

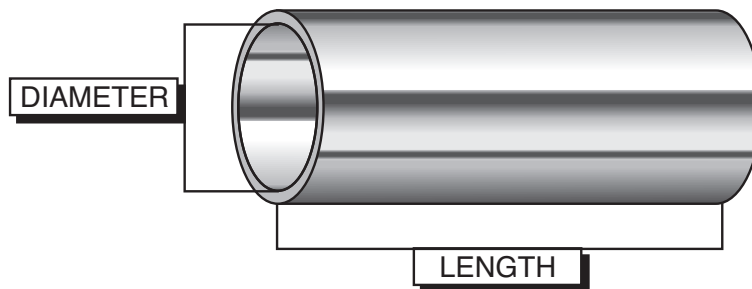
Volume Problems

How much water a pipe (cylinder) can hold is dependent on how big the pipe is (cross-sectional area) and how long it is (length). The larger and/or the longer the pipe, the more water it can hold.

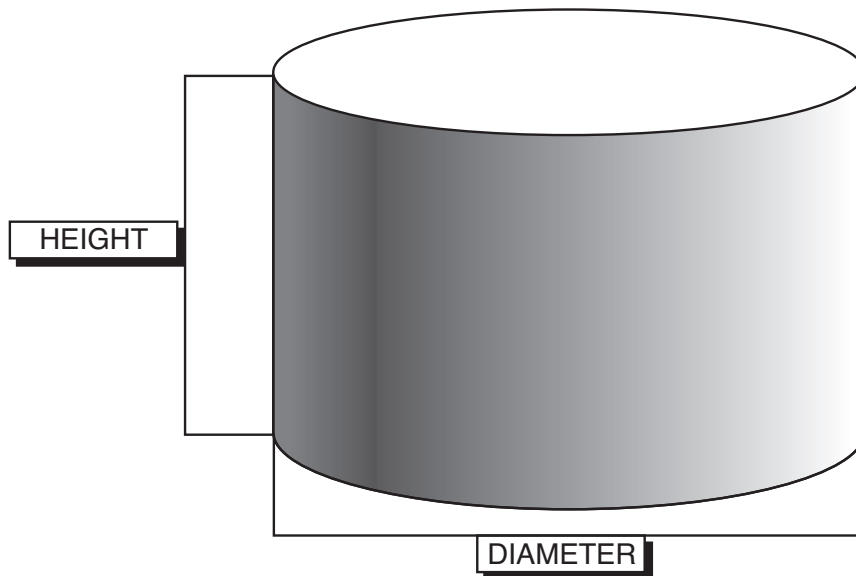
In Formulas, as stated before, letters represent numbers that are unknown or vary. For example to find the volume of a cylinder in cubic feet, multiply pi (π) times the radius squared (r^2) in feet, times the length in feet. The best way to write this, is by using the volume of a cylinder formula:

$$V = \pi r^2 L$$

This formula will give you the volume (in cubic feet) for any cylinder, such as a pipe:



or any round reservoir:



Where:

V = Volume in cubic feet

π = 3.14159265 or 3.14

r^2 = Radius (in feet) squared*

l = Length in feet

* = Squared means to be multiplied by itself, for example $4^2 = 4 \times 4$ or 16.

When using formulas, the important thing to remember is that the numbers you use must be

in the **proper** units, required by that specific formula. Apples and Apples or Oranges and Oranges, not Apples and Oranges.

When finding the volume of a cylinder such as a pipe, the length will be in feet and the radius (which is 1/2 of the diameter) will generally be in inches. For example "300 feet of 6" pipe". This is Apples and Oranges, since the length is in feet and the diameter is in inches. If the volume is to be in cubic feet, we must be sure all values are in feet.

The length is already in feet (300 feet), but the radius is in inches (3 inches, remember the radius is 1/2 of the diameter). We must change 3 inches to feet by dividing by 12. (12" in one foot) thus:

$$3/12 \text{ (3 divided by 12) } = 0.25$$

Now we have the same units of measure - length of 300 feet and radius of 0.25 feet so we can insert them into the formula for the volume of a cylinder. As was said earlier the best way to solve any problem using formulas is to use the step-by-step method:

Step One: (decide which formula applies to this problem)

Step Two: (write the formula)

$$V = \pi r^2 l$$

Step Three: (substitute the known values into the formula)

$$V = 3.14 \times (3/12)^2 \times 300$$

Step Four: (change the radius in inches into feet)

$$V = 3.14 \times .25^2 \times 300$$

You can see we still need to square the radius, so far all we have done is to convert the inches into feet. Be careful for it's very easy to forget to square the radius, especially after converting the inches to feet.

Step Five: (square the radius)

$$V = 3.14 \times 0.0625 \times 300$$

Step Six: (multiply the values together)

$$V = 58.875 \text{ Cubic Feet of water in 300 feet of 6" pipe.}$$

At this point we have found the volume in cubic feet, but in many cases you'll need to know the volume in gallons. So, how do we convert cubic feet into gallons?

From the conversion tables (on page 12) you see that 1 cubic foot of water is equal to 7.48 gallons, so roughly there is 7-1/2 gallons in every cubic foot of water. In order to find the volume in gallons for any problem, just multiply the answer in cubic feet by 7.48 and then you have the volume of water in gallons. Thus:

$$V = 58.875 \text{ Cubic Feet} \times 7.48 \text{ (gallons in each cubic foot)}$$

$$V = 440.385 \text{ gallons of water in 300 feet of 6" pipe.}$$

By following the steps outlined above, reduces the chance of making errors. Your work sheet should look something like this:

$$V = \pi r^2 l$$

$$V = 3.14 \times (3/12)^2 \times 300$$

$$V = 3.14 \times .25^2 \times 300$$

$$V = 3.14 \times 0.0625 \times 300$$

$$V = 58.875 \text{ Cubic Feet} \times 7.48 \text{ (gallons in one cubic foot)}$$

$$V = 440.385 \text{ Gallons}$$

Now, lets try another problem to be sure you know what you are doing. Find the volume in gallons for a reservoir 21 feet high and 100 feet in diameter? By entering basic known's, you know that:

$$1 - \pi (\text{pi}) = 3.14$$

$$2 - \text{radius (r)} = 50 \text{ feet (1/2 of the diameter)}$$

$$3 - \text{length (l)} = 21 \text{ feet (length or height)}$$

$$V = \pi r^2 l$$

$$V = 3.14 \times 50^2 \times 21$$

$$V = 3.14 \times 2500 \times 21$$

$$V = 164,850 \text{ Cubic Feet}$$

$$V = 164,850 \times 7.48$$

$$V = 1,233,078 \text{ gallons or 1.2 million gallons}$$

You'll notice in this problem you did not have to convert the radius into feet since it was already in feet.

Now let's find the volume of a rectangular reservoir or basin. The formula is:

$$V = LWH \text{ (Volume = Length x Width x Height)}$$

$$V = \text{Volume (in cubic feet)}$$

$$L = \text{Length (in linear feet)}$$

$$W = \text{Width (in linear feet)}$$

$$H = \text{Height (or depth) (in linear feet) [Linear Feet - is a measurement along a straight line.]}$$

Thus a settling basin 300 feet long, 100 feet wide and 50 feet deep would have a volume in cubic feet of:

Step One: (write the formula)

$$V = LWH$$

Step Two: (substitute the known values into the formula)

$$V = 300' \times 100' \times 50'$$

Step Three: (multiply the values together)

$$V = 1,500,000 \text{ Cubic Feet}$$

If you want this total in gallons, just multiply the volume in cubic feet by 7.48 (gallons in one cubic foot).

$$V = 1,500,000 \times 7.48$$

$$V = 11,220,000 \text{ gallons or } 11.2 \text{ million gallons of water in the basin.}$$

REVIEW

Do ...Be sure all numbers you put into a formula are in the correct units, apples and apples not apples and oranges.

Don't ...Forget to square the radius after you have changed the inches to feet.

Now, let's try a different kind of volume problem, This time find the volume of a CONE. The formula to find the volume in cubic feet of a cone is:

$$V = 1/3 \pi r^2 h$$

Note: This formula shows that a cone is 1/3 the volume of a cylinder with the same radius and height or length, where:

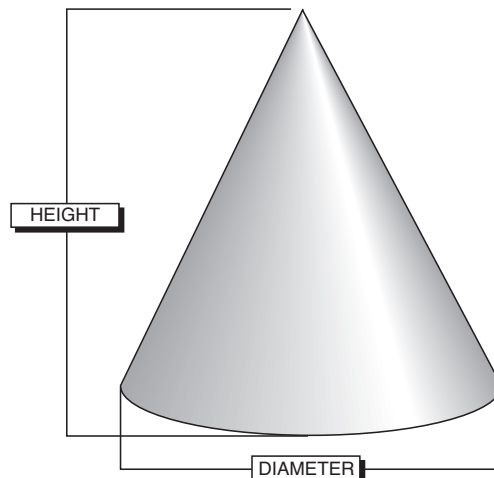
V = Volume in cubic feet

1/3 = 0.33 (one divided by three)

π = 3.14 (pi)

r^2 = Radius of the base (or widest point) of the cone in feet, squared

h = Height of the cone (vertical) in feet



Find the volume of a cone which is 10 feet in diameter at the base and is 12 foot high?
Remember that with all formulas eliminate possible mistakes by solving them step by step.
The known unit values are:

1 - $1/3$ is the same as 0.33

2 - π (pi) equals 3.14

3 - radius = 5 feet

4 - height = 12 feet

Step One: (write the formula)

$$V = 1/3 \pi r^2 h$$

Step Two: (substitute the known values into the formula)

$$V = 0.33 \times 3.14 \times 5^2 \times 12$$

Step Three: (square the radius)

$$V = 0.33 \times 3.14 \times 25 \times 12$$

Step Four: (multiply the values together)

$$V = 310.86 \text{ cubic feet}$$

Now, if you want the volume in gallons, multiply the cubic feet by 7.48 (gallons in one cubic foot) thus:

$$V = 310.86 \times 7.48$$

$$V = 2325.2328 \text{ gallons}$$

Your work sheet should look like this:

$$V = 1/3 \pi r^2 h$$

$$V = 0.33 \times 3.14 \times 5^2 \times 12$$

$$V = 0.33 \times 3.14 \times 25 \times 12$$

$$V = 310.86 \times 7.48$$

$$V = 2325.2328 \text{ gallons}$$

Simplified Math for Waterworks Operators

Now lets find the volume of a SPHERE. The formula for finding the volume in cubic feet for a sphere is:

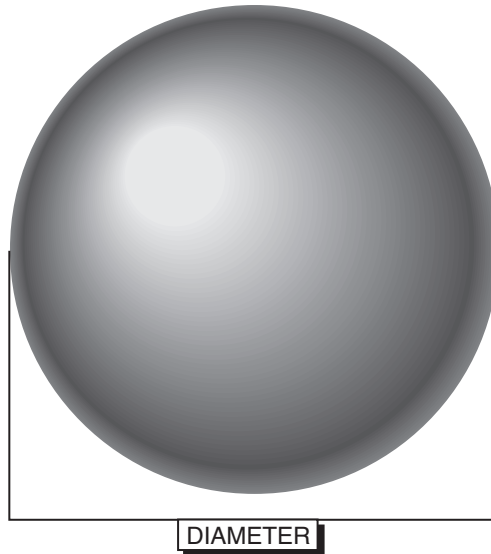
$$V = 4/3 \pi r^3$$

V = Volume in cubic feet

$$4/3 = 1.333$$

$$\pi = 3.14 \text{ (pi)}$$

r^3 = Radius of the sphere cubed (cubed means to multiply a number by itself three times, such as 3^3 means $3 \times 3 \times 3 = [9] \times 3 = 27$)



Find the volume of a sphere which is 36 feet in diameter? Again be sure to use the step by step process. The basic known's are:

$$4/3 = 1.333$$

$$\pi \text{ (pi)} = 3.14$$

$$\text{radius (r) cubed} = 18 \times 18 \times 18 \text{ or } 5,832 \text{ (} 18^3 \text{)}$$

Step One: (write the formula)

$$V = 4/3 \pi r^3$$

Step Two: (Substitute the known values into the formula)

$$V = 1.33 \times 3.14 \times 18^3$$

Step Three: (cube the radius)

$$V = 1.33 \times 3.14 \times 5,832$$

Step Four: (multiply the values together)

$$V = 24,355.598 \text{ cubic feet}$$

(Now, if you want gallons, just multiply the cubic feet by 7.48):

$$V = 24,355.598 \times 7.48$$

$$V = 182,179.88 \text{ gallons}$$

Your worksheet should look like this:

$$V = \frac{4}{3} \pi r^3$$

$$V = 1.33 \times 3.14 \times 18^3$$

$$V = 1.33 \times 3.14 \times 5,832$$

$$V = 24,355.598 \times 7.48$$

$$V = 182,179.88 \text{ gallons}$$

As you can see, solving volume problems is easy as long as you remember the rules. Apples and apples, not apples and oranges, and most important of all, do them step by step writing down each step at a time. This admittedly takes time, but it is the one sure way to eliminate simple errors such as conversions and/or missing important steps which are real easy especially when using a calculator.

Now, here is a practice problem to test your skills in solving volume problems.

Practice Problem #1

(answer on page 54)

Find the volume of water in gallons for this reservoir?

