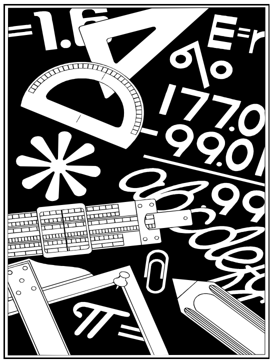
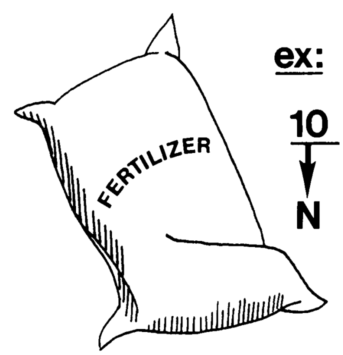


Turfgrass Mathematics

by Wallace Menn and Mark Hall

Hey, dudes (and dudettes) its not like this stuff is rocket science. It's only math, pure and simple with maybe a hint of algebra, sometimes. What can I say? I used to be deathly afraid of "word problems" (ie a train leaves N.Y. going West at 60 mph and another train leaves L.A. going East at 72 mph, etc, etc....). Turf math just isn't that difficult. It's just using the correct formula or setting the problem up correctly to arrive at the right answer or solution. As I have told hundreds or maybe even thousands of students in classes at Texas A&M, there is usually more than one way to setup a Turf math problem. Find a method or way that you understand and are comfortable with and stick with it. I might work the problem completely different than you; however, as long as we both come up with the correct answer, that's all that counts. It doesn't really matter if you're using "new math" and I'm still using methods from the Dark Ages. I can personally attest to the fact that the more you work Turf Math problems, the easier they get. But, don't become overly confident to the point that you don't double-check your answers, especially when calculating rates for pesticides, fertilizers, etc. You need to be able to recognize an unreasonable answer when you see it. For example, if you are calculating the amount of ammonium sulfate fertilizer (21-0-0) to apply to a 10,000 ft^2 putting green and you come up with an answer of 500 pounds, a red flag should pop up or a buzzer should go off in your head alerting you to think about how many pounds of nitrogen that you're about to apply to a fairly small area. A lot of this just comes with experience. Just look at your answer and ask yourself, "does this sound reasonable or ridiculous". In the following sections, I will be discussing fertilizer calculations, pesticide calculations, spreader and sprayer calibration and what I refer to as miscellaneous calculations that most Turf Managers have to face on a day-to-day basis.

Fertilizer Calculations



Grasses require 12 or so minerals which are commonly referred to as "essential elements". These elements are required in varying amounts for normal, healthy growth of the grass plant. An insufficient supply of these elements produces a weak plant which would be more stress sensitive. On the other hand, an over-abundance of some of these nutrients may produce a plant that is less hardy, less drought tolerant and less disease resistant. Therefore, it is very important to develop a sound fertility program for your turf and to apply the nutrients required at the recommended rates. The following are examples of fertilizer calculations for both dry and liquid fertilizers.

<u>Dry Formulation</u>:

$$\frac{\text{Recommended Rate of Nutrient per Unit Area}}{\text{Percent Nutrient in the Fertilizer}} = \text{Amount of Fert./Unit Area}$$

Example: Apply 1.5 lbs of Potassium (K_20) per 1,000 ft^2 to an area measuring 57,600 ft^2 using potassium sulfate (0-0-50).

$$\frac{1.5 \text{ lbs } K0}{0.50} = 3 \text{ lbs of Fertilizer} / 1{,}000 \text{ ft}^2$$

3 lbs Fert. x 57.6 Thousand square feet = 172.8 lbs of 0-0-50 for the job.

Liquid Formulation: (must know weight per gallon.)

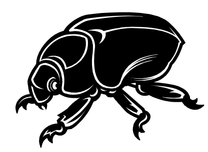
$$\frac{\text{Recommended Rate (lbs} / 1{,}000\text{ft}^2)}{\text{lbs. of nutrient / gallon}} = \text{gallons of fert.}/1{,}000\text{ft}^2$$

Example: Calculate the amount of liquid fertilizer (28-0-0) required to apply 1.0 lb of Nitrogen per 1,000 ft^2 to an area measuring 6,000 ft^2. (the liquid formulation weighs 10 lbs per gallon).

10 lbs per gallon x .28 = 2.8 lbs of N/gallon

$$\frac{1.0 \text{ lb of N} / 1{,}000 \text{ ft}^2}{2.8 \text{ lbs N / gallon}} = 0.36 \text{ gallons Fert.}/1{,}000 \text{ ft}^2$$

0.36 gallons x 6,000 ft^2 = 2.16 gallons of Fert./6,000 ft^2



Pesticide Calculations

Pesticides are formulated as either dry or liquid products. Percent active ingredient (A.I.) will be listed on the container (ie bag, box, etc.) of the dry pesticide formulation. Dry pesticide materials are offered as Dusts (D), Granules (G), Dry Flowables (DF), Water Dispersible Granules (WDG), Wettable Powders (WP) or Soluble Powders (SP).

Liquid pesticides are also produced in various formulations such as Emulsifiable Concentrates (EC), Solutions (S), Liquids (L) or Flowables (F). Concentration of the active ingredient is usually listed immediately in front of the formulation abbreviation (ie 3EC, 2L, 4F, etc). The number indicates the pounds of active ingredient contained in one gallon of product (ie 3 EC would mean that the product was an emulsifiable concentrate containing 3 pounds of active ingredient per gallon). In some cases, the concentration and formulation are not given as part of the product name. In these instances, look directly below the active ingredient statement on the label and usually, there will be a statement as to the equivalent pounds of active ingredient per gallon.

When calculating rates for a dry pesticide formulation, you use the same formula that was used in determining dry fertilizer rates. For example:

$$\frac{\text{Recommended Rate of A.I./Ac}}{\text{Percent A.I. of the Product}} = \text{Amount of Product / Acre}$$

Example: I want to apply Weed-Prevent 60 DG at a rate of 3 lbs A.I./Ac and I want to treat 5 acres. How much product do I need?

$$\frac{3.0\ \text{lb A.I./Ac}}{.60} = 5\ \text{lbs of WeedPrevent / Acre}$$

5 lbs product/Ac x 5 Acres = 25 lbs of Weed-Prevent 60 DG for the job.

When calculating rates for a liquid pesticide formulation, you divide the recommended rate of A.I. by the pounds of A.I. per gallon of product to get the number of gallons of product per unit area.

Example: I want to apply Pest-B-Gone 2L at a recommended rate of 0.5 lbs A.I./Ac to an area measuring 12 acres. How much Pest-B-Gone 2L do I need for the job?

$$\frac{\text{Recommended Rate A.I. / Ac}}{\text{Pounds of A.I./gallon of Product}} = \text{gallons of product per acre}$$

$$\frac{0.5\ \text{lbs A.I./Ac}}{2\ \text{lbs A.I./gal}} = 0.25\ \text{gallons of product / acre}$$

$$.25\ \text{gallons / Ac x 12 Ac} = 3\ \text{gallons of Pest - B - Gone for the job.}$$

Now that we know how to purchase or obtain the correct amount of fertilizer or pesticide for a given area, we come to the more difficult aspect of the job. How do we go about applying the recommended amount to a given area? There are several methods that can be used for calibrating spreaders and sprayers. Find a method that you understand and are comfortable with and then use it. I am reminded of an old saying about pesticide application. "Three things can happen when you apply pesticides and two of them are bad". What I'm getting at here is that if you don't put out enough pesticide to kill the targeted pest, then you have just wasted your time and a costly plant protectant. If you over apply a pesticide, you will probably kill the pest; however, you run the risk of doing damage to the plants you are trying to protect not to mention again wasting expensive chemicals. It is imperative that fertilizers and pesticides be applied according to label recommendations. It is in the best interest of your budget, the plants that you are trying to grow and the environment in which we live.

Spreader Calibration

There are basically 2 types of spreaders available for applying granular fertilizers and pesticides. They are the drop spreader and the rotary or broadcast spreader. The drop spreader consists of a hopper on top of an adjustable, lever operated opening on the bottom which allows material to drop directly to the turf below. These types of spreaders range in size from about 2 feet to 8 feet in width. There are several approaches to calibrating a drop spreader. One method involves marking a measured test strip on a clean floor where the material can be dropped, swept up, collected and weighed. For example, if you were calibrating a 3 foot wide drop spreader, you might measure a test strip of say, 20 feet. Place the material to be applied in the hopper, set the opening on a reasonable setting and then operate the spreader over the 20 foot test strip. Sweep and collect the applied product which was dispersed over 60 square feet (20 ft x 3 ft). Let's assume you were trying to calibrate the spreader to apply 3 pounds of product per 1,000 ft^2. Use the following equation to determine how much to apply to 60 ft^2 (ie your test area).

$$\frac{3.0 \text{ lbs}}{1{,}000 \text{ ft}^2} = \frac{x \text{ lbs}}{60 \text{ ft}^2}$$

1,000x = 180

x = 0.18 per 60 ft^2

0.18 lbs x 16 oz/lb = 2.88 oz per 60 ft^2

If you are putting out more than 2.88 oz per 60 ft^2, decrease the spreader setting. If you are putting out less than 2.88 oz per 60 ft^2, increase the spreader setting and try again. This is a "trial and error" method and may take a little time to zero in on the correct rate setting. Instead of working on a clean surface and sweeping the material for collection, you can use the same technique except have your test strip over a sheet of plastic for easier collection. Collection trays can also be constructed that fit beneath the spreader and is my preferred method of calibrating a drop spreader. One problem associated with using a drop spreader is the possibility of skips or not overlapping properly. To diminish this problem, you might want to calibrate the drop spreader to apply half of the recommended rate and then make 2 applications in different directions preferably perpendicular to each other.

The other type of spreader mentioned earlier is the rotary or broadcast. These spreaders are equipped with a spinning plate or disk located beneath the hopper. As the material falls from the hopper on to the spinning disk, it is thrown in a semi-circular pattern in front and to either side of the spreader. When calibrating this type of spreader, you need to determine the width of the spreader pattern. This width will change depending on particle size and density or weight of the material being applied. Most small, push-type rotary spreaders will have an application pattern width of 8 to 12 feet. Larger units (ie. tractor drawn or truck mounted) will have much wider patterns. Operating instructions received with the spreader should give a recommendation for overlapping patterns to give uniform distribution of materials.

Once you have determined the effective swath width for your spreaders, measure a test strip of say, 40 to 50 feet. By multiplying the length of your test strip times the width of your application pattern, you will determine the size of your calibration area. For example, if the length of your test strip is 50 feet and the effective swath width is 10 feet, just multiply 50 x 10 to determine your test area to be 500 ft^2. Next, place a measured amount of product in your spreader, adjust the hopper opening to a reasonable setting and apply the material (at that setting) to your predetermined test strip. For example, place 5 pounds of product in your spreader. After determining a setting for the spreader, apply the material to the test strip. After making one pass over the test strip, collect and re-weigh the material remaining in the hopper of the spreader. Subtract the remaining amount from the original 5 pounds to determine the amount applied to your 500 ft^2 test area.

Example: 5.0 lbs orig. wt.
- 3.8 lbs remain. wt.
1.2 lbs applied per 500 ft^2

$$\frac{1.2\ \text{lbs}}{500\ \text{ft}^2} = \frac{x}{1{,}000\ \text{ft}^2}$$

$$500x = 1{,}200$$

$$x = 1200 \div 500$$

$$x = 2.4\ \text{lbs} / 1{,}000\ \text{ft}^2$$

Here again, if you are putting out too much material, lower the setting on the spreader and try again. If you're not putting out enough material, raise the setting and try again. As with the drop spreader, this is a trial and error method of calibration.

With larger rotary spreaders, you also need to determine application pattern width and how much to overlap. Due to the size of the larger units, collecting the remaining material after making a test run is not very practical. With larger rotaries, place a known quantity of material in the hopper and then at a selected setting, operate the spreader until all of the material is applied. Then measure the size of the area treated. For example, place 50 pounds of product into the hopper of your spreader. Operating the spreader until all of the material is applied, you find that you have treated 18,000 ft^2. Use the same equation as before:

$$\frac{50\ \text{lbs}}{18{,}000\ \text{ft}^2} = \frac{x\ \text{lbs}}{43{,}560\ \text{ft}^2\ (1\ \text{acre})}$$

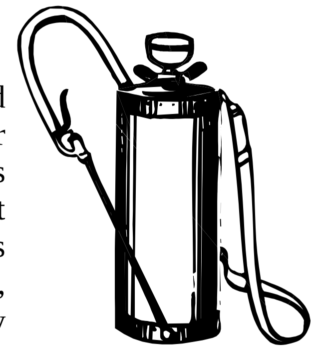
$$18{,}000x = 2{,}178{,}000$$

$$x = 2{,}178{,}000 \div 18{,}000$$

$$x = 121\ \text{lbs of product/acre}$$

As with the drop spreader, you can apply materials with a single pass of a rotary spreader; however, calibrating the rotary spreader to apply half the recommended rate and then applying in 2 passes made at perpendicular directions will yield a much more uniform application of product and most likely a more desired response. This is especially true with the smaller spreaders.

Sprayer Calibration



Many of the new turf spraying machines are computer controlled and all the operator has to do is put the correct amount of pesticide or fertilizer into the spray tank, punch in various bits of information such as travel speed, operating pressure, desired output, etc. and then start spraying. If you have such a sprayer, you may think that all of this calibration stuff is for the birds (or for those of us stuck with the older, conventional sprayers). I guess I'm just old fashioned, but I don't fully trust computer controlled equipment and I certainly don't trust myself to always punch in the correct information necessary for accurate spraying. So, I'm one of those people who likes to go out and manually calibrate the computer controlled sprayer just to see if we are "on the same playing field". It doesn't take that long and is certainly worth the time and effort necessary to insure accurate application of pesticides and liquid fertilizers.

There are several different types of sprayers used in turf management; however, the one most commonly used is the self-propelled, boom sprayer. Since the procedures used for calibrating are similar for most of the different types, I will concentrate on methods of calibration used on the self-propelled, boom sprayer.

When discussing sprayer calibration, it is very important that we understand the importance of speed and flow rate. For example, doubling your travel speed decreases your application rate by one half. A four-fold increase in pressure only doubles the nozzle flow rate. Therefore, when we are calibrating spray equipment, it is imperative that we travel at a constant speed and operate at a constant pressure which is within a recommended range for your particular nozzle.

The first method of calibration is a simple 5 step process:

Step 1 - Using a speedometer, tachometer, or throttle setting, decide on a desirable speed for your location and application (usually between 3 and 6 mph)

Step 2 - Decide on a suitable spray pressure based on nozzle type and size.

Step 3 - Mark off a known distance test strip (ie. 50, 100 or 150 feet). Make note of the width of the spray pattern as determined by the length of the spray boom (ie. 12 ft, 16 ft, 18 ft, etc.). This will give you the information used in determining the size of your test area.

Step 4 - With the sprayer tank filled to half capacity with water, operate the sprayer over your test strip and note the time required to cover the test strip (ie. 12 sec., 15 sec., etc.). You may want to make several passes over the test strip and then use the average time required to travel the distance.

Step 5 - Once you determine the time required to travel over the test strip, stop the sprayer but keep the sprayer operating at the application pressure. Collect the spray from one nozzle for the number of seconds required to travel over the test strip. Multiply the amount of spray collected from 1 nozzle by the number of nozzles on the spray boom. This will give you the amount of spray applied to the test area.

Example: Test area measures 100 feet in length and your boom sprays a swath 16 feet wide.
A = L x W
A = 100' x 16'
A = 1600 ft^2 in test area

Spray collected from one nozzle equals 12 oz. There are 10 nozzles on the boom
12 oz/noz. x 10 noz. = 120 oz/1600 ft^2

$$\frac{120\,oz}{1600\,ft^2} = \frac{x}{43{,}560\,ft^2}$$

1600x = 120 x 43,560
1600x = 5,227,200
x = 5,227,000 ÷ 1600
x = 3267 oz
3267 oz ÷ 128 oz/gal. = 25.5 gallons per acre.

This sprayer is calibrated to apply 25.5 gallons per acre.

Another and perhaps easier method for calibrating a boom sprayer is known as the "Ounce Calibration Method". This method also involves using a measured distance test strip; however, the distance is determined by the nozzle spacing on the boom (see chart below). Set the throttle for spraying and operate the sprayer at a constant speed and pressure. With the spray tank half filled with water, drive the recommended, measured distance, noting the time required to travel the test strip. You may want to travel in 2 directions and calculate the average time required to travel the distance. With the sprayer stopped but continuing to spray, catch the spray from one nozzle for the amount of time (seconds) required to travel the distance of the test strip. The amount of fluid ounces collected from one nozzle will equal the number of gallons per acre that the sprayer is calibrated to apply.

Nozzle Spacing vs Nozzle Spacing (inches)	Test Run Distance Distance (Feet)
14	291
16	255
18	277
20	204
22	185
24	170
26	157
28	146

Example: Assume the spacing between nozzles on your boom to be 20 inches and it takes an average of 24 seconds to travel the test strip distance of 204 feet. When you catch the spray from one nozzle for 24 seconds, you find that you have collected 30 ounces of water. Your sprayer is calibrated to apply 30 gallons per acre.

When using either of the 2 methods of calibration, once you determine gallons per acre applied, then you simple divide the capacity (in gallons) of your spray tank by the gallons per acre of the spray volume to determine how many acres you can treat with one tankful of spray mix. Once you have determined how many acres you can spray with one tankful of spray mix, multiply acres times rate of product per acre to get the amount of product per tank. For mixing less than a tankful of spray mix, divide gallons per acre into the gallons of spray mix you intend to use. This will give you the number acres you can treat and you can then calculate how much product to add to the spray mix.

Miscellaneous Calculations

Topdressing

Most of us in the Turf Management industry have had to determine how much sand or soil it's going to take for a specific purpose whether it be topdressing, building a rootzone, filling a sand bunker, or creating a sand volleyball court. I'm afraid many people just order a whole bunch and hope that it's enough. So what if you have a few yards left over; maybe you can use it for something else. I see way too many of the mounds of "left-over" soil or sand sitting beside or behind maintenance shops just because someone didn't order the correct amount for a specific job. Usually those mounds have long since been covered over by the infamous weed, Common Bermudagrass, thereby hindering the use of that soil or sand in the future.

Previously, we discussed fertilizer and pesticide application which dealt with a 2 dimensional plane we called "area". When you start calculating the need for topdressing materials, rootzone mixes, etc., you must consider another dimension. Area deals with length and width; while topdressing etc. also requires a third dimension (ie. height, depth, or thickness) which calls for volume calculations. The only thing to remember when making volume calculations, is that all dimensions need to be in the same units of measure (ie. inches, feet, yards, etc.). Basically, what I'm saying is that you can't multiply inches times feet and come up with a legitimate answer; you must convert units to either all inches or all feet.

When calculating topdressing requirements, you will be determining the amount of topdressing to apply to a given size area. The depth or thickness of topdressing will normally be in a fraction of an inch (ie. 1/4 inch, 3/8 inch, 1/2 inch, etc.). Assuming that you already know or have calculated the size of the area to be topdressed, you just need to determine what part of a foot the depth is going to be.

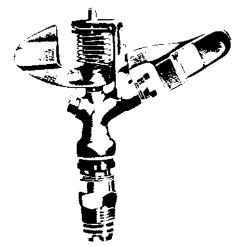
Example: 1/16 inch depth
$1 \div 16 = 0.0625$ inches
$0.0625 \div 12$ inches/ft = 0.0052 feet

Multiply depth (0.0052 ft) times the area measured in square feet which will yield cubic feet of topdressing required.

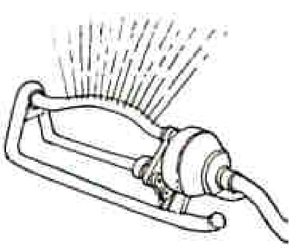
Example: 20,000 ft^2 area to be topdressed with a 1/16 inch layer of material (ie sand, soil, etc).

20,000 ft^2 x 0.0052ft = 104 cubic feet. 104 $ft^3 \div 27\ ft^3/yd^3 = 3.85\ yd^3$ of topdressing required for the job.

Irrigation Calculations



This section will not deal with sprinkler spacing, pipe sizing etc. because those things are best left to the Turf irrigation specialist. There are instances when the turf manager needs to be able to calculate how much water is being used at a particular site, how much water to apply in order to incorporate certain pesticides or if your supply will meet your demands during peak seasons of irrigation. Seasonal water demands are usually expressed in terms such as acre feet or acre inches of water. An acre foot of water is equal to 325,829 gallons; while, an acre inch of water is equal to 27,152 gallons. On large turf areas such as golf courses, athletic fields, sod farms, etc., it is very important to know and keep records of how much water is being used during the growing season. This can be especially important in areas where water rationing is a common occurrence. At these locations, water allocation is often based on historical water use records. During peak water use periods such as July, August and early September, it is not uncommon for the evaportranspiration rate (ET) to be between 0.3 and 0.4 inches per day on many turf areas. This means that the turf area is transpiring and evaporating about 2.5 inches of water per week. In order to maintain healthy growth of the grass under these high moisture loss conditions, you are going to have to replace at least about 75% of the water via irrigation and/or rainfall. Now this is where it gets kind of tricky. Do you know how much water your sprinkler system is putting out when it is operating? You would be surprised how many people don't have a clue, they simply irrigate until it looks wet. It's really not that difficult to determine how much water you are using per day, week or year if you know the actual precipitation rate of your sprinklers and if you know how long they operate. Let's say that the precipitation rate is 0.5 inches per hour and you run those sprinklers for 20 minutes every night. You are only applying 0.17 inches of water per day to your turf area or about 1.17 inches per week. This is hardly enough to keep up with the E.T. rate mentioned earlier.



Also, if you know the size of the area that you are irrigating, you can calculate the amount of water used per day, week, month or year.

Example: You have a 10 acre turf area that you irrigate for 45 minutes three times per week. Your sprinklers are putting out .45 inches per hour. How much water are you using per week?

$$\frac{.45 \text{ inches / hr}}{60 \text{ minutes / hr}} = \frac{x \text{ inches}}{45 \text{ minutes}}$$

$60x = .45 \times 45$
$60x = 20.25$

$x = 20.25 \div 60$
$x = 0.34$ inches per cycle

0.34 in./cycle x 3 cycles/wk = 1.02 inches/wk
1.02 in. x 27,152 gal/acre inch = 27,695 gals/ac
27,695 gal/ac x 10 acres = 276,950 gals of water used per week to irrigate the 10 acre site.

Supposing that in the example above, the water was purchased from a municipality whose rates were $1.50 per 1,000 gallons. You would be paying approximately $415.00 per week for irrigation water (ie 276.95 thousand gallons x $1.50 per thousand = $415.00 per week)

If you don't know the precipitation rate of your sprinklers, you may want to purchase a half dozen or so rain gauges and place them at random locations within your irrigated turf area. Operate the system for a predetermined amount of time (ie 20 minutes) and observe how much water is collected during that time frame. Example: 0.18 inches of water collected in 20 minutes would mean your precipitation rate was 0.54 inches per hour (ie. 60 min./hr. ÷ 20 min run time = 3 run times per hour; 0.18 inches per run time x 3 run times per hour = 0.54 inches per hour). For a more accurate determination of water use and distribution, you may want to contact a Turf Extension Specialist or an independent irrigation consultant who can conduct a water audit of your entire irrigation system.

Seeding Rate Calculations

Seeding rate recommendations for seeded turfgrasses are usually given in terms of Pure Live Seed (PLS) per unit area. Pure live seed can be defined as the percentage of a seed lot which is pure to a variety or species and which is alive and will germinate. The formula commonly used to determine PLS requires the use of information normally found on the seed certification tag which accompanies the container of seed. That information includes <u>percent purity</u> and <u>percent viability</u> (sometimes referred to as germination percentage). Simply, multiply percent purity times percent viability to get percent pure live seed. Example: A seed source contains a purity of 98% and a viability (or germination) of 80%.

0.98 x 0.80 = 0.784 or 78.4% PLS. If the recommended rate for this seed is 20 lbs of pure live seed per 1,000 $ft.^2$, you would divide recommended rate (20 lbs) by the percent of PLS to get pounds of seed per 1,000 ft^2. Example: 20 lbs ÷ 0.784 = 25.5 lbs of seed per 1,000 ft^2.

Turfgrass mathematics is not difficult. You will find that the more you work these problems, the easier they become. My only concern is that you might become overly confident in your mathematical skills and fail to double check your calculations. Double checking only takes a few minutes and is well worth the time to insure correct application of fertilizers, pesticides, seeds, topdressing and water.

Useful Conversion Factors

1 pint = 16 oz.
2 pints = 32 oz = 1 quart
4 quarts = 128 oz = 1 gallon
500 gallons = a lot of anything

12 inches = 1 foot
3 feet = 1 yd
144 in^2 = 1 ft^2
43,560 ft^2 = 1 acre
9 square feet = 1 yd^2
27 cubic feet = 1 cubic yard (3 ft x 3 ft x 3 ft)
5,280 feet = 1 mile
5 miles = a long way to walk

16 ounces = 1 pound
2,000 lbs = 1 ton
1 ton = 0.74 cubic yds of sand
1 acre inch = 27,152 gallons
1 acre foot = 325,829 gallons
1 cubic foot of water = 7.48 gallons

Formulas:
Rectangle - Area = Length x Width

Triangle - Area = $\frac{\text{base x height}}{2}$

Trapezoid - Area = $\frac{A + B}{2}$ x height

Circle - Area = 3.14 x radius^2
Cube - Volume = Length x Width x Height
Cylinder - Volume = 3.14 x r^2 x Height

Cone - Volume = $\frac{3.14 \times r^2 \times h}{3}$

18 inches = 1 cubit (important if you're building an Ark)

A Useful Calibration Formula

$$GPA = \frac{GPM\ (\text{per nozzle}) \times 5940}{mph \times W}$$

Where:
GPA = gallons per acre
GPM = gallons per minute
mph = miles per hour
W = Nozzle spacing (in inches)
5940 = constant for the conversion to GPA

With this formula, it does not matter how many nozzles you have, as long as they all work properly.

A Method to Calculate Speed

Time the sprayer in seconds as it travels along a test track measured in feet.

$$\text{Miles per hour} = \frac{\text{Track length in ft.}}{\text{Time in seconds}} * 0.68$$

Example: 23 seconds to travel 100 ft track length

$$\text{Miles per hour} = \frac{100}{23} * 0.68 = 2.96 \text{ miles per hour}$$

Determining Quantities Using a Ratio

$$\frac{\text{A units}}{\text{B area}} = \frac{\text{X units}}{\text{Y area}}$$

Cross multiply and divide to solve:
$A * Y = B * X$

Example: $$\frac{100 \text{ lbs}}{1 \text{ acre}} = \frac{X \text{ lbs}}{10{,}000 \text{ ft}^2}$$

1 acre = 43,560 ft^2

$$\frac{100 \text{ lbs}}{43{,}560 \text{ ft}^2} = \frac{X \text{ lbs}}{10{,}000 \text{ ft}^2}$$

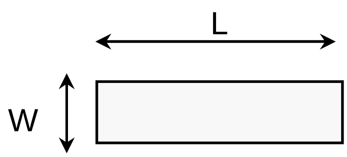
Units must be the same on both sides of the ratio!

$100 * 10{,}000 = 43{,}560 * X$

$$\frac{1{,}000{,}000}{43{,}560} = \frac{43{,}560 * X}{43{,}560}$$

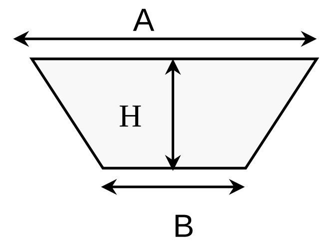
X = 22.95 lbs

Rectangle



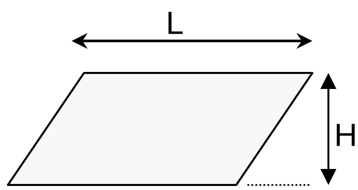
Area = L x W

Trapezoid



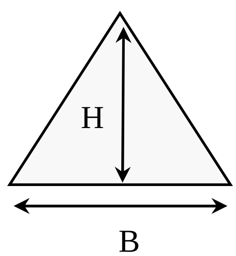
$$\text{Area} = \frac{A + B}{2}\,(H)$$

Parallelogram



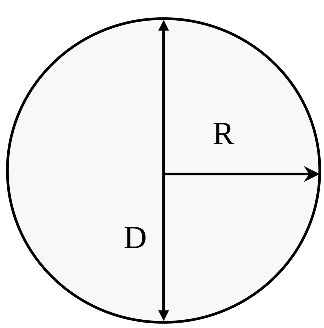
Area = L x H

Triangle



$$\text{Area} = \frac{(B)\,(H)}{2}$$

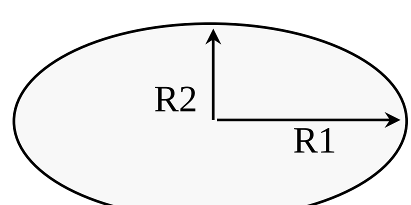
Circle



Area = (3.14) R^2

Circumference = (3.14) D

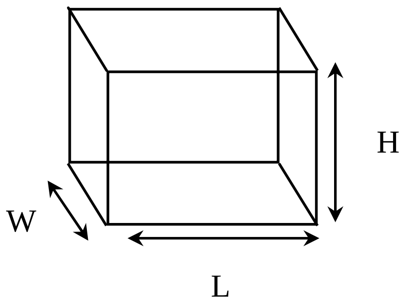
Oval



Area = (R1) (R2) (3.14)

A
R
E
A
S

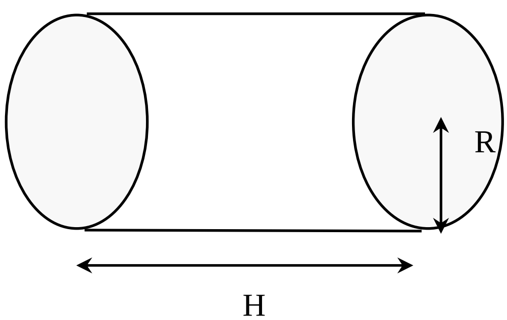
Cube or Rectangular Prism



Volume = (L) (W) (H)
or
Volume = area x (H)

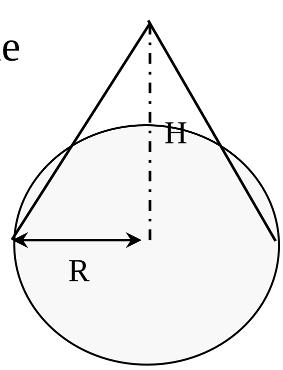
V O L U M E S

Cylinder



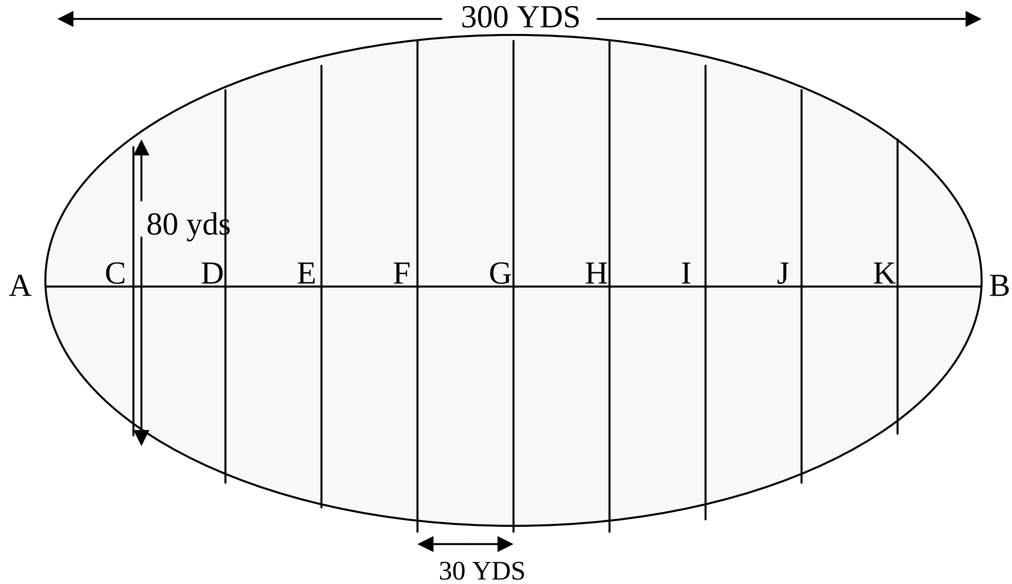
Volume = $(3.14)(R^2)(H)$

Cone



$$\text{Volume} = \frac{(3.14)(R^2)(H)}{3}$$

Offset Method For Determining Area



A = 0
B = 0
C = 80 yds
D = 100 yds
E = 120 yds
F = 130 yds

G = 150 yds
H = 140 yds
I = 125 yds
J = 95 yds
K = 75 yds

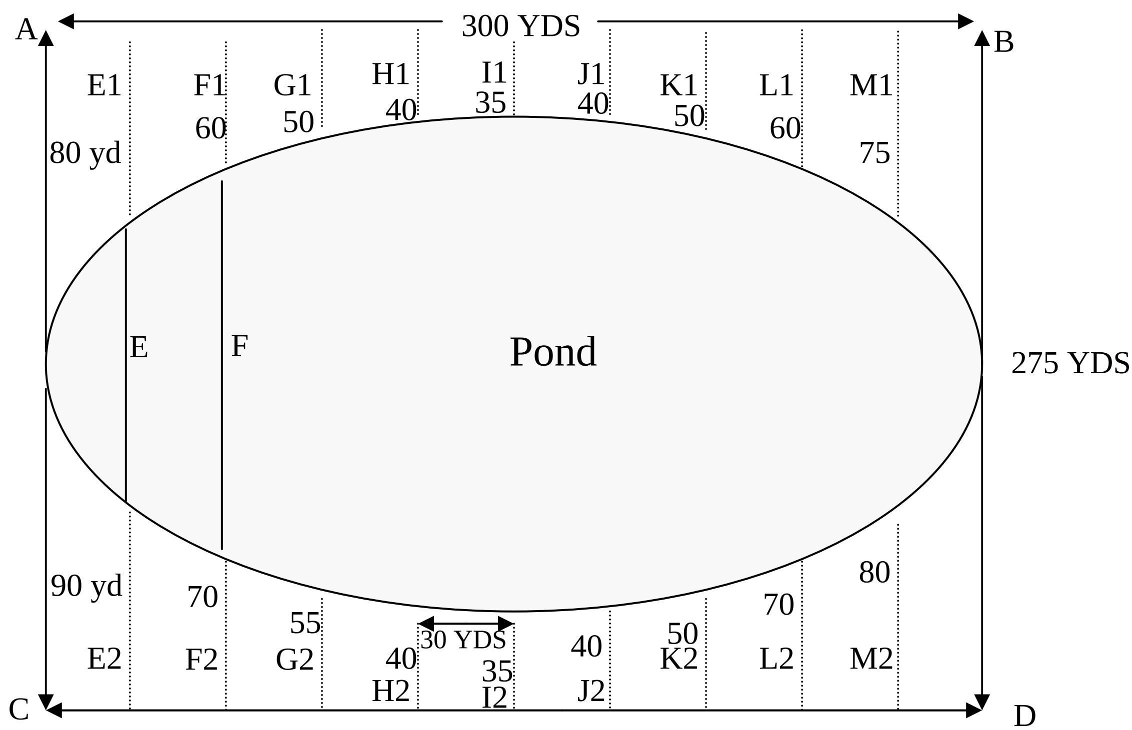
A+B+C+D+E+F+G+H+I+J+K = 1015 yds

1015 yds * 30 yds = 30,450 square yds

30,450 sq yds * 9 sq. ft/sq yd = 274,050 sq ft

$$\frac{274{,}050 \text{ sq ft}}{43{,}560 \text{ sq ft/acre}} = 6.3 \text{ acres}$$

Modified Offset Method For Determining Area



AB = 300 YDS
AC = 275 YDS
300 * 275 = 82,500 sq yds

E1 = 80, E2 = 90
275 – (80+90) = 105

F1 = 60, F2 = 70
275 – (60+70) = 145

etc

E = 105
F = 145
G = 170
H = 195
I = 205

J = 195
K = 175
L = 145
M = 120

105+145+170+195+205+195+175+145+120 = 1,455 yds

1,455 yds * 30 yds (offset) = 43,650 sq yds

43,650 sq yds * 9 sq ft/sq yd = 392,850 sq ft

$$\frac{392{,}850 \text{ sq ft}}{43{,}560 \text{ sq ft/acre}} = 9.0 \text{ acres}$$