Basic Math for Water and Wastewater Operators

Course # 1001

Fleming Training Center

March 11-15, 2013

TDEC
TENNESSEE DEPARTMENT OF ENVIRONMENT AND CONSERVATION

http://www.tn.gov/environment/fleming/

BASIC MATH FOR WATER & WASTEWATER OPERATORS

COURSE #1001
MARCH 11-15, 2012

Monday, March 11

8:30 am	Solving Math Problems; Use of Calculator	Amanda Carter
10:00	Fractions, Decimals, Percents, Averages	Amanda
11:00	Lunch	
12:00 pm	Powers, Roots, and Scientific Notation	Amanda
1:00	Solving for the Unknown Value	Amanda

Tuesday, March 12

8:30 am	Solving for the Unknown Value	Amanda
11:00	Lunch	
12:00 pm	Ratios and Proportions	Amanda
1:00	Metric System/Temperature	Amanda

Wednesday, March 13

8:30 am	Dimensional Analysis, Conversions	Amanda
12:00	Lunch	
1:00 pm	Length, Area, and Volume	Amanda

Thursday, March 14

8:30 am	Velocity and Flow Calculations	Amanda
12:00	Lunch	
1:00 pm	Review	Amanda

Friday, March 15

8:30 am	Course Evaluation and Exam	Amanda

Fleming Training Center

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Section 1

Math Strategies and Calculator Review

Calculator Review

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2nd, SHIFT, or FUNC key
Instructs the calculator to use the 2nd function. The function written above the key.

CE/C, or CLEAR key
Pressed once during a number entry will clear the display.
Pressed twice during a number entry will clear the display and all previous operations.

ON, or ON/C key
Turns the calculator on.

÷ Division key
Performs division

x Multiplication key
Performs multiplication

- Subtraction key
Performs subtraction

+ Addition key
Performs addition

= Equals key
Performs all pending operations

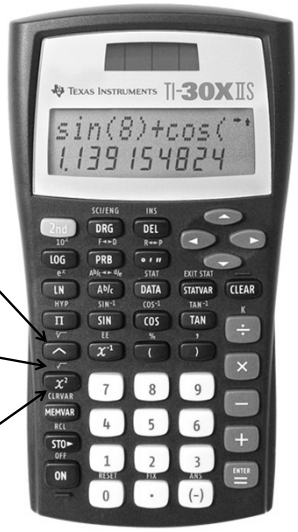
π the pi key
Enters the value of pi with as many decimals as the calculator can display.
3.141592654

EE or Enter Exponent key
This key uses the scientific notation mode.
Sometimes you may see a number like 6.945_{10} or 5.31_{-4}
They would be written out long hand as
69,450,000,000
0.000531
You can use EE to get scientific notation into the longhand.
1.23_{4} = 1.23 EE 4 = 12300
5.73_{-3} = 5.73 EE-3 = 0.00573

^ key
This key will take a number to another power.
9^3 = 9 x 9 x 9 = 729
Nine cubed or nine to the third power is 729.
2^ 5 = 2 x 2 x 2 x 2 x 2 = 32
Two to the fifth power is 32.

√ or Square Root key
This key will take the square root of a number.
√144 = 12
√9 = 3
On this calculator you must push the 2nd key and then the X^2 key to use this function.

X^2 key or Square key
This key takes a number and squares it. The number times itself.
5^2 = 5 x 5 = 25



LOG key
Takes the Base 10 logarithim of a number
LOG 100 = 2
LOG10,000 = 4
LOG 200 = 2.30

% , or Percent key
This key divides the displayed value by 100 showing it's decimal form.
50 (%) = .5
250 x 5 (%) = 12.5
On this calculator you must press 2nd and then (to use this function.

Math Problem Strategies

Use these rules of operation to approach math problems (*especially when working with formulas*):

1) Work from left to right.
2) Do all the work inside the parentheses first.
3) Do all the multiplication/division above the line (numerator) and below the line (denominator).
4) Then do all the addition and subtraction above and below the line.
5) Perform the division (divided the numerator by the denominator).

Calculator Review Problems

Solve the following equations

1. 4 ÷ 18 +236 =
2. 53.867 + 243.1234 =
3. 98.12-64.5 =
4. (48) (643) (210) =
5. 47 ÷ 6.4 =
6. 5 +231 x 15 =

Convert Scientific notation into long hand

1. 1.478×10^{8} =
2. 3.45×10^{5} =
3. 7.66×10^{-4} =
4. 5.4876×10^{-3} =

Use ^, x^2 and √ functions

1. 16^2 =
2. 47^4 =
3. 9^3 =
4. √169 =
5. √52.6 =

Convert percent to decimal

1. 42% =
2. 0.07% =
3. 19% =
4. 30.94% =

Find the LOG of the following numbers

1. 1000 =
2. 234=
3. 600 =

Answers

1. 236.22
2. 296.9904
3. 33.62
4. 6,481,440
5. 7.34
6. 3470

1. 147,800,000
2. 345,000
3. 0.000766
4. 0.0054876

1. 256
2. 4,879,681
3. 729
4. 13
5. 7.25

1. 0.42
2. 0.0007
3. 0.19
4. 0.3094

1. 3
2. 2.37
3. 2.78

Section 2

Fractions, Decimals, and Percents

Fractions, Decimals, Percents and Averages

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Fractions

- Fractions were developed thousands of years ago so that portions of a whole object could be counted, recorded and perhaps be shared equally.

Fractions

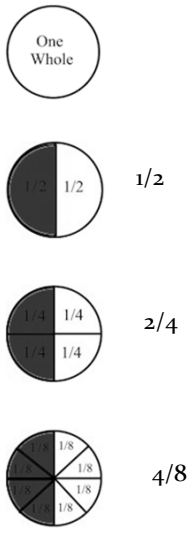
$$\frac{3}{10}$$

Division line

- The **numerator** is the number above the division line. The numerator indicates how many parts of the whole object are being considered.
- The **denominator** gives the name of the fraction. It tells how many equal parts that the whole object has been divided into.

Equivalent Fractions

- The best way to think about equivalent fractions is that they are fractions that have the **same overall value**. Equivalent fractions represent the same part of **a whole**.
- ½, 2/4, and 4/8 are equivalent fractions.
- To determine if fractions are equivalent, cross multiply.



Are these two fractions equivalent fractions? $\frac{3}{4} = \frac{9}{12}$

$\frac{3}{4} = \frac{9}{12}$

Only if...

$3 \times 12 = 4 \times 9$

Check...

$36 = 36$

Take the two fractions and set them up side by side. Multiply the numbers that are diagonal from one another.
3 is diagonal from 12
4 is diagonal from 9

Compare the results of the two multiplications.
If the numbers are the same they are equivalent fractions.

Reducing Fractions

$\frac{9}{12}$ $9 \div 3 = 3$ $12 \div 3 = 4$ $\frac{3}{4}$

- It is easier to work with fractions that have small numbers in the numerator and denominator.
- To reduce a fraction you must find a number that will divide evenly into both the numerator and the denominator, then divide by that number.
- Then write the reduced numerator over the reduced denominator

Decimals

000.1000

Tenth

Hundredth

Thousandth

- The word decimal comes from the Latin *decem* which means ten.
- This is also where we get the name of the month December which was the tenth month in the Roman calendar.
- The decimal system is based on the number ten and multiples of ten.

Converting Fractions to Decimals

- To convert fractions into decimals simply divide the numerator by the denominator.
- ½ (1 ÷ 2) = 0.5
- 10/13 (10 ÷ 13) = 0.7692
- 43/100 (43 ÷ 100) = 0.43

Converting Decimals to Fractions

- The entire number goes in the numerator, disregarding the decimal point.
- The denominator is determined by how many decimal places to the right the number goes.
- 0.56 = 56/100
- 0.5 = 5/10
- Reduce the fraction if possible
- 56/100 =14/25
- 5/10 = 1/2

Percents

$\frac{30}{100} = 30\%$

$\frac{85}{100} = 85\%$

$\frac{0.5}{100} = 0.5\%$

- The word percent comes from the Latin phrase *per centum,* which means per hundred.
- In mathematics, we use the symbol, %, for percent.
- Percents are ratios with 100 in the denominator

Changing Percents into Fractions

$33\% = \frac{33}{100}$

$75\% = \frac{75}{100}$

$\frac{75}{100} \frac{(75 \div 25)}{(100 \div 25)} = \frac{3}{4}$

- To convert percents into fractions, simply write the number over 100 and drop the % symbol.
- Reduce the fraction if possible.

Changing Percents into Decimals

$45\% = \frac{45}{100} = 0.45$

$23\% = 0.23 = 0.23$

2 1

Move left

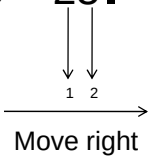
- To change percents into decimals, divide the number by 100 and drop the percent sign.
- Or, move the decimal 2 places to the left and drop the percent sign.

Changing Decimals into Percents

- To convert a decimal into a percent, multiply by 100, add the percent symbol.
- Or, you can take the decimal two places to the right and add the percent symbol.

$0.53 = (0.53 \times 100) = 53\%$

$0.25 = 25. = 25\%$



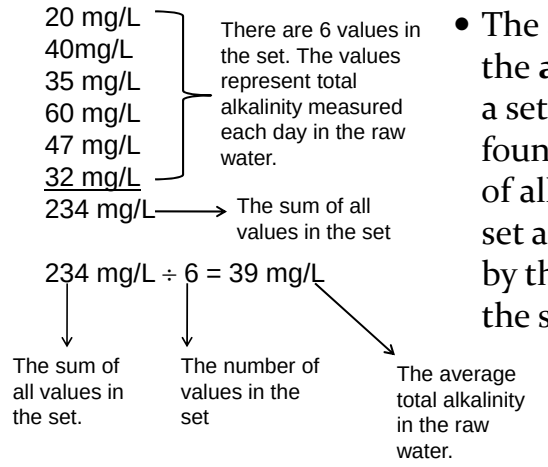
Percents: Word Problems

Word	Math Symbol
of	multiply (x)
is	equal to (=)
what	unknown (N)
find	N =

- What is 5% of 400?

N = 5% x 400
N = 0.05 x 400
N= 20

Averages



- The **average,** also called the **arithmetic mean,** for a set of numbers can be found by taking the **sum** of all the numbers in the set and dividing the sum by the number of values in the set.

Fractions, Decimals, Percents and Averages

Are the following fractions equivalent? (Circle your answer.)

1. $\frac{3}{4} = \frac{75}{100}$ Y or N

2. $\frac{15}{32} = \frac{10}{25}$ Y or N

3. $\frac{5}{6} = \frac{20}{36}$ Y or N

Reduce the fractions to simplest terms.

4. a) $\frac{10}{30} =$ b) $\frac{9}{27} =$ c) $\frac{25}{200} =$ d) $\frac{4}{32} =$

5. a) $\frac{6}{8} =$ b) $\frac{16}{20}$ c) $\frac{15}{25} =$ d) $\frac{72}{81} =$

6. a) $\frac{7}{19} =$ b) $\frac{132}{352} =$ c) $\frac{17}{30} =$ d) $\frac{16}{52} =$

7. a) $\frac{9}{16} =$ b) $\frac{10}{56} =$ c) $\frac{12}{144} =$ d) $\frac{5}{60} =$

Convert the following fractions into decimals.

8. a) $\frac{3}{5} =$ b) $\frac{9}{13} =$ c) $\frac{7}{4} =$ d) $\frac{1}{3} =$

9. a) $\frac{5}{6}$ = b) $\frac{17}{53}$ = c) $\frac{2}{5}$ = d) $\frac{13}{169}$ =

10. a) $\frac{9}{3}$ = b) $\frac{16}{56}$ = c) $\frac{11}{15}$ = d) $\frac{4}{9}$ =

11. a) $\frac{1}{4}$ = b) $\frac{6}{2}$ = c) $\frac{22}{100}$ = d) $\frac{33}{99}$ =

Convert the following decimals into fractions in lowest terms.

12. 0.98 =

13. 0.516 =

14. 1.23 =

15. 0.84 =

16. 7.5 =

Change the following percents into fractions in lowest terms.

17. 33% =

18. 12% =

19. 45% =

20. 75% =

21. 110% =

22. 0.5% =
23. 16.3% =

24. 25% =

25. 100% =

26. 30.4% =

Change the following percents into decimals.

27. 16% =

28. 75% =

29. 20% =

30. 0.07% =

31. 120% =

32. 88.7% =

Change the following decimals into percents.

33. 0.531 =

34. 0.66 =

35. 1.21 =

36. 0.08 =

37. 19.5 =

38. 0.406 =

39. 11.0 =

40. 1.0 =

41. 0.278 =

Solve the following word problems.

42. What is 10% of 55?

43. What is 15% of 125?

44. 50% of 840 is what?

45. What is 7% of 1125?

46. 110% of 50 is what?

47. 50 is what % of 300?

48. 29 is what % of 200?

49. What is 5% of 10.7?

50. 20 is what % of 110?

51. 15 is what % of 40?

52. 10 is what % of 5?

53. 28% of what is 53?

54. 292 is what % of 2952?

55. 68% of 2140 is how much?

56. 9 is what percent of 48?

57. 219 is what percent of 302?

58. 167 is 4% of what number?

59. You need to disinfect a 300,000 gallon storage tank. The method you are using calls for you to dose 5% of the tank volume with 50 mg/L chlorine. What is 5% of 300,000 gallons?

Find the arithmetic mean (average) of the following sets of values.

60. What is the high temperature of the week in ^{o}C? (Data for seven days : 21^{o}C, 25.2^{o}C, 19^{o}C, 22^{o}C, 20^{o}C, 19.4^{o}C, and 20.1^{o}C)

61. What was the average chlorine residual measured in the distribution system? (0.2 mg/L, 0.7 mg/L, 0.5 mg/L, 0.8 mg/L, 1.2 mg/L)

62. What is the average weight of a 1 L volumetric flask? (700 g, 701 g, 698 g, 690 g, 704 g, 697 g, 705 g)

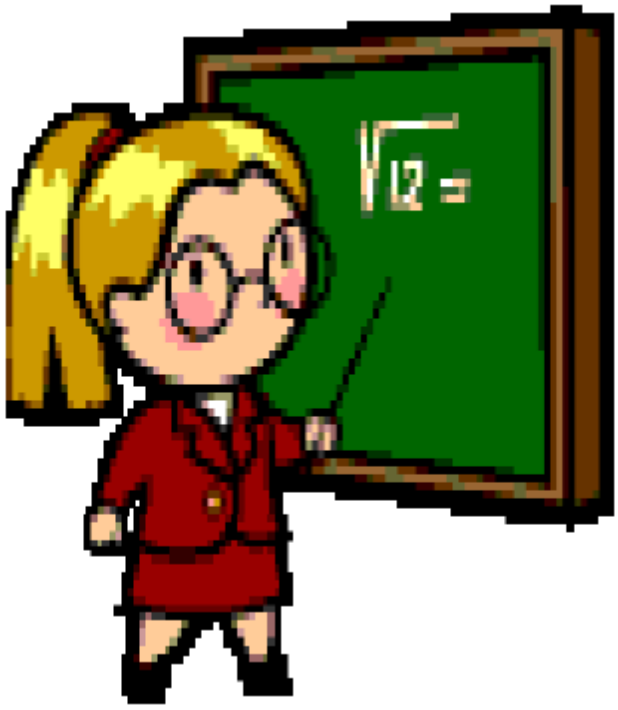
63. What was the average flow for the year in MGD through the Randyville Wastewater Plant? (Jan = 1.32 MGD, Feb=1.21 MGD, Mar=1.5 MGD, Apr=1.6 MGD, May=1.95 MGD, June=1.8 MGD, July=1.7 MGD, Aug=1.65 MGD, Sep=1.5 MGD, Oct=1.25 MGD, Nov=1.6 MGD, Dec=1.92 MGD)

Answers

1. Yes	2. No	3. No		
4. a) 1/3	b) 1/3	c) 1/8	d) 1/8	
5. a) 3/4	b) 4/5	c) 3/5	d) 8/9	
6. a) 7/19	b) 3/8	c) 17/30	d) 4/13	
7. a) 9/16	b) 5/28	c) 1/12	d) 1/12	
8. a) 0.6	b) 0.69	c) 1.75	d) 0.33	
9. a) 0.83	b) 0.32	c) 0. 4	d) 0.08	
10. a) 3	b) 0.29	c) 0.73	d) 0.44	
11. a) 0.25	b) 3	c) 0.22	d) 0.33	
12. 49/50	13. 129/250	14. 123/100	15. 21/25	16. 15/2
17. 33/100	18. 3/25	19. 9/20	20. 3/4	21. 11/10
22. 1/200	23. 163/1000	24. 1/4	25. 1	26. 38/125
27. 0.16	28. 0.75	29. 0.20	30. 0.0007	31. 1.2
32. 0.887				
33. 53.1%	34. 66%	35. 121%	36. 8%	37. 1950%
38. 40.6%	39. 1100%	40. 100%	41. 27.8%	
42. 5.5	43. 18.75	44. 420	45. 78.75	46. 55
47. 16.67%	48. 14.5%	49. 0.535	50. 18.2%	51. 37.5%
52. 200%	53. 189.29	54. 9.9%	55. 1455.2	56. 18.75%
57. 72.5%	58. 4175	59. 15,000 gal		
60. 20.96^{o}C	61. 0.68 mg/L	62. 699.3g	63. 1.58 MGD	

Section 3

Powers, Roots and Scientific Notation



Powers, Roots, and Scientific Notation

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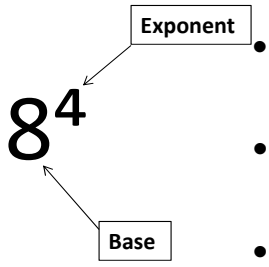
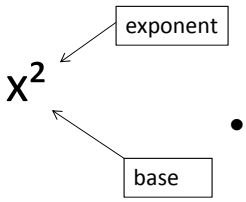
Powers



(8) (8) (8) (8) = 4096

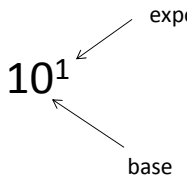
- An expression such as 8^4 is called a **power**.
- It is read as 8 to the fourth power.
- The **exponent** indicates how many times a number is to be multiplied together.
- The **base** is the number that is being multiplied.

Powers



$x^2 = (x)\,(x)$

- The same consideration can be applied to letters as well.



$(10) = 10$

- Any number that is not written with an exponent is considered to have an exponent of 1.

Powers

$7^0 = 1$
$4^0 = 1$
$x^0 = 1$

- Any number that has an exponent of 0 is equal to one.

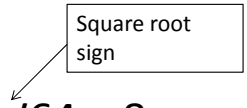
$3^{-2} = \frac{1}{3^2}$

$\frac{1}{(3)\,(3)}$

0.111

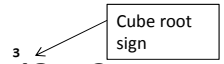
- Any number that has a negative exponent can be inverted and written with a positive exponent.

Roots



$\sqrt{64} = 8$

$(8)(8) = 64$

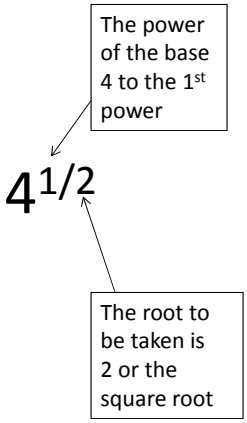


$\sqrt[3]{8} = 2$

$(2)(2)(2) = 8$

- A **root** is a number that when multiplied together two or more times, equals the original number.
- A **square root** is a number that which when multiplied together 2 times, equals the original number.
- A **cube root** is a number that when multiplied together 3 times, equals the original number

Roots



$4^{1/2}$

$4^{1/2} = \sqrt[2]{4^1}$

$= \sqrt{4}$

$= 2$

- Fractional exponents indicate that a root is to be taken.
- The numerator of the fractional exponent is the power of the base.
- The denominator of a fractional exponent is the root to be taken.

Calculators and Powers and Roots

^ key

Takes a number to a power.
For example , if you want to know what 7^9 is you would type in 7 ^ key 9 =

x^2 key

Squares the number. Takes the number and multiplies it by itself.
For example if you want to know what 54^2 is you would type in 54 x^2 key =

Calculators and Powers and Roots

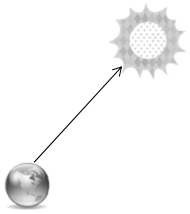
√ key

Takes the square root of a number.
For example to find the √144
Type √ then 144 =
On this calculator, it's a second function
Type 2nd then x^2 then 144

$\sqrt[x]{}$ key

Takes any root of a number.
For example, to find the $\sqrt[3]{8}$
Type 3 then $\sqrt[x]{}$ then 8 =
On this calculator, it's the second function.
Type 3 then2nd then ^ then 8 =

Scientific Notation



Scientists (and operators) often work with numbers that are very large or very small.

For example the distance from Earth to the sun.

149,476,000 km

The mass of an atom in grams

0.000000000000000000000000166 g

Or flow through a Tennessee water plant in gallons per day

6,301,000 gpd

Scientific Notation

- Scientific Notation is a method of writing large and small numbers with out all the zeros.
- The number is written multiplied by a power of 10.
- To write a large number move the decimal place to the left until there is only one number to the left of the decimal.
- The resulting number is multiplied by a power of 10, (positive exponent) equal to the number of decimal places moved.

$6{,}301{,}000. = 6.301 \times 10^{6}$

6 places

Original position of the decimal point

Positive exponent

Scientific Notation

- Small numbers are changed in the same way but in the opposite direction.
- The number is written multiplied by a power of 10, but a negative exponent.
- To write a small number move the decimal place to the right until there is only one number to the left of the decimal.
- The resulting number is multiplied by a power of 10, (negative exponent) equal to the number of decimal places moved.

$0.0000562 = 5.62 \times 10^{-5}$

5 places

Original position of decimal

Negative exponent

Scientific Notation

- Taking numbers out of scientific notation.
- To take a number out of scientific notation simply multiply the number by the power of 10 that is indicated.

$4.56 \times 10^{6} =$
$4.56 \times (10)(10)(10)(10)(10)(10)$
$4.56 \times 1{,}000{,}000 = 4{,}560{,}000$

$1.54 \times 10^{-3} =$
$1.54 \times 1/(10)(10)(10)$
$1.54 \times 1/1000$
$1.54 \times 0.001 = 0.00154$

Calculators and Scientific Notation

SCI/ENG mode key
If you want to get numbers into Scientific Notation.
Press 2nd then this key. A menu with three options FLO or NORM, SCI, and ENG will appear.
Choose SCI to go into Scientific Notation.

EE or Enter Exponent key
This key uses the scientific notation mode.
You can use EE to get scientific notation into the longhand.
1.23_4 = 1.23 EE 4 = 12300
5.73_{-3} = 5.73 EE-3 = 0.00573

Powers, Roots and Scientific Notation Practice Problems

Write the following numbers in expanded form as factors.

1. 6^2 _____

2. 10^4 _____

3. x^3 _____

4. 5^0 _____

5. 13^6 _____

6. D^2 _____

7. 8^1 _____

8. 14^4 _____

Write the following numbers using exponential notation.

9. (4) (4) (4) _____

10. (x) (x) (x) (x) _____

11. (9) (9) _____

12. (16) (16) (16) (16) (16) _____

13. (2)(2)(2)(2)(2) _____

14. (D) (D) (D) _____

15. (8) _____

16. (2)(2) (3)(3) (3) _____

Solve the following problems.

17. (0.785) (4^2) =_____

18. (2^2) (3^4) = _____

19. (36) (14) (2^3) =_____

20. (5^3) * (2^3) = _____

Write the following in radical form. (fractional exponents into $\sqrt{x}$)

21. $144^{1/2}$ = _____

22. $27^{1/3}$ = _____

Write the following numbers in exponent form ($\sqrt{x}$ into fractional exponents).

23. $\sqrt{450}$ = _____

24. $\sqrt[3]{27}$ = _____

Complete the following problems.

25. $144^{1/2}$ = _____

26. $\sqrt{6400}$ = _____

27. $\sqrt[3]{1000}$ = _____

28. $\sqrt{4}^3$ =_____

29. $64^{1/3}$ = _____

30. (2) (3) ($\sqrt{81}$) = _____

Write the following numbers in Scientific Notation.

31. 6,150,000 _____

32. 0.00345 _____

33. 1004 _____

34. 0.000007 _____

35. 849,200 _____

Write the following scientific notation numbers as normal numbers.

36. 2.34×10^{6} _____

37. 9.28×10^{-2} _____

38. 7.34×10^{3} _____

39. 8.032×10^{-4} _____

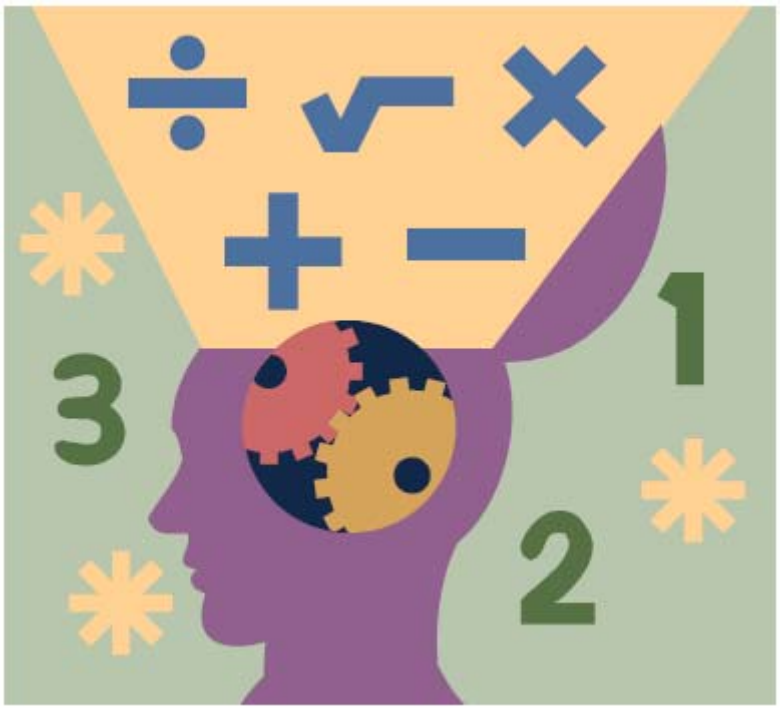
40. 1.234×10^{2} _____

Answers

1. (6)(6)
2. (10)(10)(10)(10)
3. (x)(x)(x)
4. 1
5. (13)(13)(13)(13)(13)(13)
6. (D)(D)
7. (8)
8. (14)(14)(14)(14)
9. 4^3
10. x^4
11. 9^2
12. 16^5
13. 2^5
14. D^3
15. 8^1
16. $(2^2)\ (3^3)$
17. 12.56
18. 324
19. 4032
20. 1000
21. $\sqrt{144}$
22. $\sqrt[3]{27}$
23. $450^{1/2}$
24. $27^{1/3}$
25. 12
26. 80
27. 10
28. 8
29. 4
30. 54
31. 6.15×10^6
32. 3.45×10^{-3}
33. 1.004×10^3
34. 7.0×10^{-6}
35. 8.492×10^5
36. 2,340,000
37. 0.0928
38. 7,340
39. 0.0008032
40. 123.4

Section 4

Solving for the Unknown



Solving for the Unknown

Basics

- The unknown is a variable in the equation that we are trying to solve.
- The unknown variable is usually represented by a letter such as, ***x.***

Basics

When solving for an unknown variable, ***x.***

1. ***X*** must be in the numerator.
2. ***X*** must be by itself on one side of the equation

Is *x* in the numerator?

1. $23x = 145$ — 1. Yes
2. $1 + x = 27$ — 2. Yes
3. $13 = (2)(x)(4)$ — 3. Yes
4. $107 = 42 - x$ — 4. Yes
5. $\frac{1}{x}(2) = 67$ — 5. No

How do I get *x* by itself?

$x - 10 = 35$

$x - 10 = 35 + 10$

$x = 35 + 10$

$x = 45$

$16 = x + 4$

$16 - 4 = x + 4$

$16 - 4 = x$

$12 = x$

Part 1: Addition and Subtraction

- To get numbers away from x we must move them across the = sign.
- When a number crosses the equal sign it does the opposite of what it was doing on the other side.
- If 10 is being subtracted on one side, than it will be added when it crosses the equal sign.

How do I get x by itself?

Part 2: Multiplication and Division

- If a number is being multiplied by or divided into **x** is must be moved across the **=** to get **x** by itself.
- Numbers will move at a diagonal when they cross the equal sign.

$(6)x = 60$

$x = \frac{60}{6}$

$x = 10$

$\frac{x}{3} = 12$

$x = 12\,(3)$

$x = 36$

What if x is not in the numerator?

$\frac{2}{x} = \frac{4}{}$

$\frac{2}{4} = x$

$0.5 = x$

- If x is in the denominator it can trade places with a number on the other side of the = sign.
- Flip-flop
- This is the only time you can move x.
- If x is in the numerator DO NOT MOVE x.

When solving for X, if you have +/- and */÷

$2x - 5 = 40$
$2x - 5 = 40 + 5$
$2x = 45$

$x = \frac{45}{2}$

$x = 22.5$

When solving for an unknown that involves more than one process.

1. Do the addition and subtraction first
2. Then do the multiplication and division.

Practice

$(23)(x)(7.48) = 542$

Step 1. Determine if x is in the numerator
Step 2. Simplify the numbers
Step 3. Get x by itself
Step 4. Solve the equation

Step 1 yes
Step 2
$(23)(7.48) = 172.04$
$(172.04)(x) = 542$

Step 3
$(172.04)(x) = 542$

$x = \frac{542}{172.04}$

Step 4
$x = 3.15$

Practice

$\frac{(8)(x)}{(3)(3)} = 21$

Step 1. Determine if x is in the numerator
Step 2. Simplify the numbers
Step 3. Get x by itself
Step 4. Solve the equation

Step 1 yes
Step 2
$\frac{(8)(x)}{9} = 21$

Step 3
$\frac{(8)(x)}{9} = 21$ $(8)(x) = (21)(9)$ $x = \frac{(21)(9)}{8}$

Step 4
$x = 23.625$

Practice

$\frac{80}{x} = 3700$

Step 1. Determine if x is in the numerator
Step 2. Simplify the numbers
Step 3. Get x by itself
Step 4. Solve the equation

Step 1 No
Step 2
Already simplified
Step 3

$\frac{80}{x} = \frac{3700}{}$ $80 = x(3700)$

Step 4
$0.0216 = x$

Solving for x^2

- The procedure for solving for x^2 is the same as solving for x.
- There is one extra step at the end.

Step 1. Determine if x^2 is in the numerator
Step 2. Simplify the numbers
Step 3. Get x^2 by itself
Step 4. Solve the equation
Step 5. Take the square root of both sides of the equation

Solving for x^2

$(x^2)(0.785) = 2826$

Step 1 Yes

Step 2 already simplified

Step 3

$(x^2)(0.785) = 2826$

$(x^2) = \frac{2826}{0.785}$

Step 4

$(x^2) = 3600$

Step 5

$\sqrt{x^2} = \sqrt{3600}$

$x = 60$

Step 1. Determine if x^2 is in the numerator

Step 2. Simplify the numbers

Step 3. Get x^2 by itself

Step 4. Solve the equation

Step 5. Take the square root of both sides of the equation

Things to remember

- Only move x if it is the denominator.
- If x is in the numerator leave x where it is and move the other numbers away from x.
- It does not matter if x is on the left side or the right side of the equation.
- $x = 5$
- $5 = x$
- They mean the same thing!

Solving for the Unknown

Basics – finding x

1. $8.1 = (3)(x)(1.5)$

2. $(0.785)(0.33)(0.33)(x) = 0.49$

3. $\frac{233}{x} = 44$

4. $940 = \frac{x}{(0.785)(90)(90)}$

5. $x = \frac{(165)(3)(8.34)}{0.5}$

6. $56.5 = \frac{3800}{(x)(8.34)}$

7. $114 = \frac{(230)(1.15)(8.34)}{(0.785)(70)(70)(x)}$

8. $2 = \frac{x}{180}$

9. $46 = \frac{(105)(x)(8.34)}{(0.785)(100)(100)(4)}$

10. $2.4 = \frac{(0.785)(5)(5)(4)(7.48)}{x}$

11. $19{,}747 = (20)(12)(x)(7.48)$

12. $\dfrac{(15)(12)(1.25)(7.48)}{x} = 337$

13. $\dfrac{x}{(4.5)(8.34)} = 213$

14. $\dfrac{x}{246} = 2.4$

15. $6 = \dfrac{(x)(0.18)(8.34)}{(65)(1.3)(8.34)}$

16. $\dfrac{(3000)(3.6)(8.34)}{(0.785)(x)} = 23.4$

17. $109 = \dfrac{x}{(0.785)(80)(80)}$

18. $(x)(3.7)(8.34) = 3620$

19. $2.5 = \dfrac{1{,}270{,}000}{x}$

20. $0.59 = \dfrac{(170)(2.42)(8.34)}{(1980)(x)(8.34)}$

Finding x^2

21. $x^2 = 100$

22. $(2)(x^2) = 288$

23. $(0.785)(D^2) = 5024$

24. $(x^2)(10)(7.48) = 10{,}771.2$

25. $51 = \dfrac{64{,}000}{(0.785)(D^2)}$

26. $(0.785)(D^2) = 0.54$

27. $2.1 = \dfrac{(0.785)(D^2)(15)(7.48)}{(0.785)(80)(80)}$

Extra Problems: Solving for the Unknown

Basics – finding x

1. $7 + 10 + x + 7 + 9 = 41$

2. $9.5 - x = 8.7$

3. $x + 93 = 165$

4. $10.1 = 9.5 + x$

5. $x + 15 = 19 + 22$

6. $16 = (2)(x)$

7. $8.1 = (3)(x)(1.5)$

8. $(0.785)(0.33)(0.33)(x) = 0.49$

9. $\frac{100}{x} = 50$

10. $\frac{233}{x} = 44$

11. $56.5 = \frac{3800}{(x)(8.34)}$

12. $10 = \frac{x}{4}$

13. $940 = \frac{x}{(0.785)(90)(90)}$

14. $x = \frac{(165)(3)(8.34)}{0.5}$

15. $114 = \frac{(230)(1.15)(8.34)}{(0.785)(70)(70)(x)}$

16. $2 = \frac{x}{180}$

17. $46 = \frac{(105)(x)(8.34)}{(0.785)(100)(100)(4)}$

18. $2.4 = \frac{(0.785)(5)(5)(4)(7.48)}{x}$

19. $19{,}747 = (20)(12)(x)(7.48)$

20. $\dfrac{(15)(12)(1.25)(7.48)}{x} = 337$

21. $\dfrac{x}{(4.5)(8.34)} = 213$

22. $\dfrac{x}{246} = 2.4$

23. $6 = \dfrac{(x)(0.18)(8.34)}{(65)(1.3)(8.34)}$

24. $\dfrac{(3000)(3.6)(8.34)}{(0.785)(x)} = 23.4$

25. $109 = \dfrac{x}{(0.785)(80)(80)}$

26. $(x)(3.7)(8.34) = 3620$

27. $2.5 = \frac{1{,}270{,}000}{x}$

28. $0.59 = \frac{(170)(2.42)(8.34)}{(1980)(x)(8.34)}$

29. $142 = (2)(x) + 13$

30. $(3.5)(x) - 62 = 560$

Finding x^2

31. $x^2 = 100$

32. $(2)(x^2) = 288$

33. $942 = (0.785)(x^2)(12)$

34. $6358.5 = (0.785)(x^2)$

35. $835 = \dfrac{4{,}200{,}000}{(0.785)(x^2)}$

36. $920 = \dfrac{3{,}312{,}000}{x^2}$

37. $23.9 = \dfrac{(3650)(3.95)(8.34)}{(0.785)(x^2)}$

38. $(0.785)(D^2) = 5024$

39. $(x^2)(10)(7.48) = 10{,}771.2$

40. $51 = \frac{64{,}000}{(0.785)(D^2)}$

41. $(0.785)(D^2) = 0.54$

42. $2.1 = \frac{(0.785)(D^2)(15)(7.48)}{(0.785)(80)(80)}$

Solving for Unknown Answers

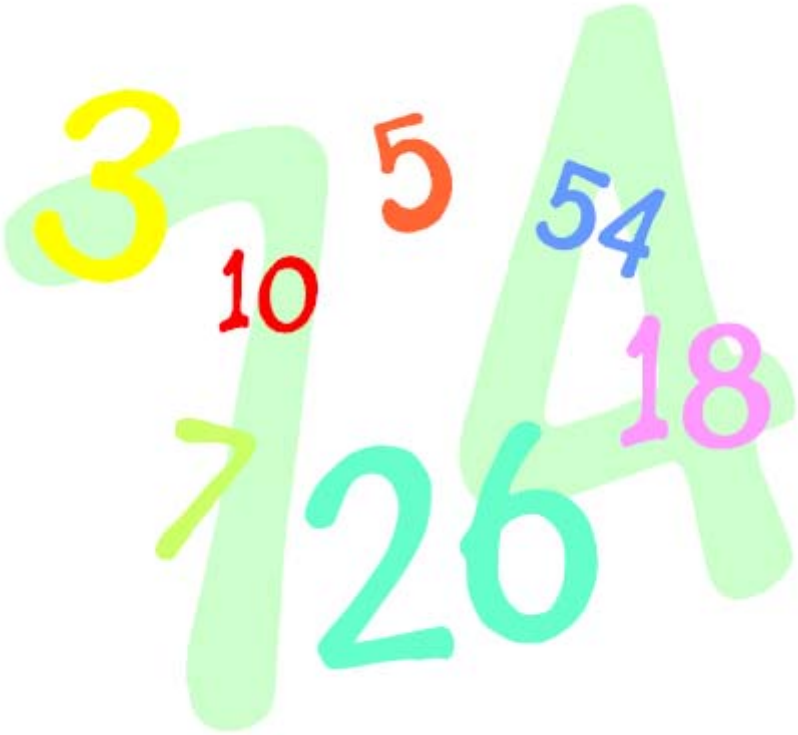
1. 1.8
2. 5.73
3. 5.3
4. 5,976,990
5. 8256.6
6. 8.06
7. 0.005
8. 360
9. 1649.4
10. 244.7
11. 11
12. 4.99
13. 7993.9
14. 590.4
15. 2816.7
16. 4903.5
17. 547,616
18. 117.3
19. 508,000
20. 0.35
21. 10
22. 12
23. 80
24. 12
25. 40
26. 0.83
27. 10.9

Extra Problems Answers

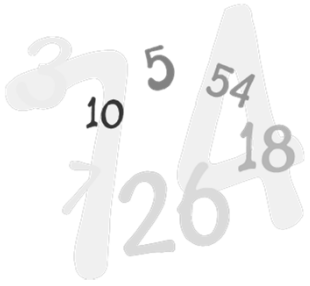
1. 8
2. 0.8
3. 72
4. 0.6
5. 26
6. 8
7. 1.8
8. 5.73
9. 2
10. 5.3
11. 8.06
12. 40
13. 5,976,990
14. 8256.6
15. 0.005
16. 360
17. 1649.42
18. 244.66
19. 10.99
20. 4.99
21. 7993.89
22. 590.4
23. 2816.67
24. 4903.48
25. 547,616
26. 117.31
27. 508,000
28. 0.35
29. 64.5
30. 177.71
31. 10
32. 12
33. 10
34. 90
35. 80
36. 60
37. 80
38. 80
39. 12
40. 39.98
41. 0.83
42. 10.94

Section 5

Ratios and Proportions



Ratios and Proportions



Ratio

- A ratio is a comparison of two numbers.
- We generally separate the two numbers in the ratio with a colon (:).
- For example, suppose we want to write the ratio of 8 and 12.
  We can write this as 8:12 or as a fraction 8/12, and we say the ratio is *eight to twelve*.

Ratios

- We use ratios to make comparisons between two things.
- Ratios can be written 3 ways.

What is the ratio of squares to triangles?

- Fraction — 3/ 4
- Word (to) — Three to four
- Colon (:) — 3: 4

Comparing Ratios

Is 3:4 equal to 6:8

$\frac{3}{4} = \frac{6}{8}$ Cross multiply

3 * 8 = 24
4 * 6 = 24
24=24
The ratios are equal

- To compare two ratios we write them as fractions.
- If the cross products of the fractions are equal than the ratios are equal.
- HINT(remember the equivalent fractions from Section 1)

Proportion

- A proportion is an equation with a ratio on each side. It is a statement that two ratios are equal. 3/4 = 6/8 is an example of a proportion.
- When one of the four numbers in a proportion is unknown, cross products may be used to find the unknown number.
- This is called solving the proportion.
- Question marks or letters (such as x) are frequently used in place of the unknown number.

Solving proportions

2:3 = 6: x

$\frac{2}{3} = \frac{6}{x}$ Step 1

2 * x = 2x Step 2

3 * 6 = 18

2x = 18

2x = 18 Step 3

$x = \frac{18}{2}$ x = 9

Step 1 If the proportions are not written as fractions, change them to fractions.

Step 2 Then cross multiply.

Step 3 Then solve for the unknown.

Solving Proportion Problems

- <u>One ft^3 is equivalent to 7.48 gallons. How many ft^3 is equivalent to 35 gallons?</u>

- The word problem must be written as mathematical ratios.
- How would we re-write the word problem into mathematical ratios?

Solving Proportion Problems

- One ft^3 is equivalent to 7.48 gallons. How many ft^3 is equivalent to 35 gallons?

- $1\ ft^3 : 7.48\ gal = x\ ft^3 : 35\ gal$

Practice Solving Proportions

1 ft^3 : 7.48 gal = x ft^3 : 35 gal

$\frac{1}{7.48} = \frac{x}{35}$ Step 1 Set up as fractions

1 * 35 = 35
7.48 * x = 7.48 x
35= 7.48 x Step 2 Cross multiply

Step 3 Solve for x

$\frac{35}{7.48} = x$

4.679 = x So, 4.679 ft^3 is equivalent to 35 gallons

Basic Math for Water and Wastewater
Proportions

Solving a Proportion Problem

1. $2 : 3 = 6 : X$

2. $25 : X :: 10 : 2$

3. $\frac{9}{3} = \frac{X}{8}$

4. $\frac{X}{27} = \frac{3}{9}$

5. $1 : 144 :: X : 1296$

6. $15 : 3 :: X : 4$

7. $X : 30 = 8 : 12$

8. $\frac{3}{8} = \frac{21}{X}$

9. $\frac{4}{X} = \frac{196}{1225}$

10. $\frac{X}{8} = \frac{49}{56}$

Setting Up a Proportion

11. One gallon is equivalent to 3.785 liters. How many gallons are equivalent to 75 liters?

12. On the average one bag of chemical is used up in 3.5 days. At this rate, how many bags of chemical will be required during a 120-day period?

13. Suppose you wish to maintain a weir overflow rate of 12,000 gpd/ft (this is 12,000 gpd flow for each one-foot of weir length). If the weir length is 180 ft, what gpd flow will result in the desired weir overflow rate?

14. A total of 5.4 lbs of hypochlorite are dissolved in 80 gallons of water. For a solution with the same concentration, how many lbs of hypochlorite must be dissolved in 30 gallons of water?

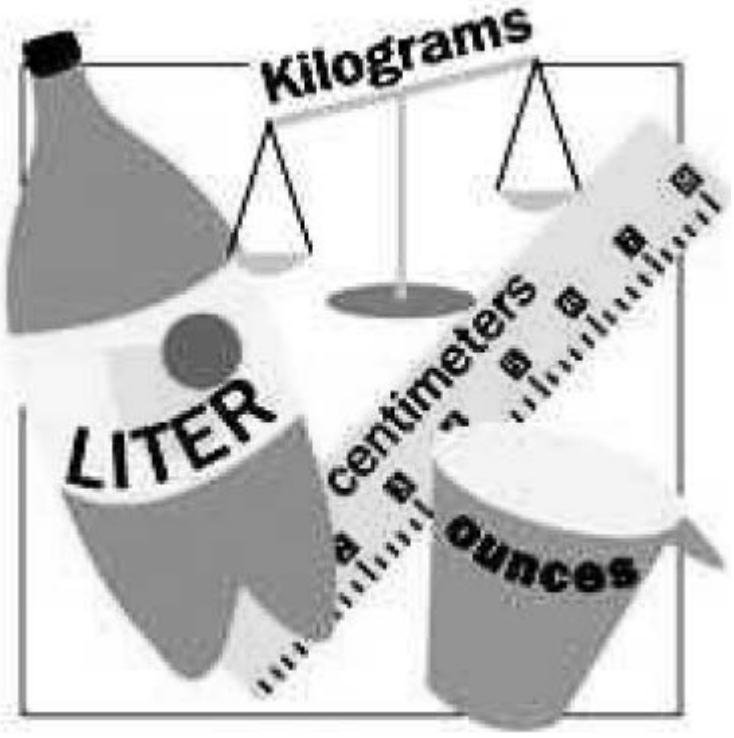
15. A treatment pond is designed for a population loading of 300 persons per acre of pond. If the population to be served is 1240 people, how many acres of treatment pond will be required?

Answers Proportion Problems

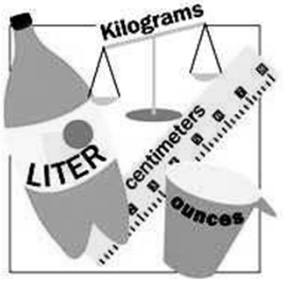
1. 9
2. 5
3. 24
4. 9
5. 9
6. 20
7. 20
8. 56
9. 25
10. 7
11. 19.82 gal
12. 34.29 bags
13. 2,160,000 gpd
14. 2 lbs
15. 4.1 acres

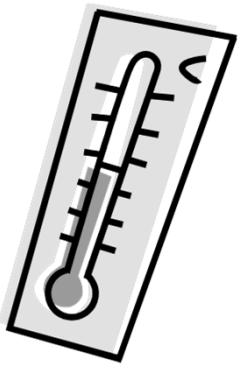
Section 6

Metric System and Temperature



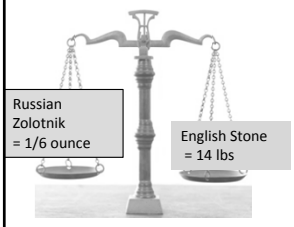
The Metric System and Temperature Conversions

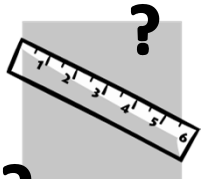




TENNESSEE DEPARTMENT OF ENVIRONMENT AND CONSERVATION

The Metric System





- Designed during the 1790's, the metric system brought order out of the conflicting and confusing traditional systems of weights and measures then being used in Europe.
- Prior to the introduction of the metric system, it was common for units of length, land area, and weight to vary, not just from one country to another but from one region to another within the same country.

So why is it important to have a common system of measurement?

Metric mishap caused loss of NASA orbiter (September 30, 1999)

NASA lost a $125 million Mars orbiter because a Lockheed Martin engineering team used English units of measurement while the NASA team used the more conventional metric system for a key spacecraft operation.

The engine fired but the spacecraft came within 60 km (36 miles) of the planet -- about 100 km closer than planned and about 25 km (15 miles) beneath the level at which the it could function properly, mission members said.

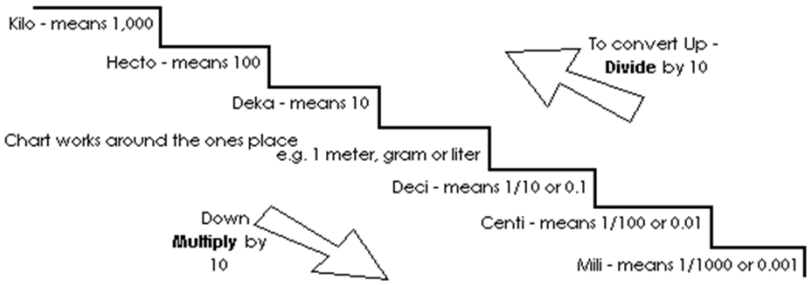
The Metric System

- The metric system is founded on base units.
- The base unit of mass is the **gram**.
- The base unit of length is the **meter**.
- The base unit of volume is the **Liter**.
- To go from small to large quantities the base units are described by prefixes which represent a power of ten.

The Metric System

Prefix	Symbol	It means	What it means in words
mega	M	1 000 000	One million
kilo	k	1 000	One thousand
hecto	h	100	One hundred
centi	c	.01	One hundredth
milli	m	.001	One thousandth
micro	µ	.000 001	One millionth
nano	n	.000 000 001	One billionth

The Metric System: Conversions

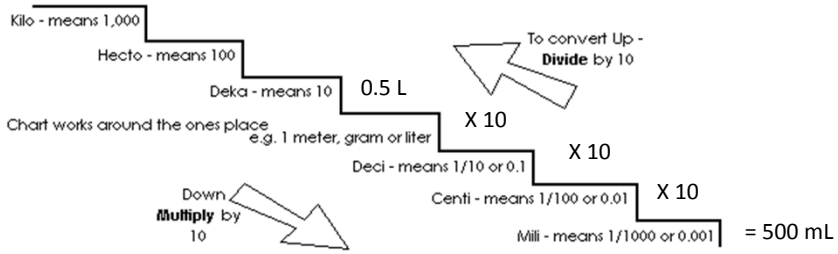


When converting any type of measures
- To convert from a **larger to smaller** metric unit you always **multiply**
- To convert from a **smaller to larger** unit you always **divide**
- The Latin prefixes used in the metric system literally mean the number they represent.

Metric System Problems

Convert 0.5 L into mL.

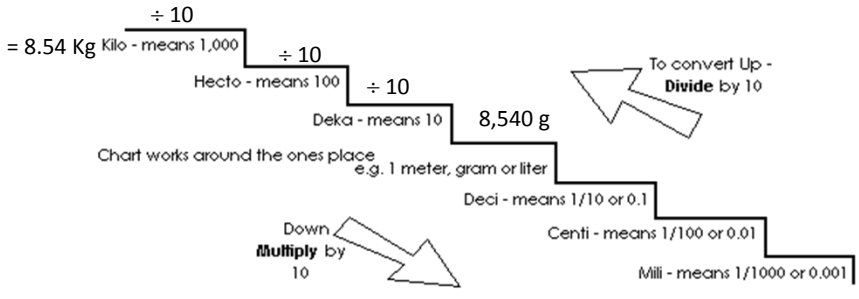
Large to small (multiply)



Metric System Problems

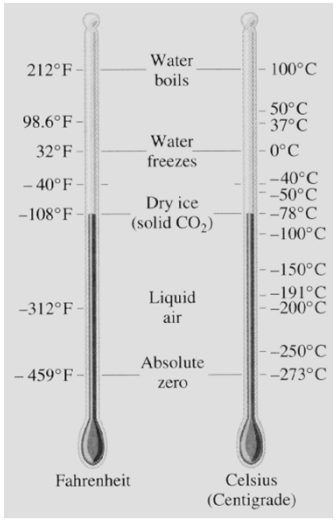
Convert 8,540 grams into Kg.

Small to large (divide)



Temperature Scales

The **Fahrenheit** scale is named for the 18th-century German physicist Daniel Fahrenheit.
His scale is based on 32 for the freezing point of water and 212 for the boiling point of water, the interval between the two being divided into 180 parts.
The scale was in common use in English speaking countries until the 1970's when Europe and Canada adopted the centigrade (Celsius) scale.
The U.S is the only country that still uses the Fahrenheit scale.



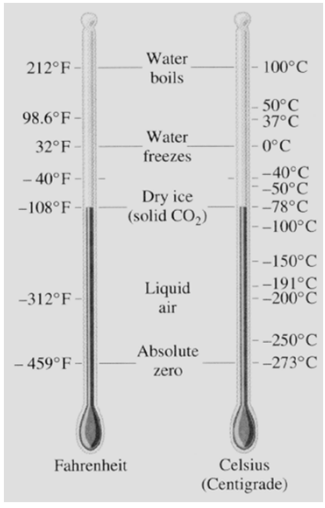
The **Celsius** temperature scale is named for the in the Swedish astronomer Anders Celsius who invented the scale in 1742.

The scale is based on 0 for the freezing point of water and 100 for the boiling point of water.

It is sometimes called the centigrade scale because of the 100-degree interval between the defined points.

Temperature Scales

The conversion formula for a temperature that is expressed on the Celsius (°C) scale to its Fahrenheit (°F) representation is:
F° = (9/5)(°C) + 32.



The following formula can be used to convert a temperature from its representation on the Fahrenheit (°F) scale to the Celsius (°C) value:
°C = (5/9)(°F- 32).

Temperature Conversions

You are going on a vacation in the U.K. The BBC news weather report says the temperature in London is 22°C, so should you pack shorts or sweaters?

°F = (9/5)(°C) + 32
°F = (1.8) (22°C) + 32
°F = (39.6) + 32 = 71.6
°F = 71.6°F

?

Temperature Conversions

You are calculating the Langelier Index which is a measure of a water's corrosiveness. The formula requires that you know your water temperature in °C . Your thermometer only reads °F.

The temperature of the water is 50°F.

°C = (5/9)(°F- 32)
°C = (5/9) (50 -32)
°C = (0.556) (18) = 10
°C = 10°C

Metric System and Temperature Conversion Practice Problems

Convert the following.

1. 23 g into _____ mg
2. 12,456 m into _____ km
3. 4235 mL into _____ L
4. 200 mg into _____ kg
5. 1000 watts into_____ kwatts
6. 0.05 g into _____ *u*g
7. 20 deciliters into _____ mL
8. 140 kg into _____ g
9. 9.5 cm into _____mm
10. 100 milliseconds into_____seconds

Convert the following.

1. 12 C° into _____ °F
2. 80 F° into _____ °C
3. 150 F° into _____ °C
4. 100 C° into _____ °F
5. 32 F° into _____ °C

Answers

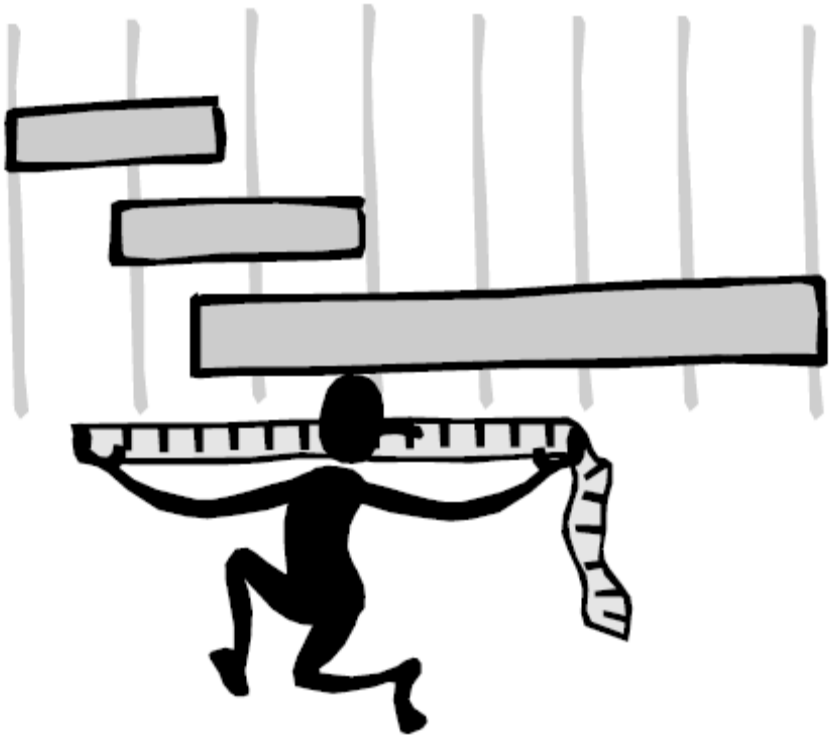
1. 23,00 mg
2. 12.456 km
3. 4.235 L
4. 0.0002 kg
5. 1 kwatt
6. 50,000 *u*g
7. 2000 mL
8. 140,000 g
9. 95 mm
10. 0.1 seconds

Part 2

1. 53.6°F
2. 26.67°C
3. 65.6°C
4. 212°F
5. 0°C

Section 7

Unit Conversions and Dimensional Analysis

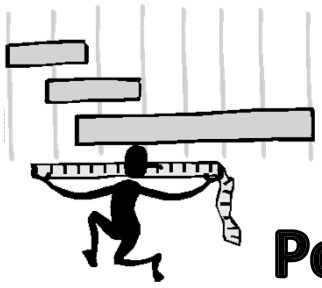


Conversions and Dimensional Analysis

Feet ?

Acres ?

Minutes ?



Gallons ?

MILES ?

Pounds?

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Conversions

To convert between units you need to know two things

1. **The number that relates the two units**
   - For example, 1 foot = 12 inches
2. **Whether to multiply or divide by that number.**
   - Smaller to larger unit or larger to smaller unit

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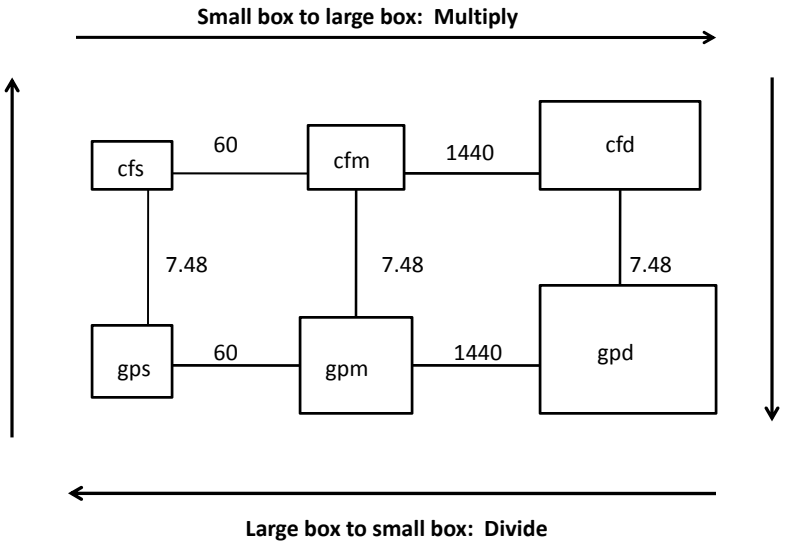
Flow Conversions – Box Method



Dimensional Analysis

ft^3

↓

gallons

↓

POUNDS

- Dimensional analysis is by far the most useful math trick you'll ever learn.
- This trick is about applied math, not about numbers in the abstract.
- We're talking about measurable stuff, stuff you can count or measure. Anything you measure will have a number with some sort of "unit of measure" (the dimension) attached.
- A unit could be miles, gallons, pounds, milligrams per liter, pounds per day,etc.

Dimensional Analysis

- Dimensional analysis is not just a way to work math problems.
- It is an easy way to verify that your formula is set up properly before the calculation is performed.
- If it is set up properly, the units in the formula will cancel out giving you the units of your desired answer.

$$V, gal = (l\ ft)(w\ ft)(depth\ ft)\left(\frac{7.48\ gal}{1\ ft^3}\right)$$

$$V, gal = (10\ ft)(10\ ft)(10\ ft)\left(\frac{7.48\ gal}{1\ ft^3}\right)$$

$$V, gal = (1000\ ft^3)\left(\frac{7.48\ gal}{1\ ft^3}\right)$$

$$V, gal = (1000\ \cancel{ft^3})\left(\frac{7.48\ gal}{1\ \cancel{ft^3}}\right) = 7{,}480\ gal$$

Dimensional Analysis

How many gallons is 8 ft^3 ?

Step 1- Determine what is being asked. We are given a number of ft^3 and are asked to convert it to gallons.

We are converting ft^3 into gallons.

Our answer should be in gallons.

Dimensional Analysis

Step 2- Write down what's given. What numbers are you given to work with? In this problem, all that's been given is that you have **8 ft^3**.

Step 3- Write down the conversion you need.

The useful conversions can be found in the first part of the formula book, top of page 1.

1 ft^3 of water = 7.48 gallons

Dimensional Analysis

Step 4- set up the problem and do the calculation. The basic setup is the following:

$$(\text{given}) \left(\frac{\text{conversion}}{\text{as a fraction}} \right) = \text{answer}$$

The hardest part is deciding just how to put in the conversion. There are always two choices when putting a conversion in a mathematically useful form?

$$\frac{\textbf{1 ft}^3}{\textbf{7.48 gal}} \quad \textbf{or} \quad \frac{\textbf{7.48 gal}}{\textbf{1 ft}^3}$$

Dimensional Analysis

$$\frac{1\ ft^3}{7.48\ gal} \quad \text{or} \quad \frac{7.48\ gal}{1\ ft^3}$$

Which one? Simply put, which one allows us to have an answer with the proper units? This is where we use the idea of multiplying and dividing units.

$8\ ft^3 \left(\frac{1\ ft^3}{7.48\ gal}\right) \left(\frac{ft^3}{gal}\right)\left(ft^3\right) = 1.069\ \frac{ft^6}{gal}$

The units ft^6 /gal are not what we were looking for

$8\ ft^3 \left(\frac{7.48\ gal}{1\ ft^3}\right) \left(\frac{\cancel{ft^3}}{\cancel{ft^3}}\right)(gal) = 59.84\ gal$

The $ft^3 / ft^3 = 1$
The ft^3 units cancel out and we are left with an answer in gallons

Dimensional Analysis: practice

We have a flow of 10 ft^3/min what is that in gal/day?

Step 1: What are we asked to find?

Gal/day

Convert ft^3 /min into gal/day

Step 2: Write down what's given.

10 ft^3 /min

Dimensional Analysis: practice

Step 3 : Write down the conversion you need.

We need two conversions.

1 ft^3 = 7.48 gallons

1 day = 1440 minutes

$$\frac{60\ \text{min}}{1\ \text{hr}} \quad \frac{24\ \text{hr}}{\text{day}} = 1440\ \frac{\text{min}}{\text{day}}$$

Dimensional Analysis: practice

Step 4 - set up the problem and do the calculation. The basic setup is the following:

(given) $\frac{\text{conversion}}{\text{as a fraction}}$ = answer

$$\left(\frac{10\ \text{ft}^3}{\text{min}}\right)\left(\frac{7.48\ \text{gal}}{1\ \text{ft}^3}\right)\left(\frac{1440\ \text{min}}{1\ \text{day}}\right) = 107{,}712\ \frac{\text{gal}}{\text{day}}$$

Basic Math
Dimensional Analysis

Dimensional analysis is not just a way to work math problems. It is an easy way to verify that your formula is set up properly before the calculation is performed.

Rules to follow:

- ✓ Units written in abbreviated or horizontal form should be rewritten in a vertical format. For example:

$$\text{cfs} \Rightarrow \frac{\text{ft}^3}{\text{sec}} \qquad \text{gal/cu ft} \Rightarrow \frac{\text{gal}}{\text{ft}^3}$$

- ✓ Any unit that is a common factor to both the numerator and denominator of a fraction may be divided out. For example:

$$\left(\frac{20\ \text{ft}^3}{\text{sec}}\right)\left(\frac{60\ \text{sec}}{\text{min}}\right) = \frac{(20)(60)\text{ft}^3}{\text{min}}$$

- ✓ An exponent of a unit indicates how many times that unit is to be multiplied together. For example:

$$\text{ft}^3 = (\text{ft})(\text{ft})(\text{ft})$$

  - o Sometimes it is necessary to write terms with exponents in expanded form, while other times it is advantageous to keep the unit in exponent form. This choice depends on which other units are part of the calculation and how these units might divide out.

Remember: Fractions must be multiplied or divided to do any canceling. Fractions that are added and subtracted can't be cancelled.

Basics:
Use dimensional analysis to determine the **units** of the answers:

1. (0.785)(ft)(ft)(ft)

2. (120 ft^3/min)(1440 min/day)

3. $\frac{(8ft)(10ft)(xft)}{sec}$

Verify the mathematical setup for each problem. If the setup is incorrect, correct the setup:

4. (1.6 fpm)(60 sec/min) = fps

5. (70 in)(1 ft/12 in)(0.3048 m/ft) = m

1. ft^3 2. ft^3/day 3. ft^3/sec 4. Incorrect 5. Correct

Complex Fractions:

- ✓ When the units of a given problem are written as a complex fraction:
  - o Invert the denominator and multiply. For example:

$$\frac{2{,}808{,}000 \text{ gpd}}{1440 \text{ min/day}} = \frac{\text{gal}}{\frac{\text{min}}{\text{day}}} = \left(\frac{\text{gal}}{\text{day}}\right)\left(\frac{\text{day}}{\text{min}}\right)$$

  - o Shortcut: If the numerator is the same in both the top and bottom fractions, they will cancel when the bottom fraction inverts and multiplies. The same goes if the denominator is the same in both the top and the bottom fractions.

Use dimensional analysis to determine the **units**:

1. $\frac{(4140 \text{ gpm})}{(60 \text{ sec/min})}$

2. $\frac{(880 \text{ cu ft})(1440 \text{ min/day})}{6.2 \text{ cu ft/day}}$

3. $\frac{587 \text{ gal}}{246 \text{ gph}}$

Verify the mathematical setup for each problem. If the setup is incorrect, correct the setup:

4. $\frac{(40 \text{ in})(1.5 \text{ ft})(2.3 \text{ fpm})}{12 \text{ in/ft}} =$ cfm

5. $\frac{\left(\frac{2{,}400{,}000 \text{ gpd}}{7.48 \text{ gal/ft}^3}\right)}{635{,}400 \text{ ft}^2} =$ ft/day

1. gal/sec 2. min 3. hour 4. ft^3/min 5. ft/day

Basic Math for Water and Wastewater
Conversions

mg/L & %

1. 340 mg/L = %

2. 0.6% = mg/L

3. 120 mg/L = %

4. 0.025% = mg/L

5. 1.5% = mg/L

6. 5000 mg/L = %

7. The suspended solids concentration of the return activated sludge is 6800 mg/L. What is the concentration expressed as a percent?

8. A concentration of 195 mg/L is equivalent to a concentration of what percent?

Metric/English Conversions

9. 20 feet = meters

10. 50 L = gal

11. 70 cm = in

12. 35 yds = feet

13. 600 mL = gal

14. 1 lb = mg

15. 1000 mL = L

16. 2.7 gal = mL

Linear Measurement

17. ¼ mile = feet

18. 4200 feet = miles

19. 17 feet = yds

20. 122 inches = feet

21. 30 yds = inches

22. 0.6 feet = inches

23. 492 inches = feet

24. The total weir length for a sedimentation tank is 142 feet 7 inches. Express this length in terms of feet only.

25. A one-eighth mile section of pipeline is to be replaced. How many feet of pipeline is this?

26. 2.7 miles of pipe is how many inches?

Area Measurement

27. 1017 in^2 = ft^2

28. 500 yd^2 = ft^2

29. 4 acres = ft^2

30. 1 yd^2 = in^2

31. 9.5 ft^2 = in^2

32. 78.5 in^2 = ft^2

33. 25,000 ft^2 = acres

34. 0.9 acre = ft^2

35. For solids treatment, a total of 60,000 ft^2 will be required. How many acres is this?

36. A pipe has a cross-sectional area of 452 in^2. How many ft^2 is this?

Volume Measurement

37. 325 ft^3 = yd^3

38. 2512 in^3 = ft^3

39. 25 yd^3 = ft^3

40. 1500 in^3 = ft^3

41. 2.2 ac-ft = yd^3

42. 21 ft^3 = yd^3

43. 92,600 ft^3 = ac-ft

44. 17,260 ft^3 = yd^3

45. 0.6 yd^3 = ft^3

46. 3 ft^3 = in^3

47. A screening pit must have a capacity of 400 ft^3. How many yd^3 is this?

48. A reservoir contains 50 ac-ft of water. How many ft^3 of water does it contain?

Flow Conversions

49. 3.6 cfs = gpm

50. 1820 gpm = gpd

51. 45 gps = cfs

52. 8.6 MGD = gpm

53. 2.92 MGD = gpm

54. 385 cfm = gpd

55. 1,662,000 gpd = gpm

56. 3.77 cfs = MGD

57. The flow through a pipeline is 8.4 cfs. What is the flow in gpd?

58. A treatment plant receives a flow of 6.31 MGD. What is the flow in gpm?

Basic Math for Water and Wastewater
Basic Conversions Extra Problems

1. How many seconds are in a minute?

2. How many minutes are in an hour?

3. How many hours in a day?

4. How many minutes in a day?

5. How many inches in a foot?

6. How many feet in a mile?

7. How many feet in a yard?

8. How many yards in a mile?

9. How much does one gallon of water weigh?

10. How much does one cubic foot of water weigh?

11. Express a flow of 5 cfs in terms of gpm.

12. What is 38 gps expressed as gpd?

13. What is 0.7 cfs expressed as gpd?

14. What is 9164 gpm expressed as cfs?

15. What is 1.2 cfs expressed as MGD?

16. Convert 65 gpm into lbs/day.

17. Convert 345 lbs/day into gpm.

18. Convert 0.9 MGD to cfm.

19. Convert 1.2 MGD to ft^3/hour.

20. Convert a flow of 4,270,000 gpd to cfm.

21. What is 5.6 MGD expressed as cfs?

22. Express 423,690 cfd as gpm.

23. Convert 2730 gpm to gpd.

24. Convert 1440 gpm to MGD.

25. Convert 45 gps to ft^3/day.

Answers

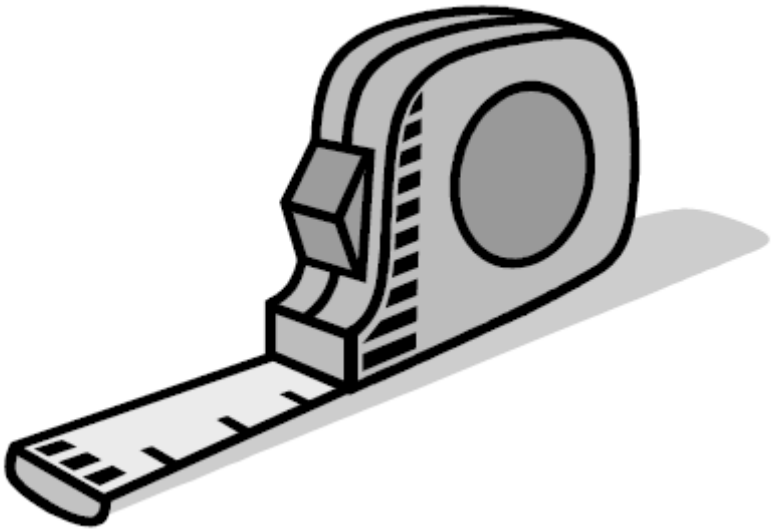
1. 0.034%
2. 6000 mg/L
3. 0.012%
4. 250 mg/L
5. 15,000 mg/L
6. 0.5%
7. 0.68%
8. 0.0195 %
9. 6.10 meters
10. 13.21 gal
11. 27.56 in
12. 105 ft
13. 0.16 gal
14. 453,600 mg
15. 1 L
16. 10,219.5 mL
17. 1320 ft
18. 0.80 mi
19. 5.67 yds
20. 10.17 ft
21. 1080 in
22. 7.2 in
23. 41 feet
24. 142.58 feet
25. 660 feet
26. 171,072 in
27. 7.06 ft^2
28. 4500 ft^2
29. 174,240 ft^2
30. 1296 in^2
31. 1368 in^2
32. 0.55 ft^2
33. 0.57 acres
34. 39,204 ft^2
35. 1.37 acre
36. 3.14 ft^2
37. 12 yd^3
38. 1.45 ft^3
39. 675 ft^3
40. 0.87 ft^3
41. 3549 yd^3
42. 0.78 yd^3
43. 2.13 ac-ft
44. 639 yd^3
45. 16.2 ft^3
46. 5184 in^3
47. 14.81 yd^3
48. 2,178,000 ft^3
49. 1616 gpm
50. 2,620,800 gpd
51. 6 cfs
52. 5972 gpm
53. 2028 gpm
54. 4,146,912 gpd
55. 1154 gpm
56. 2.44 MGD
57. 5,428,685 gpd
58. 4382 gpm

Basic Conversions Extra Problems

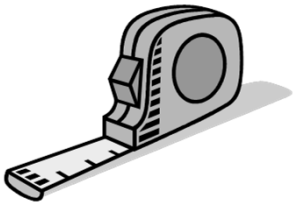
1. 60 sec/min
2. 60 min/hr
3. 24 hr/day
4. 1440 min/day
5. 12 in/ft
6. 5280 ft/mi
7. 3 ft/yd
8. 1760 yd/mi
9. 8.34 lbs/gal
10. 62.4 lbs/ft^3
11. 2244 gpm
12. 3,283,200 gpd
13. 452,390 gpd
14. 20.42 cfs
15. 0.78 MGD
16. 780,624 lbs/day
17. 0.03 gpm
18. 83.56 ft^3/min
19. 6684.49 ft^3/hr
20. 396.43 ft^3/min
21. 8.67 cfs
22. 2200.83 gpm
23. 3,931,200 gpd
24. 2.07 MGD
25. 519,786.10 ft^3/day

Section 8

Length, Area and Volume



Length, Area, and Volume



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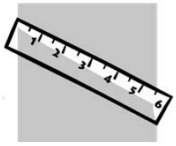
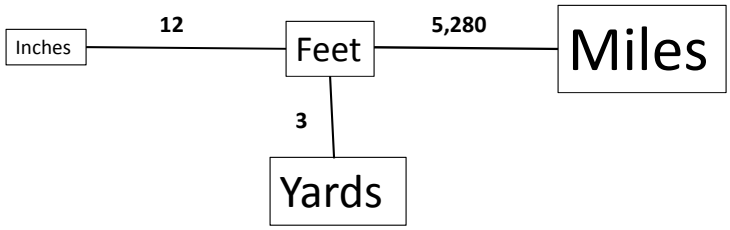
Length

- Length answers the questions **"How tall?**, **How wide?, How deep?** Or **How far is it?"**
- The Egyptian *cubit,* the first documented standard unit of length, was developed about 3000 BC, the unit was based on the length of the arm (from the elbow to the extended finger).
- The Greeks used the width of 16 fingers to find one foot. The Romans adopted the foot from the Greeks and divided it into 12 sections which was called *unicae*, which came to be known as an inch.



Units of Length

From smallest to greatest length measurements are compared as:



When converting any unit of measurements if you want:
To change from a smaller unit to a larger unit, **divide**.
To change to a larger unit to a smaller unit, **multiply**.

Units of Length

Conversion Chart

1 foot (ft. or ') = 12 inches (in. or ")

1 yard (yd.) = 3 feet (ft.)

1 mile (mi.) = 5,280 feet (ft.)

Length Conversions

A sewer collection pipe is 2.5 miles long. How long in the pipe in feet?

Miles are larger than feet.

So we are going from a larger unit to a smaller unit, so we **multiply** by the factor that relates the two units. 1 mile = 5,280 ft

$$2.5 \text{ miles} \frac{(5280 \text{ ft})}{1 \text{ miles}} = 13{,}200 \text{ ft}$$

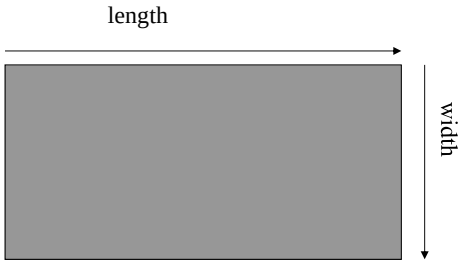
Area

- Area (symbolized by *A*)
- Two-dimensional quantity representing the amount or extent of the surface.
- Measured in square inches, square feet, square meters, etc.

Area Formulas

Area of a Rectangle

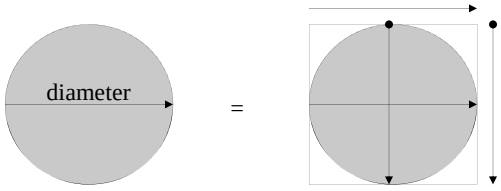
$A = (\text{length})(\text{width})$



Area Formulas

Area of a Circle

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



Diameter is equal to length and width of a square and the circle takes up 78.5% of that square.

Practice Problem

Find the area of the rectangle below.

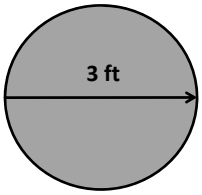
A = (length)(width)

A = (10 ft)(8 ft)

A = 80 ft^2

Practice Problem

Find the cross-sectional area of the circle below.



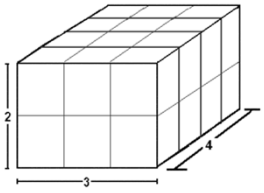
A = (0.785)(diameter)²

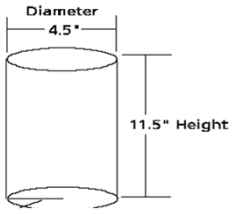
A = (0.785)(3 ft)(3ft)

A = (0.785)(9 ft^2)

A = 7.065 ft^2

Volume



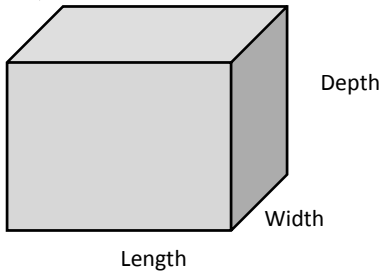


- Symbolized by *V*
- The amount of space an object occupies
- Volume = (Area)(third dimension)
- The third dimension could be length, height, or depth
- Measured in cubic inches, cubic feet, gallons, acre-feet, etc.

Volume formulas

Volume of a Rectangle

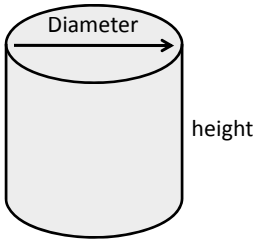
$V = (\text{length})(\text{width})(\text{depth})$



Volume formulas

Volume of a Cylinder

$V = (0.785)(D)^2(\text{height})$



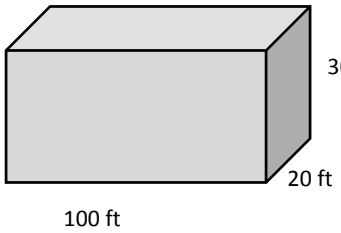
Practice Problem

Find the volume in cubic feet for the tank below.

Volume = (L, ft)(W, ft)(d, ft)

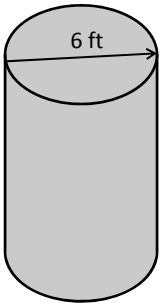
Volume = (100 ft)(20 ft)(30 ft)

Volume = 60,000 ft^3



Practice Problem

Find the volume in cubic feet for the stand pipe below.



Volume = (0.785)(diameter)^2(height)

Volume = (0.785)(6 ft)(6 ft)(50 ft)

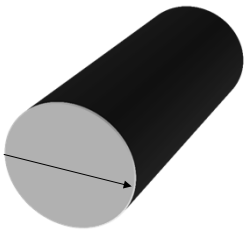
Volume = 1,413 ft^3

Note

When calculating area and volume, if you are given a pipe diameter in inches, convert it to feet.

Inches are smaller than feet.
When going from a small unit to a larger unit **divide** by the number that relates the two units.
1 ft = 12 inches.

$$8 \text{ in} \left(\frac{1 \text{ ft}}{12 \text{ in}}\right) = 0.6667 \text{ ft}$$



Diameter = 8 in

Math Problem Strategies

Strategy for solving word problems:

1) Read the problem, disregard the numbers (What type of problem is it? What am I asked to find?)
2) Refer to the diagram, if provided. If there isn't one, draw your own.
3) What information do I need to solve the problem, and how is it given in the statement of the problem?
4) Work it out.
5) Does it make sense?

It might be helpful to write out everything that is known in one column and the unknown (what am I asked to find?) in another column. Identify the correct formula and write it in the middle, plug in the numbers and solve.

Known

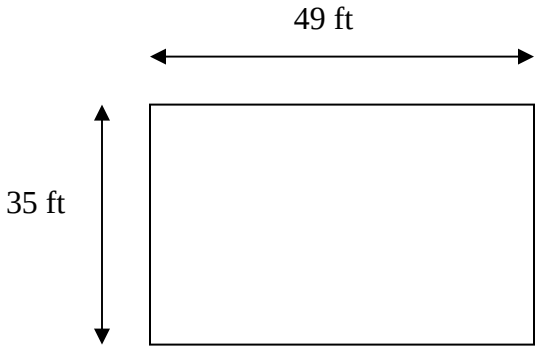
Length = 35 ft
Width = 49 ft

Unknown

Area = ?

$A = (l)(w)$

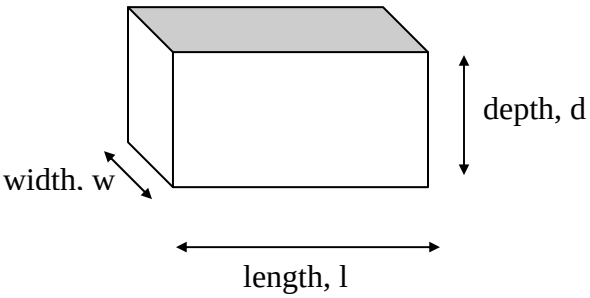
$A = (35\ ft)(49\ ft)$
$A = 1715\ ft^2$



*****Remember: make sure measurements agree; if diameter of pipe is in inches then change to feet; if flow is in MGD and you need feet or feet/sec then change to ft^3/sec before you plug values into formula.***

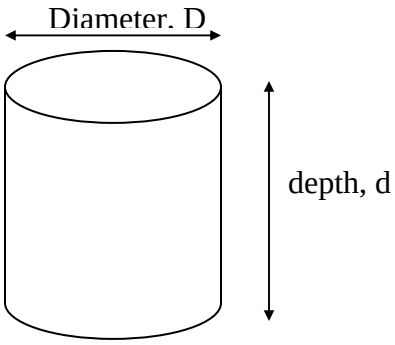
Tank Volume Calculations: Most tank volumes calculations are for tanks that are either rectangular or cylindrical in shape.

Rectangular Tank



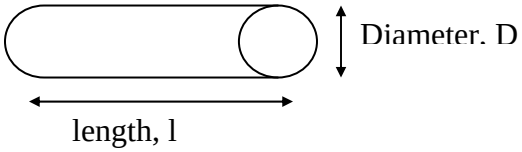
Volume = (l)(w)(d)

Cylindrical Tank



Volume = (0.785) (D)^2 (d)

Portion of a Pipeline



Volume = (0.785) (D)^2 (l)

Basic Math for Water and Wastewater
AREA, VOLUME, AND LENGTH CONVERSIONS

Conversions

1. How many yards is 350 ft?

2. How many inches is 30 ft?

3. How many miles is 10,000 ft?

4. Convert 4 miles into ft.

5. Convert 3 ft into inches.

6. Convert 1 mile into yds.

7. Convert 40 inches into ft.

8. Convert 50 yds into ft.

9. How many inches are in one mile?

10. How many ft long is a football field? (HINT: without end zones = 100 yds)

Area

1. A basin has a length of 45 feet and a width of 12 feet. Calculate the area in ft^2.

2. Calculate the surface area of a basin which is 90 feet long, 25 feet wide, and 10 feet deep.

3. Calculate the area (in ft^2) for a 2 ft diameter main that has just been laid.

4. Calculate the area (in ft^2) for an 18" main that has just been laid.

Volume

5. Calculate the volume (in ft^3) for a tank that measures 10 feet by 10 feet by 10 feet.

6. Calculate the volume (in gallons) for a basin that measures 22 feet by 11 feet by 5 feet.

7. Calculate the volume of water in a tank (in gallons), which measures 12 feet long, 6 feet wide, 5 feet deep, and contains 8 inches of water.

8. A new water main needs to be disinfected. The main is 30” in diameter and has a length of 0.25 miles. How many gallons of water will it hold?

9. A 3 million gallon water tank needs to be disinfected. The method you will use requires you to calculate 5% of the tank volume. How many gallons will this be?

DON’T THINK TOO HARD ON THIS ONE...

10. If you double the size of a pipe, does it double the volume that can be carried? For example, if you have 1000 feet of 12 inch line and you replace it with a 24 inch line, does your volume double?

ANSWERS:

Length Conversions

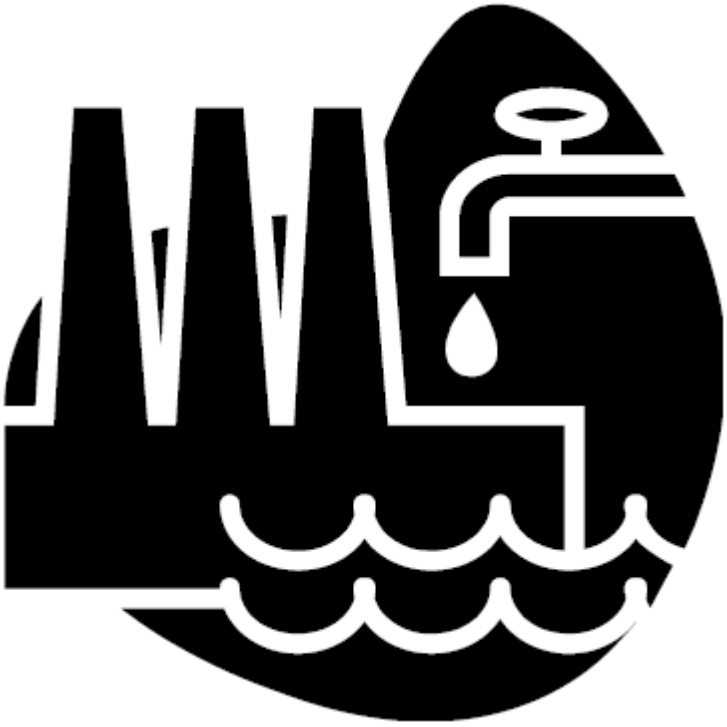
1. 116.67 yds
2. 360 inches
3. 1.89 miles
4. 21,120 ft
5. 36 inches
6. 1,760 yds
7. 3.33 ft
8. 150 ft
9. 63,360 inches
10. 300 ft

Area and Volume

1. 540 ft^2
2. 2,250 ft^2
3. 3.14 ft^2
4. 1.77 ft^2
5. 1,000 ft^3
6. 9,050.8 gal
7. 359.04 gal
8. 48,442.35 gal
9. 150,000 gal
10. no, it quadruples (4x more water)

Section 9

Flow and Velocity



Velocity and Flow

TENNESSEE DEPARTMENT OF ENVIRONMENT AND CONSERVATION

Velocity

Velocity = <u>distance</u>

time

Velocity is expressed in units such as ft/sec, miles/hour, ft/min, etc

The time unit of velocity can be different, as long as it is the same within each problem.

Velocity: Practice

The space shuttle travelled 4000 ft in 6 seconds, what was the velocity in ft/sec?

$$\text{Velocity} = \frac{\text{distance}}{\text{time}}$$

$$\text{Velocity} = \frac{4000 \text{ ft}}{6 \text{ sec}} = 666.67 \text{ ft/sec}$$

Flow

Flow is symbolized by the letter Q.

Q = (Area) (velocity)

Basically, flow is a volume over time.

Flow through a channel

Q , ft^3/sec = (width, ft)(depth, ft)(velocity, ft/sec)

What is the flow in cfs for a channel that is 2 ft wide, 4 ft deep with water moving at 1.5 ft/sec?

Q, ft^3/sec = (width, ft)(depth, ft)(velocity ft/sec)

Q, ft^3/sec = (2 ft)(4 ft)(1.5 ft/sec)

Q, ft^3/sec = 12 ft^3/sec

Flow through a pipeline

Q, ft^3 /sec = (0.785) (Diameter, ft)^2(velocity, ft/sec)

What is the flow in cfs for a 2 ft diameter pipe flowing full at a velocity of 3 ft/sec?

Q, ft^3 /sec = (0.785)(Diameter, ft)^2(velocity ft/sec)

Q, ft^3 /sec = (0.785)(2 ft)(2ft)(3 ft/sec)

Q, ft^3 /sec = 9.42 ft^3/sec

Notes

1. Make sure you square the diameter.
2. Make sure you convert inches to feet.
3. Look at the units you are asked to find.
4. The flow formulas come out in ft^3/sec but you may be asked to find gal/min or MGD.
5. Use the flow conversion box chart on page 3 or use dimensional analysis to convert flows to the units desired.

Basic Math for Water and Wastewater
FLOW RATE

$Q = AV$

1. A channel is 3 feet wide with water flowing to a depth of 2 feet. If the velocity in the channel is found to be 1.8 fps, what is the cubic feet per second flow rate in the channel?

2. A 12-inch diameter pipe is flowing full. What is the cubic feet per minute flow rate in the pipe if the velocity is 110 feet/min?

3. A water main with a diameter of 18 inches is determined to have a velocity of 182 feet per minute. What is the flow rate in gpm?

4. A 24-inch main has a velocity of 212 feet/min. What is the gpd flow rate for the pipe?

5. What would be the gpd flow rate for a 6” line flowing at 2 feet/second?

6. A 36” water main has just been installed. According to the Design Criteria for the State of Tennessee, the minimum flushing velocity is 2 ft/sec. If the main is flushed at 2.5 ft/second, how many gallons/minute should be flushed from the hydrant?

7. A 36” water main has just been installed. If the main is flows at 2 ft/second, how many MGD will the pipe deliver?

8. A certain pipe has a diameter of 18 inches. If the pipe is flowing full, and the water is known to flow a distance of 830 yards in 5 minutes, what is the MGD flow rate for the pipe?

VELOCITY (Open Channel)

9. A float is placed in a channel. It takes 2.5 minutes to travel 300 feet. What is the velocity in feet per minute in the channel? (Assume that float is traveling at the average velocity of the water.)

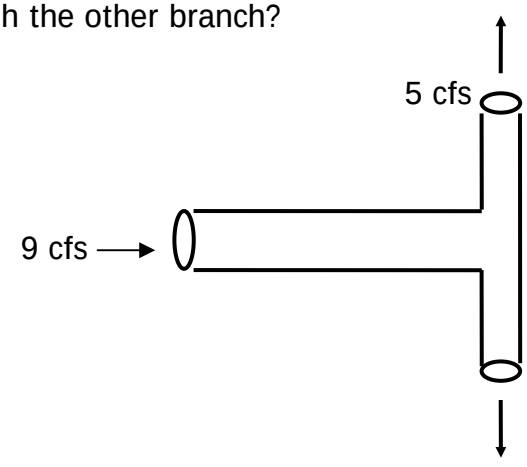
10. A cork placed in a channel travels 30 feet in 20 seconds. What is the velocity of the cork in feet per second?

11. A channel is 4 feet wide with water flowing to a depth of 2.3 feet. If a float placed in the channel takes 3 minutes to travel a distance of 500 feet, what is the cubic-feet-per-minute flow rate in the channel?

FLOW

12. The average velocity in a full-flowing pipe is measured and known to be 2.9 fps. The pipe is a 24" main. Assuming that the pipe flows 18 hours per day and that the month in question contains 31 days, what is the total flow for the pipe in MG for that month?

13. The flow entering the leg of a tee connection is 9 cfs. If the flow through one branch of the tee is 5 cfs, what is the flow through the other branch?



x cfs

ANSWERS:

Flow and Velocity

1. 185 ft/ min
2. 2.24 ft/sec
3. 210 ft/min
4. 16.8 cfs
5. 9.69 MGD
6. 1.8 ft
7. 10.05 cfs
8. 0.59 cfs
9. 6 in
10. 532.4 gpm

Flow Rate

1. 10.8 ft^3/sec
2. 86.35 ft^3/min
3. 2,405.50 gpm
4. 7,170,172.42 gpd
5. 253,661.76 gpd
6. 7,926.93 gpm
7. 9.13 MGD
8. 9.47 MGD
9. 120 ft/min
10. 1.5 ft/sec
11. 1,533.33 ft^3/min
12. 136.83 MG
13. 4 ft^3/sec

More Velocity and Flow Problems

1. A float travels 500 ft in a channel in 5 minutes and 22 seconds. What is the velocity in ft/sec?

2. A cork is placed in a channel and travels 50 ft in 9 seconds, what is the velocity in ft/min?

3. A car travels at a speed of 60 mph, what is the velocity in ft/sec?

4. The distance between a manhole A and manhole B is 400 ft. A float is dropped into manhole A and enters manhole B in 2 minutes and 30 seconds. What is the velocity of the water in ft/min?

5. A garden snail travelled 15 inches in 10 minutes, what is the snail's velocity in ft/min?

6. A channel 3 ft wide has water flowing to a depth of 11 inches. If the velocity of the water is 3.2 ft/sec, what is the flow through the channel in ft^3/sec?

7. A channel 30 inches wide has water flowing at a depth of 2 ft. If the length of the channel is 5,000 ft and the velocity through the channel is 2.5 ft/sec, what is the flow through the channel in ft^3/sec?

8. A channel is 2.5 ft wide and the water is flowing at a velocity of 3 ft/sec. I f the flow through the channel is measured to be 6.4 ft^3/sec, what is the depth of the water in the channel in ft?

9. A channel is 3 ft wide and the water is flowing at a velocity of 210 ft/min. If the water is 6 inches deep in the channel, what is the flow through the channel in gpm?

10. A channel is 24 inches wide and has water to a depth of 18 inches. If the water is flowing at a velocity of 2.9 ft/sec, what is the flow rate in cubic feet/min?

11. The flow through a channel is 100 gpm. If the channel is 3 ft wide and has water to a depth of 2 ft, what is the velocity of the water in ft/sec?

12. The flow through a 3 ft diameter pipeline is moving at a velocity of 4 ft/sec. What is the flow through the pipe in cubic feet/sec?

13. The flow through a 10 inch diameter pipe is moving at a velocity of 2 ft/sec. What is the flow rate in cubic ft/sec?

14. A 6 inch diameter pipe has water flowing at a velocity of 120 ft/min. What is the flow rate in gpm?

15. The flow through a pipe is 0.82 ft^3/sec. If the velocity of the flow is 1.5 ft/sec, and the pipe is flowing full, what is the diameter of the pipe in inches?

16. A 2 ft main has water flowing at a velocity of 4.1 ft/sec. What is the flow through the pipe in gph?

17. A 3 ft diameter main has just been installed. According to the Design Criteria for the State of Tennessee, the minimum flushing velocity is 2.5 ft/sec. if the main is flushed at a velocity of 3 ft/sec, how many gallons per minute will be flushed from the hydrant?

18. A pipe has a diameter of 24 inches. If the pipe is flowing full, and the water is known to flow a distance of 200 ft in 3 minutes, what is the flow rate for the pipe in MGD?

19. What is the flow rate in gpd for a 6 inch main flowing at a velocity of 220 ft/min?

20. If the flow through a 10 inch diameter pipe is 3.2 MGD, what is the velocity of the water in ft/sec?

21. The flow through a pipe is 320 gpm. If the velocity through the pipe is 3.6 ft/sec what is the diameter of the pipe in inches?

22. A certain pipe has a diameter or 10 inches. If the water in the pipe is known to travel 200 yds in 3 minutes, what is the flow rate for the pipe in gpd?

Answers

1. 1.55 ft/sec
2. 333.3 ft/sec
3. 88 ft/sec
4. 160 ft/min
5. 0.125 ft/min
6. 8.83 ft^3/sec
7. 12.5 ft^3/sec
8. 0.853 ft
9. 2,356 gpm
10. 522 ft^3/min
11. 0.037 ft/sec
12. 28.3 ft^3/sec
13. 1.089 ft^3/sec
14. 176 gpm
15. 10 in
16. 346,671 gph
17. 9,512 gpm
18. 2.25 MGD
19. 443,908 gpd
20. 9.09 ft/sec
21. 6 in
22. 1,173,420 gpd

Section 10

Answers

Section 1

Calculator Review Problems

1. 4 ÷ 18 +236 = 236.22
2. 53.867 + 243.1234 = 296.9904
3. 98.12-64.5 = 33.62
4. (48) (643) (210) = 6,481,440
5. 47 ÷ 6.4 = 7.34
6. 5 +231 x 15 = 3470

Convert Scientific notation into long hand

1. 1.478×10^8 = 147,809,000
2. 3.45×10^5 = 345,000
3. 7.66×10^{-4} = 0.000766
4. 5.4876×10^{-3} = 0.0054876

Use ^, x^2 and √ functions

1. 16^2 = 256
2. 47^4 = 4,879,681
3. 9^3 = 729
4. √169 = 13
5. √52.6 = 7.25

Convert percent to decimal

1. 42% = 0.42
2. .07% = 0.0007
3. 19% = 0.19
4. 30.94% = 0.3094

Find the LOG of the following numbers

1. 1000 = log(1000) = 3
2. 234= log(234) = 2.37
3. 600 = log(600) = 2.78

Fractions, Decimals, Percents and Averages

Are the following fractions equivalent? (Circle your answer.)

1. $\frac{3}{4} \times \frac{75}{100}$ (Y) or N $\quad 3 \times 100 = 300$, $4 \times 75 = 300$

2. $\frac{15}{32} \times \frac{10}{25}$ Y or (N) $\quad 15 \times 25 = 375$, $32 \times 10 = 320$

3. $\frac{5}{6} = \frac{20}{36}$ Y or N $\quad 5 \times 36 = 180$, $6 \times 20 = 120$

Reduce the fractions to simplest terms.

4. a) $\frac{10}{30} = \frac{1}{3}$ b) $\frac{9}{27} = \frac{1}{3}$ c) $\frac{25}{200} = \frac{1}{8}$ d) $\frac{4}{32} = \frac{1}{8}$

5. a) $\frac{6}{8} = \frac{2}{3}$ b) $\frac{16}{20} = \frac{4}{5}$ c) $\frac{15}{25} = \frac{3}{5}$ d) $\frac{72}{81} = \frac{24}{27}$

6. a) $\frac{7}{19} = \frac{7}{19}$ b) $\frac{132}{352} = \frac{33}{88}$ c) $\frac{17}{30} = \frac{17}{30}$ d) $\frac{16}{52} = \frac{4}{13}$

7. a) $\frac{9}{16} = \frac{9}{16}$ b) $\frac{10}{56} = \frac{5}{28}$ c) $\frac{12}{144} = \frac{1}{12}$ d) $\frac{5}{60} = \frac{1}{12}$

Convert the following fractions into decimals.

8. a) $\frac{3}{5} = 0.6$ b) $\frac{9}{13} = 0.69$ c) $\frac{7}{4} = 1.75$ d) $\frac{1}{3} = 0.33$

9. a) $\frac{5}{6} = 0.83$ b) $\frac{17}{53} = 0.32$ c) $\frac{2}{5} = 0.4$ d) $\frac{13}{169} = 0.08$

10. a) $\frac{9}{3} = 3$ b) $\frac{16}{56} = 0.29$ c) $\frac{11}{15} = 0.73$ d) $\frac{4}{9} = 0.44$

11. a) $\frac{1}{4} = 0.25$ b) $\frac{6}{2} = 3$ c) $\frac{22}{100} = 0.22$ d) $\frac{33}{99} = 0.33$

Convert the following decimals into fractions in lowest terms.

12. $0.98 = \frac{98}{100} \div \frac{2}{2} = \frac{49}{50}$

13. $0.516 = \frac{516}{1000} \div \frac{4}{4} = \frac{129}{250}$

14. $1.23 = \frac{123}{100}$ #

15. $0.84 = \frac{84}{100} \div \frac{4}{4} = \frac{21}{25}$

16. $7.5 = \frac{75}{10} \div \frac{5}{5} = \frac{15}{2}$

Change the following percents into fractions in lowest terms.

17. $33\% = \frac{33}{100}$

18. $12\% = \frac{12}{100} \div \frac{4}{4} = \frac{3}{25}$

19. $45\% = \frac{45}{100} \div \frac{5}{5} = \frac{9}{20}$

20. $75\% = \frac{75}{100} \div \frac{25}{25} = \frac{3}{4}$

21. $110\% = \frac{110}{100} \div \frac{10}{10} = \frac{11}{10}$

22. $0.5\% = \frac{0.5}{100} = \frac{5}{1000} \div \frac{5}{5} = \frac{1}{200}$

23. $16.3\% = \frac{16.3}{100} = \frac{163}{1000}$

24. $25\% = \frac{25}{100} \div \frac{25}{25} = \frac{1}{4}$

25. $100\% = \frac{100}{100} = 1$

26. $30.4\% = \frac{30.4}{100} = \frac{304}{1000} \div \frac{8}{8} = \frac{38}{125}$

Change the following percents into decimals.

27. $16\% = \frac{16}{100} = 0.16$

28. $75\% = \frac{75}{100} = 0.75$

29. $20\% = \frac{20}{100} = 0.20$

30. $0.07\% = \frac{0.07}{100} = 0.0007$

31. $120\% = \frac{120}{100} = 1.2$

32. $88.7\% = \frac{88.7}{100} = 0.887$

Change the following decimals into percents.

33. $0.531 = 0.531 \times 100 = 53.1\%$

34. $0.66 = 0.66 \times 100 = 66\%$

35. $1.21 = 1.21 \times 100 = 121\%$

36. $0.08 = 0.08 \times 100 = 8\%$

37. $19.5 = 19.5 \times 100 = 1950\%$

38. $0.406 = 0.406 \times 100 = 40.6\%$

39. $11.0 = 11.0 \times 100 = 1100\%$

40. $1.0 = 1.0 \times 100 = 100\%$

41. $0.278 = 0.278 * 100 = 27.8\%$

Solve the following word problems.

42. What is 10% of 55?
$N = 10\% * 55$
$N = 0.10 * 55$
$N = 5.5$

43. What is 15% of 125? $N = 15\% * 125$
$N = 0.15 * 125$
$N = 18.75$

44. 50% of 840 is what? $50\% * 840 = N$
$0.5 \times 840 = N$
$420 = N$

45. What is 7% of 1125? $N = 7\% * 1125$
$N = 0.07 * 1125$
$N = 78.75$

46. 110% of 50 is what? $110\% * 50 = N$
$1.1 * 50 = N$
$55 = N$

47. 50 is what % of 300? $50 = N * 300$
$\frac{50}{300} = N$
$16.67\% = N$

48. 29 is what % of 200? $29 = N * 200$
$\frac{29}{200} = N$
$14.5\% = N$

49. What is 5% of 10.7? $N = 5\% * 10.7$

$N = 0.05 * 10.7$

$N = 0.535$

50. 20 is what % of 110? $20 = N\% * 110$

$\frac{20}{110} = N$

$18.18\% = N$

51. 15 is what % of 40? $15 = N\% * 40$

$\frac{15}{40} = N$

$37.5\% = N$

52. 10 is what % of 5? $10 = N * 5$

$\frac{10}{5} = N$

$200\% = N$

53. 28% of what is 53? $28\% * N = 53$

$0.28 * N = 53$

$N = 53 / 0.28$

$N = 189.29$

54. 292 is what % of 2952? $292 = N\% * 2952$

$\frac{292}{2952} = N$

$9.89 = N$

55. 68% of 2140 is how much? $68\% * 2140 = N$

$0.68 * 2140 = N$

$1455.2 = N$

56. 9 is what percent of 48? $9 = N\% * 48$

$9/48 = N$

$18.75\% = N$

57. 219 is what percent of 302? $219 = N\% * 302$

$\frac{219}{302} = N$

$72.52\% = N$

58. 167 is 4% of what number? $167 = 4\% * N$

$167 = 0.04 * N$

$\frac{167}{0.04} = N \Rightarrow N = 4175$

59. You need to disinfect a 300,000 gallon storage tank. The method you are using calls for you to dose 5% of the tank volume with 50 mg/L chlorine. What is 5% of 300,000 gallons?

$N = 0.05 * 300{,}000\ gal$

$N = 15{,}000\ gal$

Find the arithmetic mean (average) of the following sets of values.

60. What is the high temperature of the week in °C? (Data for seven days : 21°C, 25.2°C, 19°C, 22°C, 20°C, 19.4°C, and 20.1°C)

$$\frac{21 + 25.2 + 19 + 22 + 20 + 19.4 + 20.1}{7 \text{ days}} = 20.96°C$$

61. What was the average chlorine residual measured in the distribution system? (0.2_1 mg/L, 0.7_2 mg/L, 0.5_3 mg/L, 0.8_4 mg/L, 1.2_5 mg/L)

$$\frac{0.2 + 0.7 + 0.5 + 0.8 + 1.2}{5} = 0.68 \text{ mg/L}$$

62. What is the average weight of a 1 L volumetric flask? (700_1 g, 701_2 g, 698_3 g, 690_4 g, 704_5 g, 697_6 g, 705_7 g)

$$\frac{700 + 701 + 698 + 690 + 704 + 697 + 705}{7} = 699.29 \text{ g}$$

63. What was the average flow for the year in MGD through the Randyville Wastewater Plant? (Jan = 1.32 MGD, Feb=1.21 MGD, Mar=1.5 MGD, Apr=1.6 MGD, May=1.95 MGD, June=1.8 MGD, July=1.7 MGD, Aug=1.65 MGD, Sep=1.5 MGD, Oct=1.25 MGD, Nov=1.6 MGD, Dec=1.92 MGD)

$$\frac{1.32 + 1.21 + 1.5 + 1.6 + 1.95 + 1.8 + 1.7 + 1.65 + 1.5 + 1.25 + 1.6 + 1.92}{12}$$

$$= 1.58 \text{ MGD}$$

Powers, Roots and Scientific Notation Practice Problems

Write the following numbers in expanded form as factors.

1. 6^2 (6)(6)

2. 10^4 (10)(10)(10)

3. x3 (x)(x)(x)

4. 5^0 1

5. 13^6 (13)(13)(13)(13)(13)(13)

6. D^2 (D)(D)

7. 8^1 8

8. 14^4 (14)(14)(14)

Write the following numbers using exponential notation.

9. (4) (4) (4) 4^3

10. (x) (x) (x) (x) x^4

11. (9) (9) 9^2

12. (16) (16) (16) (16) (16) 16^5

13. (2)(2)(2)(2)(2) 2^5

14. (D) (D) (D) D^3

15. (8) 8^1

16. (2)(2) (3)(3) (3) $(2^2)(3^3)$

Solve the following problems.

17. $(0.785)(4^2) =$ 12.56

18. $(2^2)(3^4) =$ 324

19. $(36)(14)(2^3) =$ 4032

20. $(5^3) * (2^3) =$ 1000

Write the following in radical form. (fractional exponents into $\sqrt{x}$)

21. $144^{1/2} = \sqrt{144}$

22. $27^{1/3} = \sqrt[3]{27}$

Write the following numbers in exponent form ($\sqrt{x}$ into fractional exponents).

23. $\sqrt{450}$ = $450^{1/2}$

24. $\sqrt[3]{27}$ = $27^{1/2}$

Complete the following problems.

25. $144^{1/2}$ = 12

26. $\sqrt{6400}$ = 80

27. $\sqrt[3]{1000}$ = 10

28. $\sqrt{4^3}$ = 8

29. $64^{1/3}$ = 4

30. (2) (3) ($\sqrt{81}^{9}$) = 54

Write the following numbers in Scientific Notation.

31. 6,150,000 1.15×10^{6}

32. 0.00345 3.45×10^{-3}

33. 1004 1.004×10^{3}

34. 0.000007 7.0×10^{-6}

35. 849,200 8.492×10^{5}

Write the following scientific notation numbers as normal numbers.

36. 2.34×10^{6} 2,340,000

37. 9.28×10^{-2} 0.0928

38. 7.34×10^{3} 7,340

39. 8.032×10^{-4} 0.0008032

40. 1.234×10^{2} 123.4

Solving for the Unknown

Basics – finding x

1. $8.1 = (3)(x)(1.5)$

$8.1 = (4.5)(x)$

$\frac{8.1}{4.5} = x$

$\boxed{1.8 = x}$

2. $(0.785)(0.33)(0.33)(x) = 0.49$

$(0.0854865)(x) = 0.49$

$x = \frac{0.49}{0.0854865}$

$\boxed{x = 5.73}$

3. $\frac{233}{x} = 44$

$\frac{233}{44} = x$

$\boxed{5.29 = x}$

4. $940 = \frac{x}{(0.785)(90)(90)}$

$940 = \frac{x}{6358.5}$

$(940)(6358.5) = x$

$\boxed{5{,}976{,}990 = x}$

5. $x = \frac{(165)(3)(8.34)}{0.5}$

$x = \frac{4128.3}{0.5}$

$\boxed{x = 8256.6}$

6. $56.5 = \frac{3800}{(x)(8.34)}$

$x = \frac{3800}{(56.5)(834)}$

$\boxed{x = 8.06}$

7. $114 = \frac{(230)(1.15)(8.34)}{(0.785)(70)(70)(x)}$

$x = \frac{(230)(1.15)(8.34)}{(0.785)(70)(70)(114)}$

$\boxed{x = 0.005}$

8. $2^{\circ} = \frac{x}{180}$

$(2)(180) = x$

$\boxed{360 = x}$

9. $46 = \frac{(105)(x)(8.34)}{(0.785)(100)(100)(4)}$

$46 = \frac{(875.7)(x)}{31400}$

$(46)(31400) = (875.7)(x)$

$\frac{(46)(31400)}{875.7} = x$

$\boxed{1649.4 = x}$

10. $2.4 = \frac{(0.785)(5)(5)(4)(7.48)}{x}$

$x = \frac{(0.785)(5)(5)(4)(7.48)}{2.4}$

$\boxed{x = 245}$

11. $19{,}747 = (20)(12)(x)(7.48)$

$19.747 = (1795.2)(x)$

$\frac{19747}{1795.2} = x$

$10.99 = x$

12. $\frac{(15)(12)(1.25)(7.48)}{x} = 337$

$\frac{(15)(12)(1.25)(7.48)}{337} = x$

$4.99 = x$

13. $\frac{x}{(4.5)(8.34)} = 213$

$x = (213)(4.5)(8.34)$

$x = 7993.89$

14. $\frac{x}{246} = 2.4$

$x = (2.4)(246)$

$x = 590.4$

15. $6 = \frac{(x)(0.18)(8.34)}{(65)(1.3)(8.34)}$

$\frac{(6)(65)(1.3)(8.34)}{(0.18)(8.34)} = x$

$2817 = x$

16. $\frac{(3000)(3.6)(8.34)}{(0.785)(x)} = 23.4$

$\frac{(3000)(3.6)(8.34)}{(0.785)(23.4)} = x$

$4903.5 = x$

17. $109 = \frac{x}{(0.785)(80)(80)}$

$(109)(0.785)(80)(80) = x$

$547616 = x$

18. $(x)(3.7)(8.34) = 3620$

$x = \frac{3620}{(3.7)(8.34)}$

$x = 117$

19. $2.5 = \frac{1{,}270{,}000}{x}$

$x = \frac{1270000}{2.5}$

$x = 508{,}000$

20. $0.59 = \frac{(170)(2.42)(8.34)}{(1980)(x)(8.34)}$

$x = \frac{(170)(2.42)(8.34)}{(1980)(0.59)(8.34)}$

$x = \frac{3431.076}{9742.788}$

$x = 0.35$

Finding x^2

21. $(0.785)(D^2) = 5024$

$$\frac{D^2}{0.785} = \frac{5024}{0.785}$$
$$\sqrt{D^2} = \sqrt{6400}$$
$$D = 80$$

22. $(x^2)(10)(7.48) = 10{,}771.2$

$$(x^2)(74.8) = 10771.2$$
$$(x^2) = \frac{10771.2}{74.8}$$
$$\sqrt{x^2} = \sqrt{144}$$
$$x = 12$$

23. $51 = \dfrac{64{,}000}{(0.785)(D^2)}$

$$D^2 = \frac{64000}{(51)(0.785)}$$
$$\sqrt{D^2} = \sqrt{1598.6}$$
$$D = 39.98$$

24. $(0.785)(D^2) = 0.54$

$$D^2 = \frac{0.54}{0.785}$$
$$\sqrt{D^2} = \sqrt{0.6879}$$
$$D = 0.829$$

25. $2.1 = \dfrac{(0.785)(D^2)(15)(7.48)}{(0.785)(80)(80)}$

$$2.1 = \frac{(88.077)(D^2)}{5024}$$
$$(2.1)(5024) = (88.077)(D^2)$$
$$\frac{(2.1)(5024)}{88.077} = D^2$$
$$\sqrt{119.786} = \sqrt{D^2}$$
$$10.94 = D$$

Extra Problems: Solving for the Unknown

Basics – finding x

1. $7 + 10 + x + 7 + 9 = 41$

$x + 33 = 41$

$x = 41 - 33$

$x = 8$

2. $9.5 - x = 8.7$

$9.5 = 8.7 + x$

$9.5 - 8.7 = x$

$0.8 = x$

3. $x + 93 = 165$

$x = 165 - 93$

$x = 72$

4. $10.1 = 9.5 + x$

$10.1 - 9.5 = x$

$0.6 = x$

5. $x + 15 = 19 + 22$

$x + 15 = 41$

$x = 41 - 15$

$x = 26$

6. $16 = (2)(x)$

$\frac{16}{2} = x$

$8 = x$

7. $8.1 = (3)(x)(1.5)$

$8.1 = (4.5)(x)$

$\frac{8.1}{4.5} = x$

$1.8 = x$

8. $(0.785)(0.33)(0.33)(x) = 0.49$

$(0.0854865)(x) = 0.49$

$x = \frac{0.49}{0.0854865}$

$x = 5.73$

9. $\frac{100}{x} = \frac{50}{}$

$\frac{100}{50} = x$

$2 = x$

10. $\frac{233}{x} = \frac{44}{}$

$\frac{233}{44} = x$

$5.3 = x$

11. $56.5 = \frac{3800}{(x)(8.34)}$

$$x = \frac{3800}{(56.5)(8.34)}$$

$$x = 8.06$$

12. $10 = \frac{x}{4}$

$$(4)(10) = x$$

$$40 = x$$

13. $940 = \frac{x}{(0.785)(90)(90)}$

$$940 = \frac{x}{6358.5}$$

$$(940)(6358.5) = x$$

$$5{,}976{,}990$$

14. $x = \frac{(165)(3)(8.34)}{0.5}$

$$x = \frac{4128.3}{0.5}$$

$$x = 8256.6$$

15. $114 = \frac{(230)(1.15)(8.34)}{(0.785)(70)(70)(x)}$

$$x = \frac{(230)(1.15)(8.34)}{(0.785)(70)(70)(114)}$$

$$x = 0.005$$

16. $2 = \frac{x}{180}$

$$(2)(180) = x$$

$$360 = x$$

17. $46 = \frac{(105)(x)(8.34)}{(0.785)(100)(100)(4)}$

$$46 = \frac{(875.7)(x)}{31400}$$

$$(46)(31400) = (875.7)(x)$$

$$\frac{1444400}{875.7} = x$$

$$1649.42 = x$$

18. $2.4 = \frac{(0.785)(5)(5)(4)(7.48)}{x}$

$$x = \frac{587.18}{2.4}$$

$$x = 244.66$$

19. $19{,}747 = (20)(12)(x)(7.48)$

$19747 = (1795.2)(x)$

$\frac{19747}{1795.2} = x$

$10.99 = x$

20. $\frac{(15)(12)(1.25)(7.48)}{x} = 337$

$\frac{1683}{337} = x$

$4.99 = x$

21. $\frac{x}{(4.5)(8.34)} = 213$

$\frac{x}{37.53} = 213$

$x = (213)(37.53)$

$x = 7993.89$

22. $\frac{x}{246} = 2.4$

$x = (2.4)(246)$

$x = 590.4$

23. $6 = \frac{(x)(0.18)(8.34)}{(65)(1.3)(8.34)}$

$6 = \frac{(x)(1.5012)}{704.73}$

$(6)(704.73) = (x)(1.5012)$

$\frac{(6)(704.73)}{1.5012} = x$

$2816.67 = x$

24. $\frac{(3000)(3.6)(8.34)}{(0.785)(x)} = 23.4$

$\frac{(3000)(3.6)(8.34)}{(0.785)(23.4} = x$

$4903.48 = x$

25. $109 = \frac{x}{(0.785)(80)(80)}$

$109 = \frac{x}{5024}$

$(109)(5024) = x$

$547{,}616 = x$

26. $(x)(3.7)(8.34) = 3620$

$(x)(30.858) = 3620$

$x = \frac{3620}{30.858}$

$x = 117.31$

27. $2.5 = \frac{1{,}270{,}000}{x}$

$$x = \frac{1270000}{2.5}$$

$$x = 508{,}000$$

28. $0.59 = \frac{(170)(2.42)(8.34)}{(1980)(x)(8.34)}$

$$x = \frac{(170)(2.42)(8.34)}{(1980)(0.59)(8.34)}$$

$$x = 0.35$$

29. $142 = (2)(x) + 13$

$$142 - 13 = (2)(x)$$

$$\frac{129}{2} = x \rightarrow x = 64.5$$

30. $(3.5)(x) - 62 = 560$

$$(3.5)(x) = 560 + 62$$

$$x = \frac{622}{3.5}$$

$$x = 177.71$$

Finding x^2

31. $x^2 = 100$

$\sqrt{x^2} = \sqrt{100}$

$x = 10$

32. $(2)(x^2) = 288$

$x^2 = \frac{288}{2}$

$\sqrt{x^2} = \sqrt{144}$

$x = 12$

33. $942 = (0.785)(x^2)(12)$

$942 = (9.42)(x^2)$

$\frac{942}{9.42} = x^2$

$\sqrt{100} = \sqrt{x^2}$

$10 = x$

34. $6358.5 = (0.785)(x^2)$

$\frac{6358.5}{0.785} = x^2$

$\sqrt{8100} = \sqrt{x^2}$

$90 = x$

35. $835 = \frac{4{,}200{,}000}{(0.785)(x^2)}$

$x^2 = \frac{4{,}200{,}000}{(0.785)(835)}$

$\sqrt{x^2} = \sqrt{6407.57}$

$x = 80$

36. $920 = \frac{3{,}312{,}000}{x^2}$

$x^2 = \frac{3312000}{920}$

$\sqrt{x^2} = \sqrt{3600}$

$x = 60$

37. $23.9 = \frac{(3650)(3.95)(8.34)}{(0.785)(x^2)}$

$x^2 = \frac{(3650)(3.95)(8.34)}{(0.785)(23.9)}$

$\sqrt{x^2} = \sqrt{6408.97}$

$x = 80$

38. $(0.785)(D^2) = 5024$

$D^2 = \frac{5024}{0.785}$

$\sqrt{D^2} = \sqrt{6400}$

$D = 80$

39. $(x^2)(10)(7.48) = 10{,}771.2$

$(x^2)(74.8) = 10{,}771.2$

$x^2 = \frac{10771.2}{74.8}$

$\sqrt{x^2} = \sqrt{144}$

$x = 12$

40. $51 = \frac{64{,}000}{(0.785)(D^2)}$

$$D^2 = \frac{64000}{(0.785)(51)}$$

$$\sqrt{D^2} = \sqrt{1598.60}$$

$$D = 39.98$$

41. $(0.785)(D^2) = 0.54$

$$D^2 = \frac{0.54}{0.785}$$

$$\sqrt{D^2} = \sqrt{0.688}$$

$$D = 0.83$$

42. $2.1 = \frac{(0.785)(D^2)(15)(7.48)}{(0.785)(80)(80)}$

$$2.1 = \frac{(88.077)(D^2)}{5024}$$

$$(2.1)(5024) = (88.077)(D^2)$$

$$\frac{10550.4}{88.077} = D^2$$

$$\sqrt{119.79} = \sqrt{D^2}$$

$$10.94 = D$$

Basic Math for Water and Wastewater
Proportions

Solving a Proportion Problem

1. 2 : 3 = 6 : X

$\frac{2}{3} = \frac{6}{X}$

$2(X) = (3)(6)$

$X = 9$

2. 25 : X :: 10 : 2

$\frac{25}{X} = \frac{10}{2}$

$(25)(2) = (X)(10)$

$5 = X$

3. $\frac{9}{3} = \frac{X}{8}$

$(9)(8) = (3)(X)$

$24 = X$

4. $\frac{X}{27} = \frac{3}{9}$

$(X)(9) = (27)(3)$

$X = 9$

5. 1 : 144 :: X : 1296

$\frac{1}{144} = \frac{X}{1296}$

$(1)(1296) = (144)(X)$

$9 = X$

6. 15 : 3 :: X : 4

$\frac{15}{3} = \frac{X}{4}$

$(15)(4) = (3)(X)$

$20 = X$

7. X : 30 = 8 :12

$\frac{X}{30} = \frac{8}{12}$

$(X)(12) = (30)(8)$

$X = 20$

8. $\frac{3}{8} = \frac{21}{X}$

$(3)(X) = (8)(21)$

$X = 56$

9. $\frac{4}{X} = \frac{196}{1225}$

$(4)(1225) = (X)(196)$

$25 = X$

10. $\frac{X}{8} = \frac{49}{56}$

$(X)(56) = (8)(49)$

$X = 7$

Setting Up a Proportion

11. One gallon is equivalent to 3.785 liters. How many gallons are equivalent to 75 liters?

$1 : 3.785 = X : 75$

$\frac{1}{3.785} = \frac{X}{75}$

$(1)(75) = (3.785)(x)$

$19.8\ gal = X$

12. On the average one bag of chemical is used up in 3.5 days. At this rate, how many bags of chemical will be required during a 120-day period?

$1\ bag : 3.5\ days = x\ bags : 120\ days$

$\frac{1}{3.5} = \frac{X}{120}$

$(1)(120) = (3.5)(x) \Rightarrow 34.29\ bags = X$

13. Suppose you wish to maintain a weir overflow rate of 12,000 gpd/ft (this is 12,000 gpd flow for each one-foot of weir length). If the weir length is 180 ft, what gpd flow will result in the desired weir overflow rate?

$\frac{1200\ gpd}{1\ ft} = \frac{X\ gpd}{180\ ft}$

$(1200)(180) = (1)(X)$

$216{,}000\ gpd = X$

14. A total of 5.4 lbs of hypochlorite are dissolved in 80 gallons of water. For a solution with the same concentration, how many lbs of hypochlorite must be dissolved in 30 gallons of water?

$\frac{5.4\ lb}{80\ gal} = \frac{X\ lb}{30\ gal}$

$(5.4)(30) = (80)(x)$

$2\ lbs = X$

15. A treatment pond is designed for a population loading of 300 persons per acre of pond. If the population to be served is 1240 people, how many acres of treatment pond will be required?

$\frac{300\ persons}{1\ acre} = \frac{1240\ persons}{X\ acres}$

$(300)(x) = (1)(1240)$

$X = 4.1\ acres$

Metric System and Temperature Conversion Practice Problems

Convert the following.

1. 23 g into 23,000 mg $\frac{23\,g}{} \mid \frac{1000\,mg}{g}$
2. 12,456 m into 12.456 km $\frac{12456\,m}{} \mid \frac{1\,Km}{1000\,m}$
3. 4235 mL into 4.235 L $\frac{4235\,mL}{} \mid \frac{1\,L}{1000\,mL}$
4. 200 mg into 0.0002 kg $\frac{200\,mg}{} \mid \frac{1\,g}{1000\,mg} \mid \frac{1\,kg}{1000\,g}$
5. 1000 watts into 1 kwatts $\frac{1000\,w}{} \mid \frac{1\,KW}{1000\,w}$
6. 0.05 g into 50,000 ug $\frac{0.05\,g}{} \mid \frac{1000\,mg}{1\,g} \mid \frac{1000\,ug}{1\,mg}$
7. 20 deciliters into 2,000 mL $\frac{20\,dL}{} \mid \frac{1\,L}{10\,dL} \mid \frac{1000\,mL}{1\,L}$
8. 140 kg into 140,000 g $\frac{140\,kg}{} \mid \frac{1000\,g}{1\,kg}$
9. 9.5 cm into 95 mm $\frac{9.5\,cm}{} \mid \frac{10\,mm}{1\,cm}$
10. ; 100 milliseconds into 0.1 seconds $\frac{100\,ms}{} \mid \frac{1\,sec}{1000\,ms}$

Convert the following. $°F = (9/5)(°C)+32$ $°C = (5/9)(°F-32)$

1. 12 C° into 53.6 F° $(9/5)(12)+32$
2. 80 F° into 26.7 C° $(5/9)(80-32)$
3. 150 F° into 65.6 C° $(5/9)(150-32)$
4. 100 C° into 212 F° $(9/5)(100)+32$
5. 32 F° into 0 C° $(5/9)(32-32)$

Basics:
Use dimensional analysis to determine the **units** of the answers:

1. (0.785)(ft)(ft)(ft) → ft^3

2. (120 ft^3/min)(1440 min/day)

$$\left(\frac{ft^3}{\cancel{min}}\right)\left(\frac{\cancel{min}}{day}\right) = ft^3/day$$

3. $\frac{(8ft)(10ft)(xft)}{sec}$ → ft^3/sec

Verify the mathematical setup for each problem. If the setup is incorrect, correct the setup:

4. (1.6 fpm)(60 sec/min) = fps

$$\left(\frac{ft}{min}\right)\left(\frac{sec}{min}\right) \neq fps \qquad \left(\frac{ft}{\cancel{min}}\right)\left(\frac{\cancel{min}}{sec}\right) = fps$$

incorrect

5. (70 in)(1 ft/12 in)(0.3048 m/ft) = m

$$\left(\frac{70\cancel{in}}{1}\right)\left(\frac{1ft}{12\cancel{in}}\right)\left(\frac{0.3048m}{\cancel{ft}}\right) = m$$

Correct

Complex Fractions:

- ✓ When the units of a given problem are written as a complex fraction:
  - o Invert the denominator and multiply. For example:

$$\frac{2{,}808{,}000 \text{ gpd}}{1440 \text{ min/day}} = \frac{\frac{\text{gal}}{\text{day}}}{\frac{\text{min}}{\text{day}}} = \left[\frac{\text{gal}}{\text{day}}\right]\left[\frac{\text{day}}{\text{min}}\right]$$

  - o Shortcut: If the numerator is the same in both the top and bottom fractions, they will cancel when the bottom fraction inverts and multiplies. The same goes if the denominator is the same in both the top and the bottom fractions.

Use dimensional analysis to determine the **units**:

1. $\frac{(4140 \text{ gpm})}{(60 \text{ sec/min})}$ $\left(\frac{\text{gal}}{\cancel{\text{min}}}\right)\left(\frac{\cancel{\text{min}}}{60\text{sec}}\right) = \frac{\text{gal}}{\text{sec}}$

2. $\frac{(880 \text{ cu ft})(1440 \text{ min/day})}{6.2 \text{ cu ft/day}}$ $\frac{(\text{cu ft})\left(\frac{\text{min}}{\text{day}}\right)}{\frac{\text{cu ft}}{\text{day}}} = \left[\frac{(\cancel{\text{cu ft}})(\text{min})}{\cancel{\text{day}}}\right]\left[\frac{\cancel{\text{day}}}{\cancel{\text{cu ft}}}\right] = \text{min}$

3. $\frac{587 \text{ gal}}{246 \text{ gph}}$ $\frac{\text{gal}}{\frac{\text{gal}}{\text{hr}}} = (\cancel{\text{gal}})\left(\frac{\text{hr}}{\cancel{\text{gal}}}\right) = \text{hr}$

Verify the mathematical setup for each problem. If the setup is incorrect, correct the setup:

4. $\frac{(40 \text{ in})(1.5 \text{ ft})(2.3 \text{ fpm})}{12 \text{ in/ft}} = \text{cfm}$ $\frac{(\text{in})(\text{ft})\left(\frac{\text{ft}}{\text{min}}\right)}{\frac{\text{in}}{\text{ft}}} = \left[\frac{(\cancel{\text{in}})(\text{ft})(\text{ft})}{\text{min}}\right]\left[\frac{\text{ft}}{\cancel{\text{in}}}\right] = \text{ft}^3/\text{min}$

5. $\frac{\left[\frac{2{,}400{,}000 \text{ gpd}}{7.48 \text{ gal/ft}^3}\right]}{635{,}400 \text{ ft}^2} = \text{ft/day}$ Correct

$$\frac{\frac{\frac{\text{gal}}{\text{day}}}{\frac{\text{gal}}{\text{ft}^3}}}{\text{ft}^2} = \left(\frac{\cancel{\text{gal}}}{\text{day}}\right)\left(\frac{\text{ft}^3}{\cancel{\text{gal}}}\right)\left(\frac{1}{\cancel{\text{ft}^2}}\right) = \text{ft/day}$$

Basic Math for Water and Wastewater

Conversions

1% = 10,000 mg/L

mg/L & %

1. 340 mg/L = $\frac{340\ mg/L \mid 1\%}{10{,}000\ mg/L}$ = 0.034 %

2. 0.6% = $\frac{0.6\% \mid 10{,}000}{1\%}$ = 6000 mg/L

3. 120 mg/L = $\frac{120\ mg/L \mid 1\%}{10{,}000\ mg/L}$ = 0.012 %

4. 0.025% = $\frac{0.025\% \mid 10{,}000\ mg/L}{1\%}$ = 250 mg/L

5. 1.5% = $\frac{1.5\% \mid 1\%}{10{,}000\ mg/L}$ = 15,000 mg/L

6. 5000 mg/L = $\frac{5000\ mg/L \mid 1\%}{10000\ mg/L}$ = 0.5 %

7. The suspended solids concentration of the return activated sludge is 6800 mg/L. What is the concentration expressed as a percent?

$$\frac{6800\ mg/L \mid 1\%}{10000\ mg/L} = 0.68\%$$

8. A concentration of 195 mg/L is equivalent to a concentration of what percent?

$$\frac{195\ mg/L \mid 1\%}{10{,}000\ mg/L} = 0.0195\%$$

Metric/English Conversions

9. 20 feet = $\frac{20\ ft \mid 1\ m}{3.28\ ft}$ = 6.1 meters

10. 50 L = $\frac{50\ L \mid 1\ gal}{3.785\ L}$ = 13.2 gal

11. 70 cm = $\frac{70\ cm \mid 1\ in}{2.54\ cm}$ = 27.6 in

12. 35 yds = $\frac{35\text{yds}}{} \left| \frac{1\text{ft}}{3\text{yds}} \right. =$ 105 feet

13. 600 mL = $\frac{600\text{mL}}{} \left| \frac{1\text{L}}{1000\text{mL}} \right| \frac{1\text{gal}}{3.785\text{L}} =$ 0.16 gal

14. 1 lb = $\frac{1\text{lb}}{} \left| \frac{453.6\text{g}}{1\text{lb}} \right| \frac{1000\text{mg}}{1\text{g}} =$ 453,600 mg

15. 1000 mL = $\frac{1000\text{mL}}{} \left| \frac{1\text{L}}{1000\text{mL}} \right. =$ 1 L

16. 2.7 gal = $\frac{2.7\text{gal}}{} \left| \frac{3.785\text{L}}{1\text{gal}} \right| \frac{1000\text{mL}}{1\text{L}} =$ 10,219.5 mL

Linear Measurement

17. ¼ mile = $\frac{0.25\text{mi}}{} \left| \frac{5280\text{ft}}{1\text{mi}} \right. =$ 1320 feet

18. 4200 feet = $\frac{4200\text{ft}}{} \left| \frac{1\text{mi}}{5280\text{ft}} \right. =$ 0.8 miles

19. 17 feet = $\frac{17\text{ft}}{} \left| \frac{1\text{yd}}{3\text{ft}} \right. =$ 5.7 yds

20. 122 inches = $\frac{122\text{in}}{} \left| \frac{1\text{ft}}{12\text{in}} \right. =$ 10.2 feet

21. 30 yds = $\frac{30\text{yd}}{} \left| \frac{3\text{ft}}{1\text{yd}} \right| \frac{12\text{in}}{1\text{ft}} =$ 1080 inches

22. 0.6 feet = $\frac{0.6\text{ft}}{} \left| \frac{12\text{in}}{1\text{ft}} \right. =$ 7.2 inches

23. 492 inches = $\frac{492\text{in}}{} \left| \frac{1\text{ft}}{12\text{in}} \right. =$ 41 feet

24. The total weir length for a sedimentation tank is 142 feet 7 inches. Express this length in terms of feet only.

$\frac{7\text{in}}{} \left| \frac{1\text{ft}}{12\text{in}} \right. = 0.5833\text{ft} + 142\text{ft} = 142.58\text{ft}$

25. A one-eighth mile section of pipeline is to be replaced. How many feet of pipeline is this? $1/8 = 0.125$

$$\frac{0.125\ \text{mi}}{1} \left| \frac{5280\ \text{ft}}{1\ \text{mi}} \right. = 660\ \text{ft}$$

26. 2.7 miles of pipe is how many inches?

$$\frac{2.7\ \text{mi}}{1} \left| \frac{5280\ \text{ft}}{1\ \text{mi}} \right| \frac{12\ \text{in}}{1\ \text{ft}} = 171{,}072\ \text{in}$$

Area Measurement

27. 1017 in^2 = $\frac{1017\ \text{in}^2}{1} \left| \frac{1\ \text{ft}^2}{144\ \text{in}^2} \right. =$ 7.1 ft^2

28. 500 yd^2 = $\frac{500\ \text{yd}^2}{1} \left| \frac{9\ \text{ft}^2}{1\ \text{yd}^2} \right. =$ 4500 ft^2

29. 4 acres = $\frac{4\ \text{ac}}{1} \left| \frac{43560\ \text{ft}^2}{1\ \text{ac}} \right. =$ 174,240 ft^2

30. 1 yd^2 = $\frac{1\ \text{yd}^2}{1} \left| \frac{9\ \text{ft}^2}{1\ \text{yd}^2} \right| \frac{144\ \text{in}^2}{1\ \text{ft}^2} =$ 1296 in^2

31. 9.5 ft^2 = $\frac{9.5\ \text{ft}^2}{1} \left| \frac{144\ \text{in}^2}{1\ \text{ft}^2} \right. =$ 1368 in^2

32. 78.5 in^2 = $\frac{78.5\ \text{in}^2}{1} \left| \frac{1\ \text{ft}^2}{144\ \text{in}^2} \right. =$ 0.5 ft^2

33. 25,000 ft^2 = $\frac{25{,}000\ \text{ft}^2}{1} \left| \frac{1\ \text{ac}}{43560\ \text{ft}^2} \right. =$ 0.6 acres

34. 0.9 acre = $\frac{0.9\ \text{ac}}{1} \left| \frac{43560\ \text{ft}^2}{1\ \text{ac}} \right. =$ 39,204 ft^2

35. For solids treatment, a total of 60,000 ft^2 will be required. How many acres is this?

$$\frac{60000\ \text{ft}^2}{1} \left| \frac{1\ \text{ac}}{43560\ \text{ft}^2} \right. = 1.4\ \text{ac}$$

36. A pipe has a cross-sectional area of 452 in^2. How many ft^2 is this?

$$\frac{452\ \text{in}^2}{1} \left| \frac{1\ \text{ft}^2}{144\ \text{in}^2} \right. = 3.1\ \text{ft}^2$$

Volume Measurement

37. 325 ft^3 = $\frac{325\ ft^3}{} \left| \frac{1\ yd}{27\ ft^3} \right.$ = 12 yd^3

38. 2512 in^3 = $\frac{2512\ in^3}{} \left| \frac{ft^3}{1728\ in^3} \right.$ = 1.5 ft^3

39. 25 yd^3 = $\frac{25\ yd^3}{} \left| \frac{27\ ft^3}{1\ yd^3} \right.$ = 675 ft^3

40. 1500 in^3 = $\frac{1500\ in^3}{} \left| \frac{1\ ft^3}{1728\ in^3} \right.$ = 0.9 ft^3

41. 2.2 ac-ft = $\frac{2.2\ ac\text{-}ft}{} \left| \frac{43560\ ft^3}{1\ ac\ ft} \right| \frac{1\ yd^3}{27\ ft^3}$ = 3549 yd^3

42. 21 ft^3 = $\frac{21\ ft^3}{} \left| \frac{1\ yd^3}{27\ ft^3} \right.$ = 0.8 yd^3

43. 92,600 ft^3 = $\frac{92600\ ft^3}{} \left| \frac{1\ ac\text{-}ft}{43560\ ft^3} \right.$ 2.1 ac-ft

44. 17,260 ft^3 = $\frac{17260\ ft^3}{} \left| \frac{1\ yd^3}{27\ ft^3} \right.$ 639 yd^3

45. 0.6 yd^3 = $\frac{0.6\ yd^3}{} \left| \frac{27\ ft^3}{1\ yd^3} \right.$ 16.2 ft^3

46. 3 ft^3 = $\frac{3\ ft^3}{} \left| \frac{1728\ in^3}{1\ ft^3} \right.$ 5184 in^3

47. A screening pit must have a capacity of 400 ft^3. How many yd^3 is this?

$\frac{400\ ft^3}{} \left| \frac{1\ yd^3}{27\ ft^3} \right.$ = 14.8 yd^3

48. A reservoir contains 50 ac-ft of water. How many ft^3 of water does it contain?

$\frac{50\ ac\text{-}ft}{} \left| \frac{43560\ ft^3}{1\ ac\text{-}ft} \right.$ = 2,178,000 ft^3

Flow Conversions

49. 3.6 cfs = $\frac{3.6\ ft^3}{sec} \mid \frac{7.48\ gal}{1\ ft^3} \mid \frac{60\ sec}{min} = 1616$ gpm

50. 1820 gpm = $\frac{1820\ gal}{min} \mid \frac{1440\ min}{day} = 2,620,800$ gpd

51. 45 gps = $\frac{45\ gal}{sec} \mid \frac{1\ ft^3}{7.48\ gal} =$ 6 cfs

52. 8.6 MGD = $\frac{8.6\ MG}{day} \mid \frac{1000000\ gal}{1\ MG} \mid \frac{1\ day}{1440\ min} =$ 5972 gpm

53. 2.92 MGD = $\frac{2.92\ MG}{day} \mid \frac{1000000\ gal}{1\ MG} \mid \frac{1\ day}{1440\ min} =$ 2028 gpm

54. 385 cfm = $\frac{385\ ft^3}{min} \mid \frac{7.48\ gal}{1\ ft^3} \mid \frac{1440\ min}{1\ day} =$ 4,146,912 gpd

55. 1,662,000 gpd = $\frac{1662000\ gal}{day} \mid \frac{1\ day}{1440\ min} = 1154$ gpm

56. 3.77 cfs = $\frac{3.77\ ft^3}{sec} \mid \frac{7.48\ gal}{1\ ft^3} \mid \frac{1\ MG}{1000000\ gal} \mid \frac{60\ s}{min} \mid \frac{1440\ MGD}{1\ day} = 2.4\ MGD$

57. The flow through a pipeline is 8.4 cfs. What is the flow in gpd?

$\frac{8.4\ ft^3}{sec} \mid \frac{7.48\ gal}{1\ ft^3} \mid \frac{60\ sec}{1\ min} \mid \frac{1440\ min}{day} = 5,428,685$ gpd

58. A treatment plant receives a flow of 6.31 MGD. What is the flow in gpm?

$\frac{6.31\ MG}{day} \mid \frac{1000000\ gal}{1\ MG} \mid \frac{1\ day}{1440\ min} = 4382$ gpm

Basic Math for Water and Wastewater
Basic Conversions Extra Problems

1. How many seconds are in a minute?

$60\ sec = 1\ min \Rightarrow 60\ sec/min$

2. How many minutes are in an hour?

$60\ min = 1\ hr \Rightarrow 60\ min/hr$

3. How many hours in a day?

$24\ hrs = 1\ day \Rightarrow 24\ hr/day$

4. How many minutes in a day?

$$\frac{60\ min}{1\ hr} \left| \frac{24\ hr}{1\ day} \right. = 1440\ min/day$$

5. How many inches in a foot?

$12\ in = 1\ ft \Rightarrow 12\ in/ft$

6. How many feet in a mile?

$5280\ ft = 1\ mile \Rightarrow 5280\ ft/mi$

7. How many feet in a yard?

$3\ ft = 1\ yd \Rightarrow 3\ ft/yd$

8. How many yards in a mile?

$$\frac{1\ yd}{3\ ft} \left| \frac{5280\ ft}{1\ mile} \right. = 1760\ yd/mi$$

9. How much does one gallon of water weigh?

$1\ gal = 8.34\ lb \Rightarrow 8.34\ lb/gal$

10. How much does one cubic foot of water weigh?

$$\frac{1\ ft^3}{} \left| \frac{7.48\ gal}{1\ ft^3} \right| \frac{8.34\ lb}{gal} = 62.4\ lb/ft^3$$

11. Express a flow of 5 cfs in terms of gpm.

$$\frac{5\ ft^3}{sec} \left| \frac{7.48\ gal}{1\ ft^3} \right| \frac{60\ sec}{1\ min} = 2244\ gpm$$

12. What is 38 gps expressed as gpd?

$(38\text{ gps})(60)(1440) = 3{,}283{,}200\text{ gpd}$

13. What is 0.7 cfs expressed as gpd?

$(0.7\text{ cfs})(60)(1440)(7.48) = 452{,}390\text{ gpd}$

14. What is 9164 gpm expressed as cfs?

$9164\text{ gpm} / 60 = 152.733 / 7.48 = 20.42\text{ cfs}$

15. What is 1.2 cfs expressed as MGD?

$$\frac{(1.2\text{ cfs})(7.48)(60)(1440)}{1{,}000{,}000} = 0.78\text{ MGD}$$

16. Convert 65 gpm into lbs/day.

$$\frac{65\text{ gal}}{\text{min}} \left| \frac{8.34\text{ lbs}}{1\text{ gal}} \right| \frac{1440\text{ min}}{1\text{ day}} = 780{,}624\text{ lb/day}$$

17. Convert 345 lbs/day into gpm.

$$\frac{345\text{ lb}}{\text{day}} \left| \frac{1\text{ gal}}{8.34\text{ lb}} \right| \frac{1\text{ day}}{1440\text{ min}} = 0.03\text{ gpm}$$

18. Convert 0.9 MGD to cfm.

$$\frac{0.9\text{ MG}}{\text{day}} \left| \frac{1000000\text{ gal}}{1\text{ MG}} \right| \frac{1\text{ ft}^3}{7.48\text{ gal}} \left| \frac{1\text{ day}}{1440\text{ min}} \right. = 83.56\text{ cfm}$$

19. Convert 1.2 MGD to ft^3/hour.

$$\frac{1.2\text{ MG}}{\text{day}} \left| \frac{1000000\text{ gal}}{1\text{ MG}} \right| \frac{1\text{ ft}^3}{7.48\text{ gal}} \left| \frac{1\text{ day}}{24\text{ hr}} \right. = 6684.49\text{ cfh}$$

20. Convert a flow of 4,270,000 gpd to cfm.

$$\frac{4270000\ \text{gal}}{\text{day}} \left| \frac{1\ \text{ft}^3}{7.48\ \text{gal}} \right| \frac{1\ \text{day}}{1440\ \text{min}} = 396.43\ \text{cfm}$$

21. What is 5.6 MGD expressed as cfs?

$$\frac{5.6\ \text{MG}}{\text{day}} \left| \frac{1000000\ \text{gal}}{1\ \text{MG}} \right| \frac{1\ \text{ft}^3}{7.48\ \text{gal}} \left| \frac{1\ \text{day}}{1440\ \text{min}} \right| \frac{1\ \text{min}}{60\ \text{sec}} = 8.67\ \text{cfs}$$

22. Express 423,690 cfd as gpm.

$$\frac{423{,}690\ \text{ft}^3}{\text{day}} \left| \frac{7.48\ \text{gal}}{1\ \text{ft}^3} \right| \frac{1\ \text{day}}{1440\ \text{min}} = 2200.83\ \text{gpm}$$

23. Convert 2730 gpm to gpd.

$$\frac{2730\ \text{gal}}{\text{min}} \left| \frac{1440\ \text{min}}{\text{day}} \right. = 3{,}931{,}200\ \text{gpd}$$

24. Convert 1440 gpm to MGD.

$$\frac{1440\ \text{gal}}{\text{min}} \left| \frac{1440\ \text{min}}{\text{day}} \right| \frac{1\ \text{MG}}{1000000\ \text{gal}} = 2.07\ \text{MGD}$$

25. Convert 45 gps to ft^3/day.

$$\frac{45\ \text{gal}}{\text{sec}} \left| \frac{1\ \text{ft}^3}{7.48\ \text{gal}} \right| \frac{60\ \text{sec}}{1\ \text{min}} \left| \frac{1440\ \text{min}}{1\ \text{day}} \right. = 519{,}786.10\ \text{cfd}$$

Basic Math for Water and Wastewater
AREA, VOLUME, AND LENGTH CONVERSIONS

Conversions

1. How many yards is 350 ft?
$$\frac{350\text{ ft} \mid 1\text{ yd}}{\mid 3\text{ ft}} = 116.67\text{ ft}$$
2. How many inches is 30 ft?
$$\frac{30\text{ ft} \mid 12\text{ in}}{\mid 1\text{ ft}} = 360\text{ in}$$
3. How many miles is 10,000 ft?
$$\frac{10000\text{ ft} \mid 1\text{ mi}}{\mid 5280\text{ ft}} = 1.89\text{ mi}$$
4. Convert 4 miles into ft.
$$\frac{4\text{ mi} \mid 5280\text{ ft}}{\mid 1\text{ mi}} = 21120$$
5. Convert 3 ft into inches.
$$\frac{3\text{ ft} \mid 12\text{ in}}{\mid 1\text{ ft}} = 36\text{ in}$$
6. Convert 1 mile into yds.
$$\frac{1\text{ mi} \mid 5280\text{ ft} \mid 1\text{ yd}}{\mid 1\text{ mi} \mid 3\text{ ft}} = 1760\text{ yd}$$
7. Convert 40 inches into ft.
$$\frac{40\text{ in} \mid 1\text{ ft}}{\mid 12\text{ in}} = 3.33\text{ ft}$$
8. Convert 50 yds into ft.
$$\frac{50\text{ yd} \mid 3\text{ ft}}{\mid 1\text{ yd}} = 150\text{ ft}$$
9. How many inches are in one mile?
$$\frac{1\text{ mi} \mid 5280\text{ ft} \mid 12\text{ in}}{\mid 1\text{ mi} \mid 1\text{ ft}} = 63{,}360\text{ in}$$
10. How many ft long is a football field? (HINT: without end zones = 100 yds)
$$\frac{100\text{ yd} \mid 3\text{ ft}}{\mid 1\text{ yd}} = 300\text{ ft}$$

Area

1. A basin has a length of 45 feet and a width of 12 feet. Calculate the area in ft^2.

$A = (L)(W)$

$A = (45\text{ ft})(12\text{ ft})$

$A = 540\text{ ft}^2$

2. Calculate the surface area of a basin which is 90 feet long, 25 feet wide, and 10 feet deep.

$A = (L)(W)$

$A = (90\,ft)(25\,ft)$

$A = 2250\,ft^2$

3. Calculate the area (in ft^2) for a 2 ft diameter main that has just been laid.

$A = (0.785)(D)^2$

$A = (0.785)(2\,ft)(2\,ft)$

$A = 3.14\,ft^2$

4. Calculate the area (in ft^2) for an 18" main that has just been laid.

$18/12 = 1.5\,ft$ $A = (0.785)(D)^2$

$A = (0.785)(1.5\,ft)(1.5\,ft)$

$A = 1.77\,ft^2$

Volume

5. Calculate the volume (in ft^3) for a tank that measures 10 feet by 10 feet by 10 feet.

$V = (L)(W)(D)$

$V = (10\,ft)(10\,ft)(10\,ft)$

$V = 1{,}000\,ft^3$

6. Calculate the volume (in gallons) for a basin that measures 22 feet by 11 feet by 5 feet.

$V = (L)(W)(D)$

$V = (22\,ft)(11\,ft)(5\,ft)$

$V = (1210\,ft^3)(7.48\,gal/ft^3)$

$V = 9050.8\,gal$

7. Calculate the volume of water in a tank (in gallons), which measures 12 feet long, 6 feet wide, 5 feet deep, and contains 8 inches of water.

$8/12 = 0.6667\,ft$

$Vol, gal = (L)(W)(D)(7.48\,gal/ft^3)$

$= (12\,ft)(6\,ft)(0.6667\,ft)(7.48\,gal/ft^3)$

$= 359.04\,gal$

8. A new water main needs to be disinfected. The main is 30" in diameter and has a length of 0.25 miles. How many gallons of water will it hold?

$(0.25 mi)(5280 ft/mi) = 1320 ft$ $\quad 30 in / 12 = 2.5 ft$

$Vol = (0.785)(2.5ft)(2.5ft)(1320 ft)$

$Vol, ft^3 = (6476.25 ft^3)(7.48 gal/ft^3)$

$Vol, gal = 48,442.35 gal$

9. A 3 million gallon water tank needs to be disinfected. The method you will use requires you to calculate 5% of the tank volume. How many gallons will this be?

5% of 3MG is what?

$(0.05)(3,000,000 gal) = 150,000 gal$

DON'T THINK TOO HARD ON THIS ONE...

10. If you double the size of a pipe, does it double the volume that can be carried? For example, if you have 1000 feet of 12 inch line and you replace it with a 24 inch line, does your volume double?

$Vol_{12in} = (0.785)(1ft)(1ft)(1000ft)$

$= (785 ft^3)(7.48 gal/ft^3)$

$Vol_{12in} = 5871.8 gal$

$Vol_{24in} = (0.785)(2ft)(2ft)(1000ft)$

$= (3140 ft^3)(7.48 gal/ft^3)$

$Vol_{24in} = 23487.2 gal$

$$\frac{23487.2 gal}{5871.8 gal} = 4$$

The volume of the 24 in line is 4 times the volume of the 12 inch line.

Applied Math for Distribution
Flow and Velocity

Velocity

1. A cork is placed in a channel and travels 370 feet in 2 minutes. What is the velocity of the wastewater in the channel, ft/min?

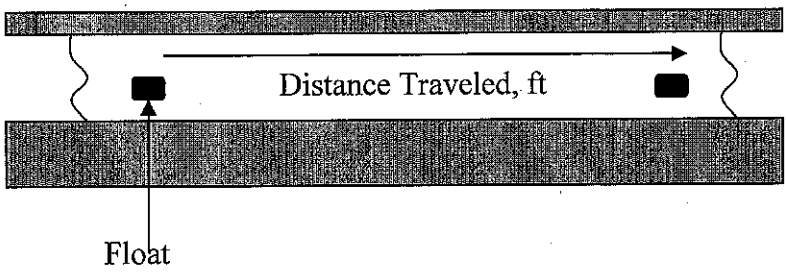
$V = \frac{\text{distance}}{\text{time}}$ $V = \frac{370\text{ ft}}{2\text{ min}} = 185\text{ ft/min}$

2. A float travels 300 feet in a channel in 2 minutes and 14 seconds. What is the velocity in the channel, ft/sec? 2 min 14 sec = 2(60) + 14 = 134 sec

$V = \frac{300\text{ ft}}{134\text{ sec}} = 2.24\text{ ft/sec}$

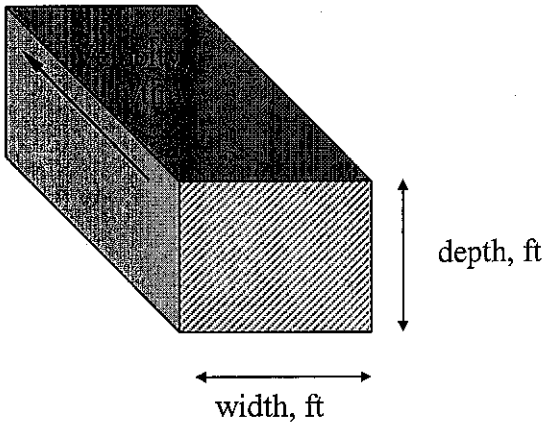
3. The distance between manhole #1 and manhole #2 is 105 feet. A fishing bobber is dropped into manhole #1 and enters manhole #2 in 30 seconds. What is the velocity of the wastewater in the sewer in ft/min? 30 sec = 0.5 min

$V = \frac{105\text{ ft}}{0.5\text{ min}} = 210\text{ ft/min}$



$\text{Velocity} = \frac{\text{Distance Traveled, ft}}{\text{Duration of Test, min}}$

$= \text{ft/min}$



Q	=	(A)	(V)
ft^3/time		(ft)(ft)	(ft/time)

A = (width)(depth)

Flow in a channel

4. A channel 48 inches wide has water flowing to a depth of 1.5 feet. If the velocity of the water is 2.8 ft/sec, what is the flow in the channel in cu ft/sec? 48 in = 4 ft

$Q = (4ft)(1.5ft)(2.8\ ft/sec)$

$Q = 16.8\ ft^3/sec$

5. A channel 3 feet wide has water flowing to a depth of 2.5 feet. If the velocity through the channel is 120 feet/min, what is the flow rate in cu ft/min? in MGD?

$Q = (3ft)(2.5ft)(120\ ft/min)$

$Q = 900\ ft^3/min$ ⟶ use flow chart to convert

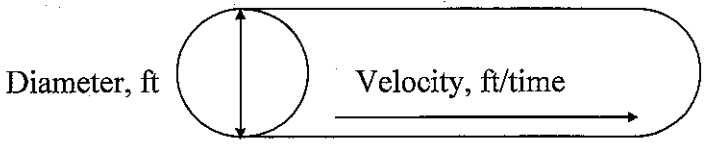
$Q = 9.69$ MGD

6. A channel is 3 feet wide and has water flowing at a velocity of 1.5 ft/sec. If the flow through the channel is 8.1 ft^3/sec, what is the depth of the water in the channel in feet?

$8.1\ ft^3/sec = (3ft)(depth)(1.5\ ft/sec)$

$\frac{8.1\ ft^3/sec}{(3ft)(1.5\ ft/sec)} = depth$

$1.8ft = depth$



$$\underset{ft^3/time}{Q} = \underset{ft^2}{(A)}\ \underset{(ft/time)}{(V)}$$

$$\underset{ft^3/time}{Q} = (0.785)\underset{(ft)(ft)}{(D)^2}\ \underset{(ft/time)}{(vel)}$$

Flow through a full pipe

7. The flow through a 2 ft diameter pipeline is moving at a velocity of 3.2 ft/sec. What is the flow rate in cu ft/sec?

$Q = (0.785)(2ft)^2(3.2\ ft/sec)$

$Q = (0.785)(4ft^2)(3.2\ ft/sec)$

$Q = 10.05\ ft^3/sec$

8. The flow through a 6 inch diameter pipeline is moving at a velocity of 3 ft/sec. What is the flow rate in ft^3/sec? $6\ in = 0.5ft$

$Q = (0.785)(0.5)(0.5)(3\ ft/sec)$

$Q = 0.59\ ft^3/sec$

9. The flow through a pipe is 0.7 ft^3/sec. If the velocity of the flow is 3.6 ft/sec, and the pipe is flowing full, what is the diameter of the pipe in inches?

$0.7\ ft^3/sec = (0.785)(D)^2(3.6\ ft/sec)$

$\frac{0.7\ ft^3/sec}{(0.785)(3.6\ ft/sec)} = D^2$

$\sqrt{0.2477\ ft^2} = \sqrt{D^2} \longrightarrow D = 0.50\ ft = 6\ in$

10. An 8 inch diameter pipeline has water flowing at a velocity of 3.4 ft/sec. What is the flow rate in gpm?

$\frac{8\ in}{1} \left| \frac{1\ ft}{12\ in} \right. = 0.667\ ft$

$Q = (0.785)(0.6667\ ft)^2(3.4\ ft/sec)$

$Q = 1.1862\ ft^3/sec \longrightarrow$ use flow chart

$Q = 532.4\ gal/min$

Basic Math for Water and Wastewater
FLOW RATE

$Q = AV$

1. A channel is 3 feet wide with water flowing to a depth of 2 feet. If the velocity in the channel is found to be 1.8 fps, what is the cubic feet per second flow rate in the channel?

$Q = (A)(V) = (L)(W)(Vel)$

$Q, ft^3/sec = (3\,ft)(2ft)(1.8\,ft/sec)$

$= 10.8\,ft^3/sec$

2. A 12-inch diameter pipe is flowing full. What is the cubic feet per minute flow rate in the pipe if the velocity is 110 feet/min?

$Q, ft^3/min = (0.785)(D)^2(Vel)$

$= (0.785)(1ft)(1ft)(110\,ft/min)$

$= 86.35\,ft^3/min$

3. A water main with a diameter of 18 inches is determined to have a velocity of 182 feet per minute. What is the flow rate in gpm? $18/12 = 1.5\,ft$

$Q = (0.785)(1.5ft)(1.5ft)(182\,ft/min)$

$Q = (321.4575\,ft^3/min)(7.48\,gal/ft^3)$

$Q = 2{,}404.50\,gal/min$

4. A 24-inch main has a velocity of 212 feet/min. What is the gpd flow rate for the pipe?

$24/12 = 2ft$

$Q = (0.785)(2ft)(2ft)(212\,ft/min)$

$Q = (665.68\,ft^3/min)(7.48\,gal/ft^3)(1440\,min/day)$

$Q = 7{,}170{,}172.42\,gal/day$

5. What would be the gpd flow rate for a 6" line flowing at 2 feet/second?

$6/18 = 0.5ft$

$Q = (0.785)(0.5ft)(0.5ft)(2\,ft/sec)$

$Q = (0.3925\,ft/sec)(7.48\,gal/ft^3)$

$Q = (2.9359\,gal/sec)(60\,sec/min)(1440\,min/day)$

$Q = 253{,}661.76\,gal/day$

6. A 36" water main has just been installed. According to the Design Criteria for the State of Tennessee, the minimum flushing velocity is 2 ft/sec. If the main is flushed at 2.5 ft/second, how many gallons/minute should be flushed from the hydrant?

$36/12 = 3ft$

$Q = (0.785)(3ft)(3ft)(2.5\ ft/sec)$

$Q = (17.6625\ ft^3/sec)(7.48\ gal/ft^3)(60\ sec/min)$

$Q = 7926.93\ gal/min$

7. A 36" water main has just been installed. If the main is flows at 2 ft/second, how many MGD will the pipe deliver?

$36/12 = 3ft$

$Q = (0.785)(3\ ft)(3ft)(2\ ft/sec)$

$$Q = \frac{(14.13\ ft^3/sec)(7.48\ gal/ft^3)(60\ sec/min)(1440\ min/day)}{1000\,000\ gal/MG}$$

$Q = 9.13\ MGD$

8. A certain pipe has a diameter of 18 inches. If the pipe is flowing full, and the water is known to flow a distance of 830 yards in 5 minutes, what is the MGD flow rate for the pipe?

$18/12 = 1.5ft$

$(830\ yd)(3\ ft/yd) = 2490\ ft$

$Vel = 2490ft / 5min = 498\ ft/min$

$Q = (0.785)(1.5\ ft)(1.5\ ft)(498\ ft/min)$

$$Q = \frac{(879.5925\ ft^3/min)(7.48\ gal/ft^3)(1440\ min/day)}{1,000,000\ gal/MG}$$

$Q = 9.47\ MGD$

VELOCITY (Open Channel)

9. A float is placed in a channel. It takes 2.5 minutes to travel 300 feet. What is the velocity in feet per minute in the channel? (Assume that float is traveling at the average velocity of the water.)

$$Vel = \frac{300ft}{2.5min} = 120\ ft/min$$

10. A cork placed in a channel travels 30 feet in 20 seconds. What is the velocity of the cork in feet per second?

$$Vel = \frac{30\ ft}{20\ sec} = 1.5\ ft/sec$$

11. A channel is 4 feet wide with water flowing to a depth of 2.3 feet. If a float placed in the channel takes 3 minutes to travel a distance of 500 feet, what is the cubic-feet-per-minute flow rate in the channel?

$$Vel = 500\ ft / 3\ min = 166.6667\ ft/min$$
$$Q = (4\ ft)(2.3\ ft)(166.6667\ ft/min)$$
$$Q = 1533.33\ ft^3/min$$

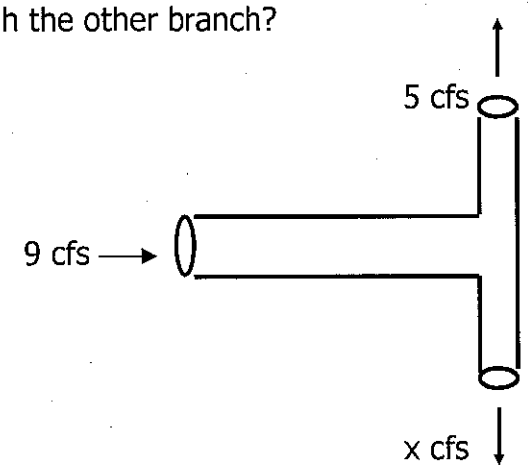
FLOW

12. The average velocity in a full-flowing pipe is measured and known to be 2.9 fps. The pipe is a 24" main. Assuming that the pipe flows 18 hours per day and that the month in question contains 31 days, what is the total flow for the pipe in MG for that month?

$$Q = (0.785)(2ft)(2ft)(2.9\ ft/sec)$$
$$Q = \frac{(9.106\ ft^3/sec)(7.48\ gal/ft^3)(60\ sec/min)(18\ hr/day)(60\ min/hr)}{1000000\ gal/MG} = 4.41\ MG/day$$
$$(4.41\ MG/day)(31\ days) = 136.83\ MG$$

13. The flow entering the leg of a tee connection is 9 cfs. If the flow through one branch of the tee is 5 cfs, what is the flow through the other branch?

$$9\ cfs - 5\ cfs = \boxed{4\ cfs}$$



More Velocity and Flow Problems

1. A float travels 500 ft in a channel in 5 minutes and 22 seconds. What is the velocity in ft/sec?
   $(5\,min)(60\,sec/min) = 300\,sec$
   $Vel = \frac{500\,ft}{300\,sec} = 1.67\,ft/sec$

2. A cork is placed in a channel and travels 50 ft in 9 seconds, what is the velocity in ft/ min?
   $Vel = \frac{50\,ft}{9\,sec} = (5.5556\,ft/sec)(60\,sec/min) = 333.33\,ft/min$

3. A car travels at a speed of 60 mph, what is the velocity in ft/sec?
   $\frac{60\,mi}{hr} \left| \frac{5280\,ft}{1\,mi} \right| \frac{1\,hr}{60\,min} \left| \frac{1\,hr}{60\,sec} \right. = 88\,ft/sec$

4. The distance between a manhole A and manhole B is 400 ft. A float is dropped into manhole A and enters manhole B in 2 minutes and 30 seconds. What is the velocity of the water in ft/min? $30/60 = 0.5\,min + 2\,min = 2.5\,min$
   $Vel = \frac{400\,ft}{2.5\,min} = 160\,ft/min$

5. A garden snail travelled 15 inches in 10 minutes, what is the snail's velocity in ft/min? $15/12 = 1.25\,ft$
   $Vel = \frac{1.25\,ft}{10\,min} = 0.125\,ft/min$

6. A channel 3 ft wide has water flowing to a depth of 11 inches. If the velocity of the water is 3.2 ft/sec, what is the flow through the channel in ft^3 /sec? $11/12 = 0.9167\,ft$
   $Q = (3\,ft)(0.9167\,ft)(3.2\,ft/sec)$
   $Q = 8.8\,ft^3/sec$

7. A channel 30 inches wide has water flowing at a depth of 2 ft. If the length of the channel is 5,000 ft and the velocity through the channel is 2.5 ft/sec, what is the flow through the channel in ft^3 /sec ? $30/12 = 2.5\,ft$
   $Q = (2.5\,ft)(2\,ft)(2.5\,ft/sec)$
   $Q = 12.5\,ft^3/sec$

8. A channel is 2.5 ft wide and the water is flowing at a velocity of 3 ft/sec. I f the flow through the channel is measured to be 6.4 ft^3 / sec, what is the depth of the water in the channel in ft? $Q = (L)(W)(vel)$

$6.4\ ft^3/sec = (d)(2.5ft)(3ft/sec) \Rightarrow 0.85\ ft = depth$

9. A channel is 3 ft wide and the water is flowing at a velocity of 210 ft/ min. If the water is 6 inches deep in the channel, what is the flow through the channel in gpm?

$6/12 = 0.5ft$

$Q = (3ft)(0.5ft)(210\ ft/min)$

$Q = (315\ ft^3/min)(7.48\ gal/ft^3)$

$Q = 2356.2\ gal/min$

10. A channel is 24 inches wide and has water to a depth of 18 inches. If the water is flowing at a velocity of 2.9 ft/sec, what is the flow rate in cubic feet/min?

$24/12 = 2ft$ $\quad Q = (2ft)(1.5ft)(2.9\ ft/sec)$

$18/12 = 1.5ft$ $\quad Q = (8.7\ ft^3/sec)(60\ sec/min) = 522\ ft^3/min$

11. The flow through a channel is 100 gpm. If the channel is 3 ft wide and has water to a depth of 2 ft, what is the velocity of the water in ft/sec?

$\left(\frac{100gal}{min}\right)\left(\frac{1ft^3}{7.48gal}\right)\left(\frac{1min}{60sec}\right) = 0.2228\ ft^3/sec$

$0.2228ft^3/sec = (3ft)(2ft)(x\ ft/sec)$

$0.037\ ft/sec = x$

12. The flow through a 3 ft diameter pipeline is moving at a velocity of 4 ft/sec. What is the flow through the pipe in cubic feet/sec?

$Q = (0.785)(3ft)(3ft)(4ft/sec)$

$Q = 28.26\ ft^3/sec$

13. The flow through a 10 inch diameter pipe is moving at a velocity of 2 ft/sec. What is the flow rate in cubic ft/sec? $10/12 = 0.8333ft$

$Q = (0.785)(0.8333ft)(0.8333ft)(2\ ft/sec)$

$Q = 1.09\ ft^3/sec$

14. A 6 inch diameter pipe has water flowing at a velocity of 120 ft/min. What is the flow rate in gpm? $6/12 = 0.5ft$

$Q = (0.785)(0.5ft)(0.5ft)(120\ ft/min)$

$Q = (23.55\ ft^3/min)(7.48\ gal/ft^3) = 176.15\ gal/min$

15. The flow through a pipe is 0.82 ft^3/sec. If the velocity of the flow is 1.5 ft/sec, and the pipe is flowing full, what is the diameter of the pipe in inches?

$0.82\,ft^3/sec = (0.785)(d)^2(1.5\,ft/sec) \Rightarrow 0.6964 = d^2 \Rightarrow 0.83 = d$

16. A 2 ft main has water flowing at a velocity of 4.1 ft /sec. What is the flow through the pipe in gph?

$Q = (0.785)(2\,ft)(2\,ft)(4.1\,ft/sec)$

$Q = (12.874\,ft^3/sec)(7.48\,gal/ft^3)(60\,sec/min)(60\,min/hr)$

$Q = 346{,}671.07\,gal/hr$

17. A 3 ft diameter main has just been installed. According to the Design Criteria for the State of Tennessee, the minimum flushing velocity is 2.5 ft/sec. if the main is flushed at a velocity of 3 ft/sec, how many gallons per minute will be flushed from the hydrant? $Q = (0.785)(3ft)(3ft)(2.5\,ft/sec)$

$Q = (17.6625\,ft^3/sec)(7.48\,gal/ft^3)(60\,sec/min)$

$Q = 7926.93\,gal/min$

18. A pipe has a diameter of 24 inches. If the pipe is flowing full, and the water is known to flow a distance of 200 ft in 3 minutes, what is the flow rate for the pipe in MGD? $24/12 = 2ft$ $Q = (0.785)(2\,ft)(2ft)(200\,ft/3min) = 209.3333\,ft^3/min$

$$Q = \frac{(209.3333\,ft^3/min)(7.48\,gal/ft^3)(1440\,min/day)}{1000000\,gal/MG} = 2.25\,MGD$$

19. What is the flow rate in gpd for a 6 inch main flowing at a velocity of 220 ft/min? $6/12 = 0.5\,ft$

$Q = (0.785)(0.5ft)(0.5\,ft)(220\,ft/min)$

$Q = (43.175\,ft^3/min)(7.48\,gal/ft^3)(1440\,min/day)$

$Q = 465046.56\,gal/day$

20. If the flow through a 10 inch diameter pipe is 3.2 MGD, what is the velocity of the water in ft /sec? $10/12 = 0.83ft$

$$\frac{3.2\,MG}{day}\left|\frac{1000000\,gal}{1\,MG}\right|\frac{1\,day}{1440\,min}\left|\frac{1\,min}{60\,sec}\right|\frac{ft^3}{7.48\,gal} = 4.9515\,ft^3/sec$$

$Vel = \frac{4.9515\,ft^3/sec}{(0.785)(0.83ft)(0.83ft)}$ $Vel = 9.08\,ft/sec$

21. The flow through a pipe is 320 gpm. If the velocity through the pipe is 3.6 ft/sec what is the diameter of the pipe in inches?

$$\frac{320\,gal}{min}\left|\frac{ft^3}{7.48\,gal}\right|\frac{min}{60\,sec} = 0.7130\,ft^3/sec$$

$0.7130\,ft^3/sec = (0.785)(D^2)(3.6\,ft/s)$

$\frac{0.7130\,ft^3/sec}{(0.785)(3.6\,ft/sec)} = D^2$

$\sqrt{0.25} = \sqrt{D^2}$

$0.5\,ft = D$

22. A certain pipe has a diameter of 10 inches. If the water in the pipe is known to travel 200 yds in 3 minutes, what is the flow rate for the pipe in gpd? $10/12 = 0.8333ft$

More Velocity and Flow Problems Answers

1. 1.55 ft/sec
2. 333.3 ft/sec
3. 88 ft/sec
4. 160 ft/min
5. 0.125 ft/min
6. 8.83 ft^3/sec
7. 12.5 ft^3/sec
8. 0.853 ft
9. 2,356 gpm
10. 522 ft^3/min
11. 0.037 ft/sec
12. 28.3 ft^3/sec
13. 1.089 ft^3/sec
14. 176 gpm
15. 10 in
16. 346,671 gph
17. 9,512 gpm
18. 2.25 MGD
19. 443,908 gpd
20. 9.09 ft sec
21. 6 in
22. 1,173,420 gpd

$$\frac{200yd \mid 3ft}{yd} = 600ft/3min = 200ft/min$$

$$Q = (0.785)(0.8333ft)(0.8333ft)(200ft/min)$$

$$Q = 109.0278ft^3/min$$

$$\frac{109.0278ft^3 \mid 7.48gal \mid 1440min}{min \mid ft^3 \mid day} =$$

1,174,360 gal/day