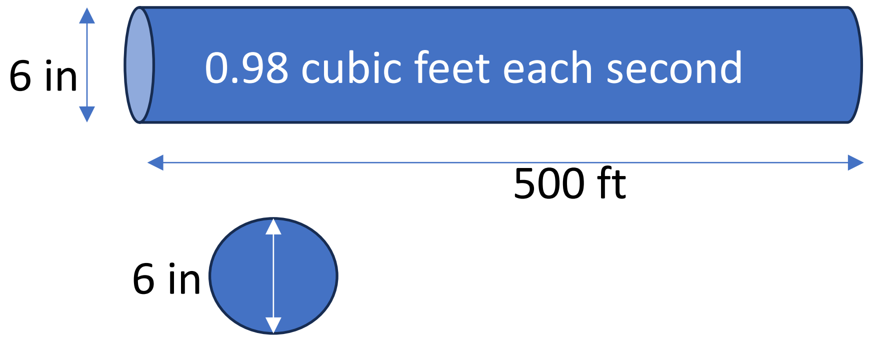
Pipe area = 0.785 x Diam x Diam ➔ 0.785 x 0.5ft x 0.5ft = **0.19625 ft^2**

Step 2 Q = A x V

Q = 0.19625 ft^2 x 5 ft/sec = **0.98125 ft^3/sec**

Step 3 Convert cfs to gpm

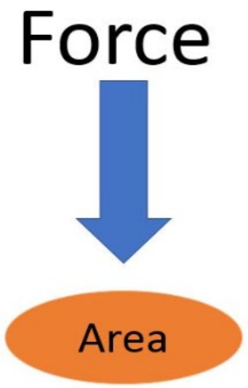
0.98125 ft^3/sec x 60 sec/min x 7.48 gal/ft^3 = **440.4 gpm, (B)**



Pressure

Force water exerts over a unit area

- Expressed in terms of pounds per square inch (psi) or per square foot
- Water weighs 8.34lbs/gal x 7.48 gal/ft³ = 62.4 lbs/ ft³



Example psi Conversion

1 sq ft = 12 in. x 12 in. = 144 sq in

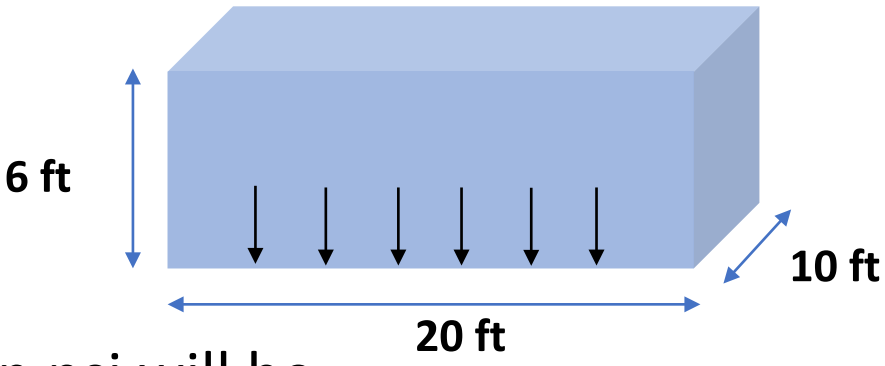
$$\frac{62.4\ \text{lbs}}{\text{ft}^2} \text{x} \frac{1\text{ft}^2}{144\ \text{in}^2} = \mathbf{0.433\ psi\ for\ 1\ ft\ of\ water}$$

1 ft = 0.433 psi , 1 psi = 1 foot/0.433 = 2.31 feet

Pressure Example - Ground Storage Tank

Example

A 10 ft wide by 20 ft long by 6 ft deep tank will hold 8967 gallons of water when full. The water weighs 74,850 lbs (8.34 lb/gal x 8976 gal) and acts on the 10 ft by 20 ft bottom of the tank. What is the pressure in psi on the bottom of the tank?



1.) Calculate pressure in lbs/ft^2

$$6 \text{ ft x } 62.4 \text{ lbs}/\text{ft}^3 = 375 \text{ lbs}/\text{ft}^2$$

2.)Convert to psi

Since 1 $\text{ft}^2 = 12 \text{ in.} \times 12 \text{ in.} = 144 \text{ in}^2$, the pressure in psi will be:

$$\frac{375 \text{ lbs}}{\text{ft}^2} \text{ x } \frac{1 \text{ft}^2}{144 \text{ in}^2} = 2.6 \frac{\text{lbs}}{\text{in}^2} = \mathbf{2.6 \ psi}$$

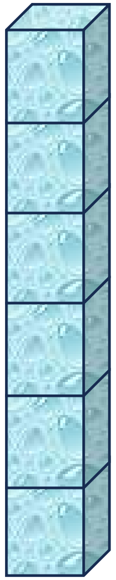
Pressure as Cubes of Water

Pressure calculations can be thought of a “cubes” of water stacked one on top of the other.

Each cube weighs 62.4 lbs and exerts pressure on a one square foot area.

With a water height of 6 feet, the pressure is:

6 ft x 62.4 lbs/ft^3 =375 lbs/ft^2



Since 1ft^2 = 12 in x 12 in or 144 in^2 the pressure in lbs/in^2 is:

375 lbs /ft^2 x 1 ft^2/144 in^2 = 2.6 psi for 6 feet of water

Water Head relationships

Converting the pressure of our 62.4 pound cube of water from the pressure on one square foot to the pressure per square inch:

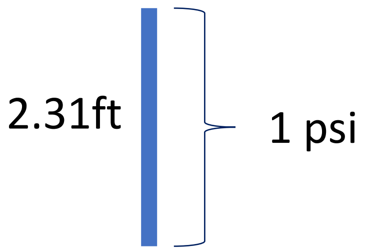
62.4 lbs/ft^2 x 1 ft^2/144 in^2 = 0.433 lb/ in^2 = 0.433 psi for one foot H_2O

0.433 psi = 1 ft of water head

$\frac{1}{0.433}$ = 2.31 ft of water head, 1 psi = 2.31 ft

Pressure

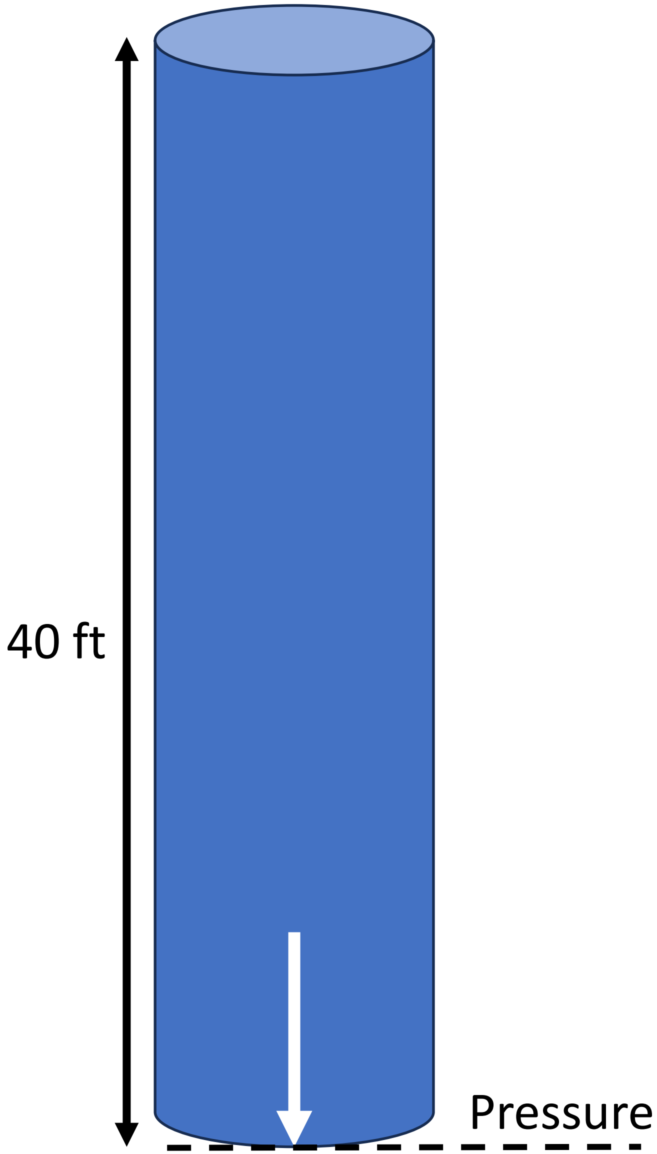
Pressure (pounds per square inch or PSI) = $\dfrac{\text{Height}}{2.31\ \text{ft/psi}}$



Every 2.31 foot of water column height adds 1 psi of static pressure

What is the pressure at the bottom of a standpipe filled to the 40 ft level?

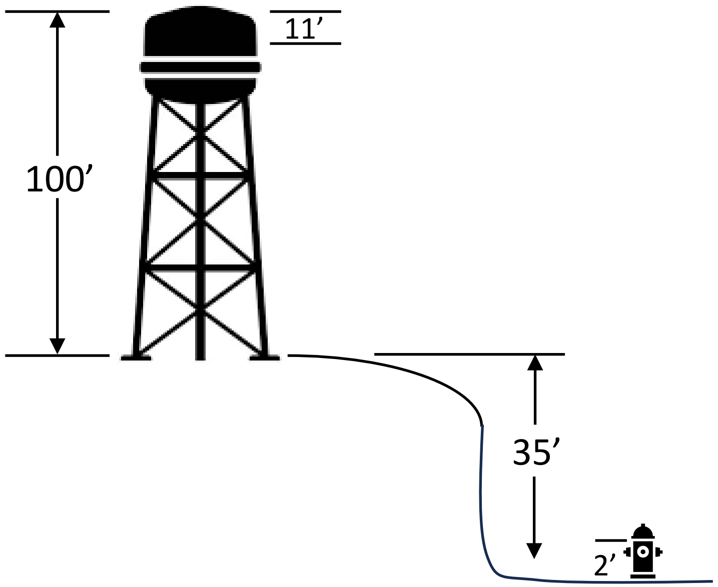
P = 40 ft x 1psi/2.31ft = 17.3 psi



Pressure Example – Elevated Storage Tank

Problem Statement

A 100ft high elevated tank sits atop a 35ft high hill. The water level in the tank is 11ft below the tank's top. There is a hydrant at the base of the hill. What is the water pressure at the hydrant nozzle if the nozzle is 2ft above ground level? (Assume static conditions—no flow or head loss)



1.) Calculate feet of head

100ft-11ft+35ft-2ft = **122 ft**

2.) Calculate pressure in psi

$$122\text{ft x } \frac{0.433 \text{ psi}}{1 \text{ ft}} = \mathbf{52.8\ psi}$$

OR

$$122\text{ft x } \frac{1 \text{ psi}}{2.31 \text{ ft}} = \mathbf{52.8\ psi}$$

Concentration

Parts per Million (ppm)

Ppm = 1 part / 1,000,000 parts

Milligrams per Liter (mg/L)

Technically, the weight of solids (expressed in mg), that are in a 1-Liter sample. It's weight per volume, however because a liter of water weighs 1,000,000 mg. We use it as ppm concentration.

Percent (%)

Expresses how many parts per hundred parts. 1/100 is expressed as 1%

10,000 mg/L = 1%

Decimal equivalent of percent: 1/100 is expressed as 0.01

Calculating feed rates

- Dry chemical feed (pounds per day)
- Liquid chemical feed (gallons per day)
- Conversions for chemical strength (if not 100%)

We use the pounds formula

Flow (MGD) x **dosage (mg/L)** x **8.34 lbs/gal** = **pounds per day**

For a liquid chemical we divide by the weight of chemical in each gallon

Pounds formula

Flow (MGD) x Conc (mg/L) x 8.34 lbs/gal = Feed rate in Lbs/Day

A well produces a flow of 600 gpm and the chlorine dose is 1.5 mg/L. What is the feed rate for gas chlorine in pounds per day?

Step 1: Convert flow to MGD

$$\frac{600\ \text{gal/min} \times 1440\ \text{min/day}}{1,000,000\ \text{gal/MG}} = \mathbf{0.864\ MGD}$$

Step 2: Use pounds formula

0.864 MG/day x 1.5 mg/L x 8.34 lbs/gal = **10.8 lbs/day**

Calculating Feed Rates for Sodium Hypochlorite

Top part of equation calculates lbs of pure Cl

$$\text{Gallons per day} = \frac{\boxed{\text{MGD} \times \text{mg/L} \times 8.34 \text{ lbs./gal}}}{\boxed{\%\text{strength}} \times \boxed{\text{weight per gallon}}}$$

Dividing by % strength gives weight of sodium hypochlorite liquid actually needed.

Dividing by weight per gallon will give you the number of gallons needed per day.

$$\textbf{Gallons per day} = \frac{\textbf{MGD} \times \textbf{mg/L} \times \textbf{8.34 lbs/gal}}{\textbf{\%strength} \times \boxed{\textbf{s.g.} \times \textbf{8.34 lb/gal}}}$$

Weight per gallon

Specific gravity

The ratio of the weight of a substance to the weight of water is called specific gravity. Water weighs **8.34 lbs./gal** and has a specific gravity of 1.0.

Calculate the weight of 1 gallon of 12.5% sodium hypochlorite, assuming it has a specific gravity of 1.2.

1.2 x **8.34 lbs./gal** = **10 lbs./gal**

Sodium Hypochlorite (Liquid Cl) feed rate calculation example

What is the feed rate for 12.5% sodium hypochlorite with a s.g. of 1.2 when the plant flow is 0.5 MGD and the dosage is 0.9 mg/L?

Solution: Use the following formula, and plug in values for flow, dosage, specific gravity, and solution strength.

$$\text{Gallons per day} = \frac{\text{Flow (MGD)} \times \text{Conc. (mg/L)} \times 8.34\ \text{lbs/gal}}{\%\text{strength} \times \text{s.g.} \times 8.34\ \text{lb/gal}}$$

$$\frac{0.5\ \text{MGD} \times 0.9\ \text{mg/L} \times 8.34\ \text{lb/gal}}{0.125 \times 1.2 \times 8.34\ \text{lb/gal}} = \textit{3 gallons per day}$$

Pounds formula can be arranged to solve for dose.

Pounds per Day = MGD(flow) x $\boxed{\text{mg/L(dose)}}$ x 8.34 lbs/gallon

$$\frac{\text{Pounds per day}}{[\text{Flow(MGD) x 8.34lb/gal}]} = \frac{\text{Dose (mg/L) x } \cancel{\text{Flow (MGD)}} \text{ x } \cancel{\text{8.34 lbs./gal}}}{[\cancel{\text{Flow (MGD)}} \text{ x } \cancel{\text{8.34lb/gal}}]}$$

$$\text{Dose (mg/L)} = \frac{\text{Pounds per Day}}{[\text{Flow(MGD) x 8.34lb/gal}]}$$

An operator checks the settings at a treatment plant and notes that the gas chlorine feed rate is set at **30 pounds per day** and that the plant flow is **2.1 MGD**. What is the **dose of chlorine in mg/L** that is being administered to this water source?

$$\text{Dose (mg/L)} = \frac{\text{Pounds per Day}}{[\text{Flow(MGD)} \times 8.34\text{lb/gal}]}$$

$$\text{Dose} = \frac{\text{30 Pounds per day feed}}{\text{2.1 MGD} \times 8.34 \text{ lb/gal}}$$

$$= 1.71 \text{ mg/L}$$

Poll 3

A ground water well produces a flow of 350 gallons per minute. The chlorine dose is 1.3 mg/L. What is the feed rate of gas chlorine in lbs per day?

a. 3.52 lbs/day
b. 4.65 lbs/day
c. 5.46 lbs/day
d. 6.82 lbs/day

Poll 3 Solution

A ground water well produces a flow of 350 gallons per minute. The chlorine dose is 1.3 mg/L. What is the feed rate of gas chlorine in lbs per day?

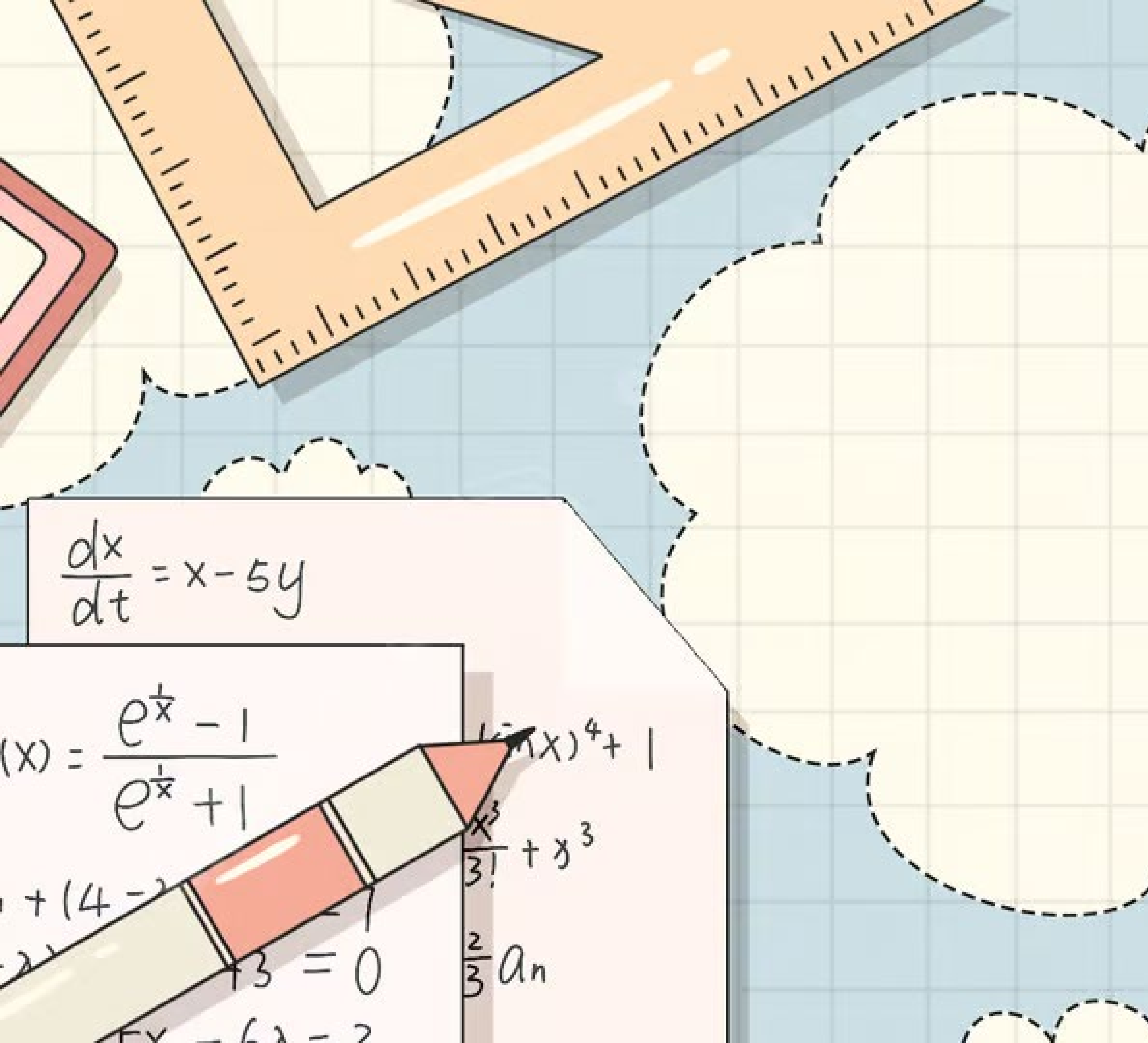
Solution:

Step 1: Convert flow to MGD

$$\frac{350\ \text{gal/min} \times 1440\ \text{min/day}}{1{,}000{,}000\ \text{gal/MG}} = 0.504\ \text{MGD}$$

Step 2: Calculate flow

0.504 MG/day x 1.3 mg/L x 8.34 lbs./gal = 5.46 lbs/day Answer is C



What We Covered Today

- Calculating Areas and Volumes
- Conversions
- Flow Rates
- Pressure
- Pounds Formula and Feed rates

Our brains can only hold **3 to 5** things at once before they start tuning out.

So how do we get the important stuff to stick?

DISTILL IT DOWN to 3.

Main Takeaways

If you remember nothing else, remember these 3 key points...

01

Use of Volumes

Areas and Volumes can be necessary for determining a variety of different things including flows, and concentrations.

02

Conversions

Conversions are important and are useful in manipulating the information that we're given into the information that we need.

03

Rates

Rates, both Feed and Flow, are critical concepts in the proper operation of drinking water systems.

Thank you for participating!

Share your thoughts on today's class in the chat.

1. Was there something you learned that was new to you?
2. What parts stimulated questions you want to explore further?
3. What can we clarify or expound on?

We're now open for questions!

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