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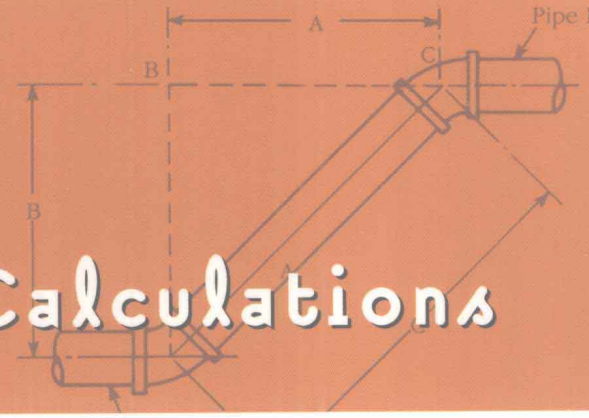

Plumber's and Pipe Fitter's Calculations Manual

Second Edition

R. DODGE WOODSON

- Estimating takeoffs included
- Greater focus on quick reference information
- Highlighted with Fast Code Facts, and Sensible Shortcut boxes to enhance ease of use

PLUMBER'S AND PIPE FITTER'S CALCULATIONS MANUAL

R. Dodge Woodson

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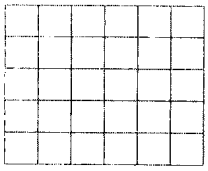
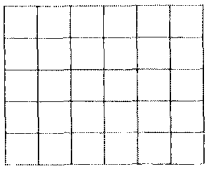


DEDICATION

I dedicate this book to Adam, Afton, and Victoria in appreciation for their patience during my writing time.



PREFACE

This book is your ticket to smooth sailing when it comes to doing the math for plumbing and pipe fitting. Most of the work is already done for you when you consult the many tables and references contained in these pages. Why waste time with calculators and complicated mathematical equations when you can turn to the ready-reference tables here and have the answers at your fingertips? There is no reason to take the difficult path when you can put your field skills to better use and make more money.

A few words of advice are needed here. Our country uses multiple plumbing codes. Every code jurisdiction can adopt a particular code and amend it to their local needs. It is impossible to provide one code source to serve every plumber's needs. The code tables in this book are meant to be used as representative samples of how to arrive at your local requirements, but they are not a substitution for your regional code book. Always consult your local code before installing plumbing.

The major codes at this time are the International Plumbing Code and the Uniform Plumbing Code. Both are excellent codes. There have been many code developments in recent years. In addition to these two major codes, there are smaller codes in place that are still active. I want to stress that this is not a handbook to the plumbing code; this is a calculations manual. If you are interested in a pure code interpretation, you can review one of my other McGraw-Hill books entitled: *International and Uniform Plumbing Codes Handbook.*

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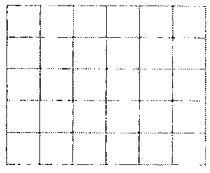
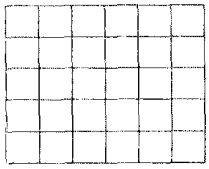


ABOUT THE AUTHOR

R. Dodge Woodson is a master plumber who lives in Maine and runs the plumbing, construction, and remodeling company The Masters Group, Inc. He has worked in the plumbing trade for 30 years and has written numerous books on plumbing. He has also been an instructor for the Central Maine Technical College for classes in code interpretation and apprenticeship.



INTRODUCTION

Are you a plumber or pipe fitter who dislikes doing the math that is required in your trade? If so, this book may be one of the best tools that you can put in your truck or office. Why? Because it does much of the math calculations for you. That's right, the tables and visual graphics between these pages can make your life much easier and more profitable.

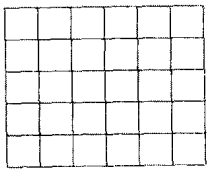
R. Dodge Woodson, the author, is a 30-year veteran of the trade who has been in business for himself since 1979. He knows what it takes to win in all financial climates as both a business owner and tradesman. This is your chance to learn from an experienced master plumber and, what is even better, you don't have to study and memorize formulas. All you have to do is turn to the section of this professional reference guide that affects your work and see the answers to your questions in black and white. How much easier could it be?

Mathematical matters are not the only treasures to be found here. You will find advice on how to comply with the plumbing code quickly, easily, and without as much thought on your part.

The backbone of this book is math for the trades, but there is much more. There is a section on troubleshooting that is sure to save you time, frustration, and money. Find out what you may need to know about septic systems. In addition to phase-specific math solutions, there is an appendix that is full of reference and conversion tables for day-to-day work situations.

Take a moment to scan the table of contents. You will see that the presentation of material here is compiled in logical, accessible, easy-to-use chapters. Flip through the pages and notice the tip boxes and visual nature of the information offered. You don't have to read much, but you will find answers to your questions.

If you are looking for a fast, easy, profitable way to avoid the dense reading and complicated math that is needed in your trade, you have found it. Once you put this ready reference guide at your fingertips, you will be able to concentrate on what you do best without the obstacles that may steal your time and your patience. Packed with 30 years of experience, you can't go wrong by using Woodson's resources to make you a better tradesman.



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chapter 1

GENERAL TRADE MATHEMATICS

Math is not always a welcome topic among tradespeople. As much as math may be disliked, it plays a vital role in the trades, and plumbing and pipe fitting are no exceptions. In fact, the math requirements for some plumbing situations can be quite complicated. When people think of plumbers, few thoughts of scholarly types come to mind. I expect that most people would have trouble envisioning a plumber sitting at a drafting table and performing a variety of mathematical functions involving geometry, algebra, and related math skills. Yet, plumbers do use high-tech math in their trade, sometimes without realizing what they are doing.

Think about your last week at work. Did you work with degrees of angles? Of course you did. Every pipe fitting you installed was an example of angles. Did you grade your drainage pipe? Sure you did, and you used fractions to do it. The chances are good that you did a lot more math than you realized. But, can you find the volume of a water heater if the tank is not marked for capacity? How much water would it take to fill up a 4-inch pipe that is 100 feet long? You might need to know if you are hauling the water in for an inspection test of the pipe. How much math you use on a daily basis is hard to predict. Much of the answer would depend on the type of work you do within the trade. But, it's safe to say that you do use math on a daily basis.

I've taught a number of classes for plumbers and plumbing apprentices. Math is usually the least appreciated part of those classes. Experience has showed me that students resist the idea of learning math skills. I remember when I took academic levels of math in school and thought that I'd never use it. Little did I know back then how valuable the skills I was learning would be.

been there **done that**

I was horrible with math in school. It was not until dollar signs were put in front of numbers that I understood math. When I entered the plumbing trade, I had no idea that I was doing a lot of math. If an employer had told me that math was a requirement for plumbers, I might not have devoted most of my adult life to the trade. Plumbing math doesn't seem like math, but it is serious math. Don't be afraid of it.

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A or a	Area, acre
AWG	American Wire Gauge
B or b	Breadth
bbl	Barrels
bhp	Brake horsepower
BM	Board measure
Btu	British thermal units
BWG	Birmingham Wire Gauge
B & S	Brown and Sharpe Wire Gauge (American Wire Gauge)
C of g	Center of gravity
cond	Condensing
cu	Cubic
cyl	Cylinder
D or d	Depth, diameter
dr	Dram
evap	Evaporation
F	Coefficient of friction; Fahrenheit
F or f	Force, factor of safety
ft (or ')	Foot
ft lb	Foot pound
fur	Furlong
gal	Gallon
gi	Gill
ha	Hectare
H or h	Height, head of water
HP	horsepower
IHP	Indicated horsepower
in (or ")	Inch
L or l	Length
lb	Pound
lb/sq in.	Pounds per square inch
mi	Mile
o.d.	Outside diameter (pipes)
oz	Ounces
pt	Pint
P or p	Pressure, load
psi	Pounds per square inch
R or r	Radius
rpm	Revolutions per minute
sq ft	Square foot
sq in.	Square inch
sq yd	Square yard
T or t	Thickness, temperature
temp	Temperature
V or v	Velocity
vol	Volume
W or w	Weight
W. I.	Wrought iron

FIGURE 1.1 ■ Abbreviations. (*Courtesy of McGraw-Hill*)

While I'm not a rocket scientist, I can take care of myself when it comes to doing math for trade applications.

I assume that your time is valuable and that you are not interested in a college course in mathematics by the end of this chapter. We're on the same page of the playbook. I'm going to give you concise directions for solving mathematical problems that are related to plumbing and pipefitting. We won't be doing an in-depth study of the history of numbers, or anything like that. The work we do here will not be too difficult, but it will prepare you for the hurdles that you may have to clear as a thinking plumber. So, let's do it. The quicker we start, the quicker we can finish.

BENCHMARKS

Before we get into formulas and exercises, we need to establish some benchmarks for what we will be doing. It always helps to understand the terminology being used in any given situation, so refer to Figure 1.1 for reference to words and terms being used as we move forward in this chapter. The information in Figure 1.2 shows you some basic formulas that can be applied

Circumference of a circle = π × diameter or 3.1416 × diameter

Diameter of a circle = circumference × 0.31831

Area of a square = length × width

Area of a rectangle = length × width

Area of a parallelogram = base × perpendicular height

Area of a triangle = ½ base × perpendicular height

Area of a circle = π radius squared or diameter squared × 0.7854

Area of an ellipse = length × width × 0.7854

Volume of a cube or rectangular prism = length × width × height

Volume of a triangular prism = area of triangle × length

Volume of a sphere = diameter cubed × 0.5236 (diameter × diameter × diameter × 0.5236)

Volume of a cone = π × radius squared × ⅓ height

Volume of a cylinder = π × radius squared × height

Length of one side of a square × 1.128 = the diameter of an equal circle

Doubling the diameter of a pipe or cylinder increases its capacity 4 times

The pressure (in lb/sq in.) of a column of water = the height of the column (in feet) × 0.434

The capacity of a pipe or tank (in U.S. gallons) = the diameter squared (in inches) × the length (in inches) × 0.0034

1 gal water = 8½ lb = 231 cu in.

1 cu ft water = 62½ lb = 7½ gal

FIGURE 1.2 ■ Useful formulas. (*Courtesy of McGraw-Hill*)

Sine	$\sin = \frac{\text{side opposite}}{\text{hypotenuse}}$
Cosine	$\cos = \frac{\text{side adjacent}}{\text{hypotenuse}}$
Tangent	$\tan = \frac{\text{side opposite}}{\text{side adjacent}}$
Cosecant	$\csc = \frac{\text{hypotenuse}}{\text{side opposite}}$
Secant	$\sec = \frac{\text{hypotenuse}}{\text{side adjacent}}$
Cotangent	$\cot = \frac{\text{side adjacent}}{\text{side opposite}}$

FIGURE 1.3 ■ Trigonometry. ***(Courtesy of McGraw-Hill)***

sensible shortcut

You don't have to do the math if you have reliable tables to use when arriving at a viable answer for mathematical questions. The types of tables that you need to limit your math requirements are available in this book.

to many mathematical situations. Trigonometry is a form of math that can send some people in the opposite direction. Don't run, it's not that bad. Figure 1.3 provides you with some basics for trigonometry, and Figure 1.4 describes the names of shapes that contain a variety of sides. Some more useful formulas are provided for you in Figure 1.5. Just in what I've provided here, you are in a much better position to solve mathematical problems. But, you probably want, or need, a little more explanation of how to use your newfound resources. Well, let's do some math and see what happens.

Pentagon	5 sides
Hexagon	6 sides
Heptagon	7 sides
Octagon	8 sides
Nonagon	9 sides
Decagon	10 sides

FIGURE 1.4 ■ Polygons. ***(Courtesy of McGraw-Hill)***

Parallelogram	Area = base × distance between the two parallel sides
Pyramid	Area = ½ perimeter of base × slant height + area of base
	Volume = area of base × ⅓ of the altitude
Rectangle	Area = length × width
Rectangular prism	Volume = width × height × length
Sphere	Area of surface = diameter × diameter × 3.1416
	Side of inscribed cube = radius × 1.547
	Volume = diameter × diameter × diameter × 0.5236
Square	Area = length × width
Triangle	Area = one-half of height times base
Trapezoid	Area = one-half of the sum of the parallel sides × the height
Cone	Area of surface = one-half of circumference of base × slant height + area of base
	Volume = diameter × diameter × 0.7854 × one-third of the altitude
Cube	Volume = width × height × length
Ellipse	Area = short diameter × long diameter × 0.7854
Cylinder	Area of surface = diameter × 3.1416 × length + area of the two bases
	Area of base = diameter × diameter × 0.7854
	Area of base = volume ÷ length
	Length = volume ÷ area of base
	Volume = length × area of base
	Capacity in gallons = volume in inches ÷ 231
	Capacity of gallons = diameter × diameter × length × 0.0034
	Capacity in gallons = volume in feet × 7.48
Circle	Circumference = diameter × 3.1416
	Circumference = radius × 6.2832
	Diameter = radius × 2
	Diameter = square root of = (area ÷ 0.7854)
	Diameter = square root of area × 1.1233

FIGURE 1.5 ■ Area and other formulas. (*Courtesy of McGraw-Hill*)

PIPING MATH

This section will profile formulas that can help you when working with pipes. Rather than talk about them, let's look at them.

What plumber hasn't had to figure the grading for a drainage pipe? Determining the amount of fall needed for a drainpipe over a specified distance is no big mystery. Yet, I've known good plumbers who had trouble with calculating the grade of their pipes. In fact, some of them were so unsure of themselves that they started at the end of their runs and worked backwards, to the beginning, to insure enough grade. Not only is this more difficult and time consuming, there is still no guarantee that there will be enough room for the grade. Knowing how to figure the grade, fall, pitch, or whatever you want to call it, for a pipe is essential in the plumbing trade. And, it's not difficult. Let me show you what I mean.

☑ *fast code* **fact**

As a rule of thumb, most codes require a minimum of one-quarter of an inch per foot of fall for drainage piping. There are exceptions. For example, large-diameter pipes may be installed with a minimum grade of one-eighth of an inch per foot. Too much grade is as bad as too little grade. A pipe with excessive grade will empty liquids before solids have cleared the pipe. Maintain a constant grade within the confines of your local plumbing code.

In a simple way of putting it, assume that you are installing a pipe that is 20 feet long and that will have a grade of ¼-inch per foot. What will the drop from the top of the pipe be from one end to the other? At a grade of ¼-inch per foot, the pipe will drop one inch for every four feet it travels. A 20-foot piece of pipe will require a 5-inch drop in the scenario described. By dividing 4 into 20, I got an answer of 5, which is the number of inches of drop. That's my simple way of doing it,

The capacity of pipes is as the square of their diameters. Thus, doubling the diameter of a pipe increases its capacity four times. The area of a pipe wall may be determined by the following formula:

$$\text{Area of pipe wall} = 0.7854 \times [(\text{o.d.} \times \text{o.d.}) - (\text{i.d.} \times \text{i.d.})]$$

FIGURE 1.6 ■ Piping. (*Courtesy of McGraw-Hill*)

The approximate weight of a piece of pipe may be determined by the following formulas:

Cast-iron pipe: weight = $(A^2 - B^2) \times \text{length} \times 0.2042$
Steel pipe: weight = $(A^2 - B^2) \times \text{length} \times 0.2199$
Copper pipe: weight = $(A^2 - B^2) \times \text{length} \times 0.2537$
A = outside diameter of the pipe in inches
B = inside diameter of the pipe in inches

FIGURE 1.7 ■ Determining pipe weight. (*Courtesy of McGraw-Hill*)

The formula for calculating expansion or contraction in plastic piping is:

$$L = Y \times \frac{T - F}{10} \times \frac{L}{100}$$

L = expansion in inches
Y = constant factor expressing inches of expansion per 100°F temperature change per 100 ft of pipe
T = maximum temperature (°F)
F = minimum temperature (°F)
L = length of pipe run in feet

FIGURE 1.8 ■ Expansion in plastic piping. (*Courtesy of McGraw-Hill*)

The formulas for pipe radiation of heat are as follows:

$$L = \frac{144}{OD \times 3.1416} \times R \div 12$$

D = outside diameter (OD) of pipe
L = length of pipe needed in feet
R = square feet of radiation needed

FIGURE 1.9 ■ Formulas for pipe radiation of heat. (*Courtesy of McGraw-Hill*)

but now let me give you the more proper way of doing it with a more sophisticated formula.

If you are going to use the math formula, you must know the terms associated with it. Run is the horizontal distance that the pipe you are working with will cover, and this measurement is shown as the letter R. Grade is the slope of the pipe and is figured in inches per foot. To define grade in a formula, the letter G is used. Drop is the amount down from level or in more plumber-friendly words, it's the difference in height from one end of the pipe to the other. As you might guess, drop is known by the letter D. Now let's put this into a formula. To determine grade with the formula above, you would be looking at something like this: $D = G \times R$. If you know some of the variables, you can find the rest. For example, if you know how far the pipe has to run and what the maximum amount of drop can be, you can determine the grade. When you know the grade and the length of the run, you can determine the drop. I already showed you how to find the drop if you know grade and run numbers. So, let's assume an example where you know that the drop is 15 inches and the run is 60 feet, what is the grade? To find the answer, you divide the drop by the run, in this case you are dividing 15 by 60. The answer is .25 or 1/4-inch per foot of grade.

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