Basic Math for All Certifications

Course # 1014

Fleming Training Center

September 27-30, 2016

Fleming Training Center
Your Partner in Clean Water

TDEC
TENNESSEE DEPARTMENT OF ENVIRONMENT AND CONSERVATION

BASIC MATH FOR ALL CERTIFICATIONS

SEPTEMBER 27-30, 2016

COURSE #1014

Tuesday

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

Wednesday

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

Thursday

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

Friday

8:30 am	Velocity and Flow Calculations	Amanda
12:00	Lunch	
1:00 pm	Course Evaluation and Exam	Amanda

Fleming Training Center
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FLEMING TRAINING CENTER

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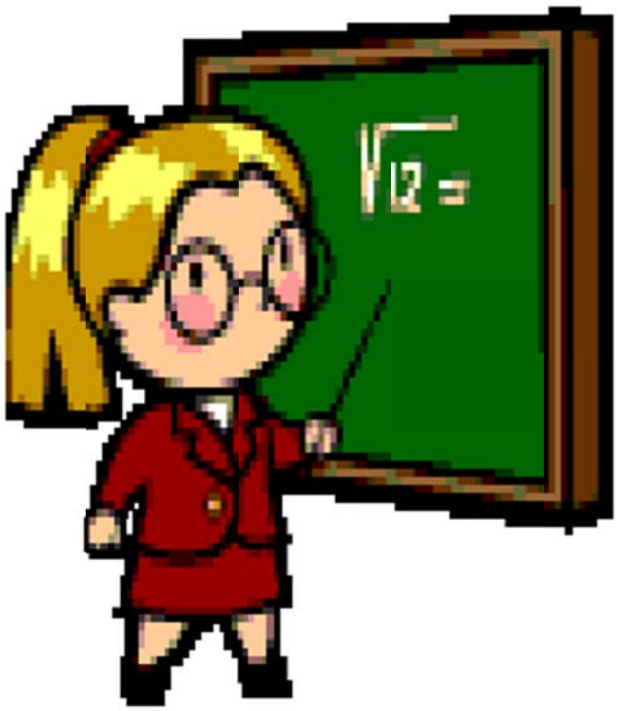
Section 1

Powers, Roots and Scientific Notation



POWERS, ROOTS & SCIENTIFIC NOTATION

BASIC MATH CONCEPTS FOR WATER AND WASTEWATER PLANT OPERATORS BY JOANNE KIRKPATRICK PRICE

TERMS

- Exponent – indicates how many times a number is to be multiplied together
- Base – the number that is being multiplied

base exponent

$$7^4 = (7)(7)(7)(7)$$

- Power – entire expression (seven to the 4th power)
- Same rule applies to letters and measurement units

$$x^3 = (x)(x)(x) \text{ or } ft^2 = (ft)(ft)$$

- Any number that does not have an exponent is considered to have an exponent of 1

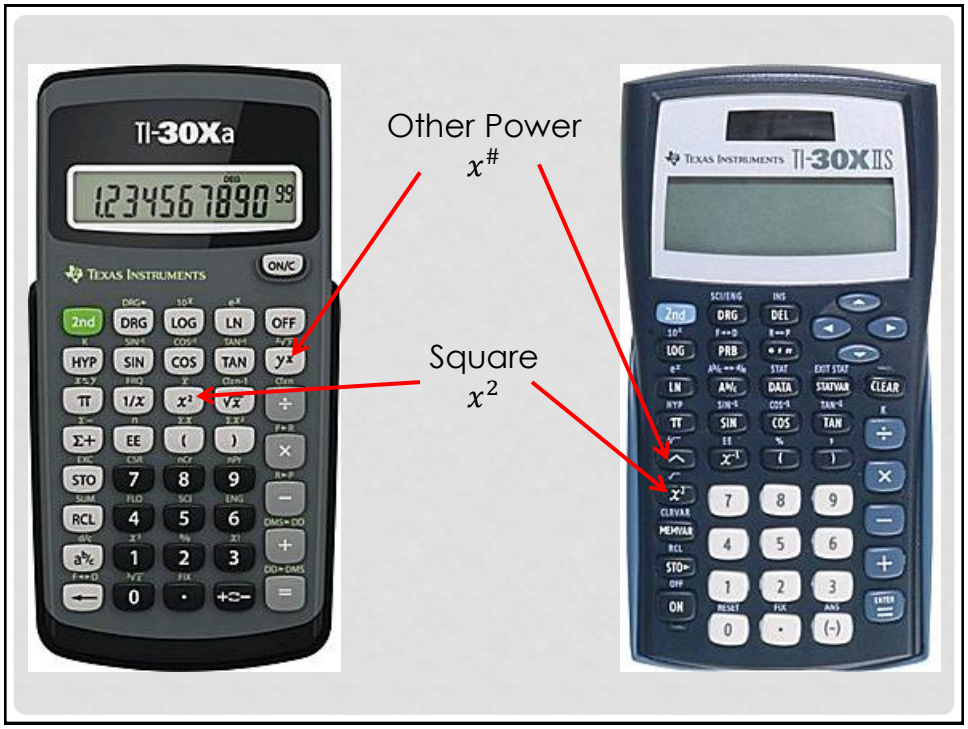
$$10 = 10^1$$

EXAMPLE 1

- Write the following numbers in expanded form:
- 6^2
  - $(6)(6)$
- 20^3
  - $(20)(20)(20)$
- 3^5
  - $(3)(3)(3)(3)(3)$
- x^3
  - $(x)(x)(x)$

EXAMPLE 2

- Write the factors using exponential notation:
- $(4)(4)(4)$
  - 4^3
- $(2)(2)(2)(2)$
  - 2^4
- $(7)(7)(7)(7)(7)(7)(7)$
  - 7^7
- $(x)(x)$
  - x^2



EXAMPLE 3

- Complete the following calculations
- 27^2
  - 729
- 14^5
  - 537824
- $5^{7.9}$
  - 332554.66

NEGATIVE EXPONENTS

- A factor with a negative exponent can be inverted and written with a positive exponent

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

- When a power is moved from the numerator to denominator (and vice versa) the sign of the exponent must be changed
- Any number that has an exponent of zero is equal to one.

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

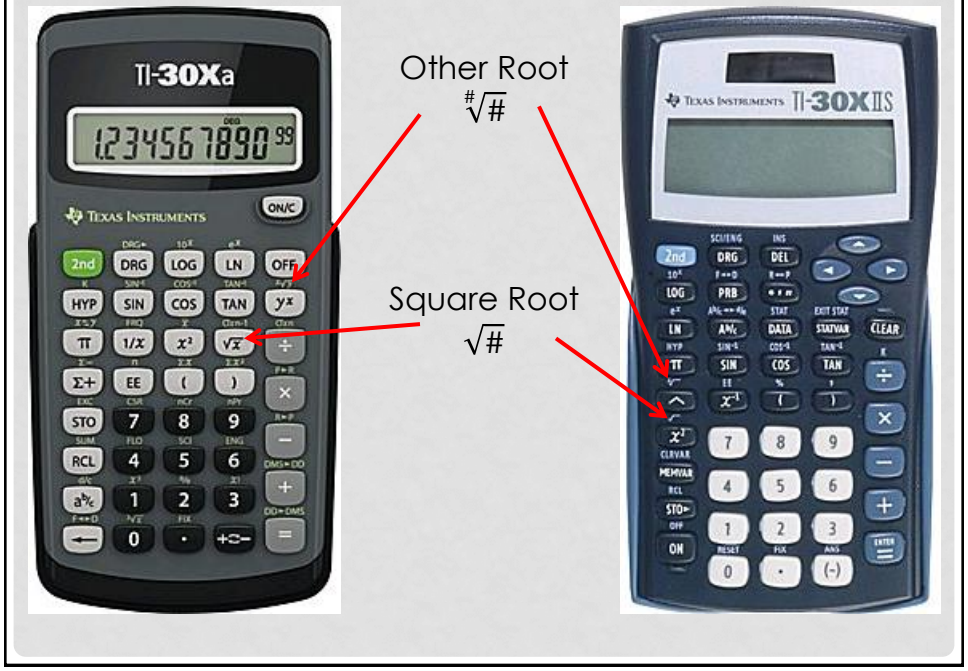
ROOTS

- Root - a number which, when multiplied together two or more times, equals the original number
- Square root – a number in which, when multiplied together twice, equals the original number

$$\sqrt[2]{100} = \sqrt{100}$$
$$10$$

- Cube root – a number which, when multiplied together three times equals the original number

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



ROOTS

- Complete the following calculations
- $\sqrt{6400}$
  - 80
- $\sqrt[3]{912673}$
  - 97
- $\sqrt[8]{390625}$
  - 5

FRACTIONAL EXPONENTS

- Fractional exponent
  - Numerator indicates power to raise base to
  - Denominator indicates root to be taken

Power to raise to → $15^{2/3}$ ← Root to be taken

$\sqrt[3]{15^2}$

$\sqrt[3]{225}$

6.08

EXAMPLE 4

- Express the following numbers using radicals
- $4^{1/2}$
  - $\sqrt{4}$
- $64^{1/3}$
  - $\sqrt[3]{64}$
- $90^{2/3}$
  - $\sqrt[3]{90^2}$
- $1.4^{5/2}$
  - $\sqrt{1.4^5}$

EXAMPLE 5

- Express the following numbers using fractional exponents
- $\sqrt{5^3}$
  - $5^{3/2}$
- $\sqrt[3]{x^2}$
  - $x^{2/3}$
- $\sqrt[5]{150}$
  - $150^{1/5}$

EXAMPLE 6

- Complete the following calculations
- $484^{1/2}$
  - $\sqrt{484} = 22$
- $\sqrt[3]{27}$
  - 3
- $4^{3/2}$
  - $\sqrt{4^3} = \sqrt{64} = 8$

MULTIPLYING POWERS

- When multiplying powers with the same base, simply add exponents

$$x^2 * x^3$$

$$x^{2+3}$$

$$x^5$$

$$x^3 \bullet x^4 = (x)(x)(x)(x)(x)(x)(x)$$

$$x^7$$

EXAMPLE 7

- Simplify the following terms using the rule for multiplying powers:
- $3^2 \bullet 3^5$
  - $3^{2+5} = 3^7$
- $x^3 \bullet x^3$
  - $x^{3+3} = x^6$

DIVIDING POWERS

- When dividing powers with the same base, subtract the power of the dominator from the power of the numerator

$$\frac{x^5}{x^3}$$

$$x^{5-3}$$

$$x^2$$

$$\frac{x^8}{x^5}$$

$$\frac{\cancel{(x)}\cancel{(x)}\cancel{(x)}\cancel{(x)}\cancel{(x)}(x)(x)(x)}{\cancel{(x)}\cancel{(x)}\cancel{(x)}\cancel{(x)}\cancel{(x)}}$$

$$x^3$$

EXAMPLE 8

- Simplify the following terms using the rule for dividing powers
- $\frac{a^3}{a^2}$
  - $a^{3-2} = a^1 \text{ or } a$
- $\frac{9^5}{9^3}$
  - $9^{5-3} = 9^2$

EXAMPLE 9

- Calculate the answer for the following problems

$$\frac{2^3 \bullet 3^4}{2^2}$$

$$2^{3-2} \bullet 3^4$$

$$2^1 \bullet 3^4$$

$$162$$

$$\frac{5^3 \bullet 7^2 \bullet 5^2}{5}$$

$$5^{3+2-1} \bullet 7^2$$

$$5^4 \bullet 7^2$$

$$30{,}625$$

SCIENTIFIC NOTATION

POWER OF TEN

- When **multiplying** by a power of 10, move the decimal to the **right** the same number of places as the power of 10

$$(3.6)(10^2) = 360.$$

- When **dividing** by a power of 10, move the decimal point to the left the same number of places as the power of 10

$$\frac{184.4}{10^2} = 184.4 \rightarrow 1.844$$

SCIENTIFIC NOTATION

- A method of writing numbers such that there is a number times a power of 10
- To put a number in scientific notation
  - Place a decimal point after the first nonzero digit
    - Called the standard position
  - Count the number of places from the standard position to the original decimal point
    - This will become the exponent
  - Determine if exponent will be positive or negative

SCIENTIFIC NOTATION

- If the original decimal to the standard position move is to **left**, the exponent is **positive**

$14{,}500$

1.45×10^{4}

- If the original decimal to the standard position move is to **right**, the exponent is **negative**

0.0035

3.5×10^{-3}

EXAMPLE 10

- Write the following numbers in scientific notation
- $14{,}500$ Moved to the left (+)
  - 1.45×10^{4}
- 0.02 Moved to the right(-)
  - 2.0×10^{-2}
- $2{,}970{,}000$ Moved to the left (+)
  - 2.97×10^{6}
- 0.0035 Moved to the right (-)
  - 3.5×10^{-3}

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

23. $15^{3/6}$ = _____

24. $10^{2/3}$ = _____

25. $54^{4/5}$= _____

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

26. $\sqrt{450}$ = _____

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

28. $\sqrt[4]{45^7}$ = _____

29. $\sqrt[8]{12^5}$ = _____

30. $\sqrt{21^3}$ = _____

Complete the following problems.

31. $144^{1/2}$ = _____

32. $\sqrt{6400}$ = _____

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

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

35. $64^{1/3}$ = _____

36. (2) (3) ($\sqrt{81}$) = _____

Write the following numbers in Scientific Notation.

37. 6,150,000 _____

38. 0.00345 _____

39. 1004 _____

40. 0.000007 _____

41. 849,200 _____

Write the following scientific notation numbers as normal numbers.

42. 2.34×10^6 _____

43. 9.28×10^{-2} _____

44. 7.34×10^3 _____

45. 8.032×10^{-4} _____

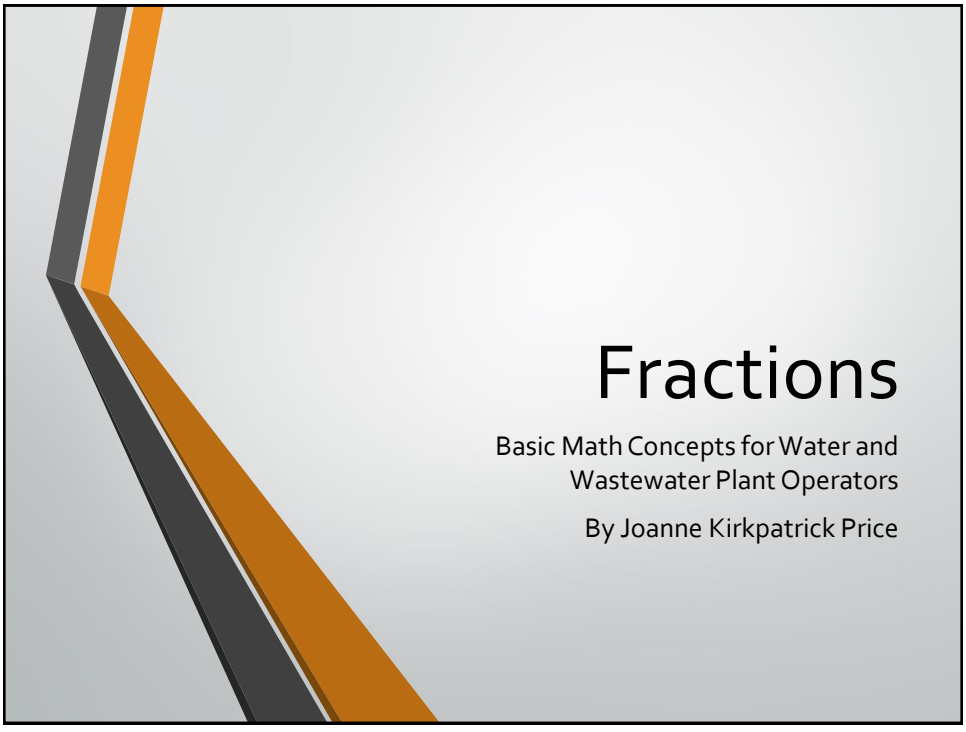
46. 1.234×10^2 _____

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. $\sqrt[6]{15^3}$
24. $\sqrt[3]{10^2}$
25. $\sqrt[5]{54^4}$
26. $450^{1/2}$
27. $27^{1/3}$
28. $45^{7/4}$
29. $12^{5/8}$
30. $21^{3/2}$
31. 12
32. 80
33. 10
34. 8
35. 4
36. 54
37. 6.15×10^6
38. 3.45×10^{-3}
39. 1.004×10^3
40. 7.0×10^{-6}
41. 8.492×10^5
42. 2,340,000
43. 0.0928
44. 7,340
45. 0.0008032
46. 123.4

Section 2

Fractions, Decimals, Ratios, Proportions, & Averages



Summary

- The concept of fractions was developed centuries ago so that portions of a whole object could be counted, recorded or perhaps shared equally.
- The idea of equal portions is fundamental to the concept of fractions.

Summary

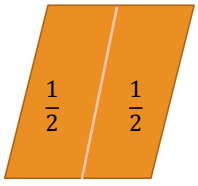
- Numerator
  - Top portion of a fraction
  - Indicates how many parts are being considered
- Denominator
  - Bottom portion of fraction
  - Tells how many equal parts the whole has been divided into

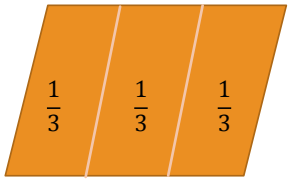
$$\frac{Numerator}{Denominator}$$

Division line

Denominator

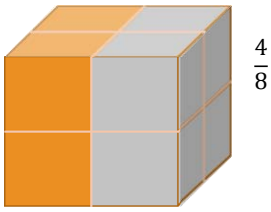
- Bottom of fraction
- Gives the name of the fraction
  - Halves, thirds, fourths, fifths, twentieths, etc
  - A denominator of two indicates that the whole has been divided into two equal parts





Numerator

- Top of fraction
- Indicates number of equal parts

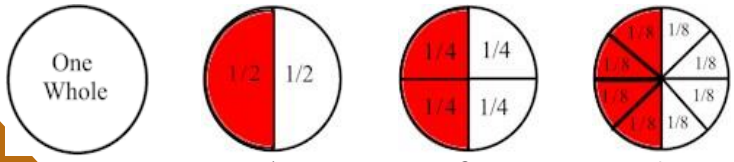


$\frac{4}{8}$

$\frac{5}{8}$

Equivalent Fractions

- Fractions with different numerators and denominators that refer to the same portion
- Fractions that represent equal parts of the whole



$\frac{1}{2}$ $\frac{2}{4}$ $\frac{4}{8}$

$\frac{4}{11}$

Equivalent Fractions

- Multiply the numerator and denominator by the same number

$$\frac{4}{11} \times \frac{3}{3} = \frac{12}{33}$$

- $^{4}/_{11}$ and $^{12}/_{33}$ are equivalent fractions

$\frac{156}{204}$

Equivalent Fractions

- Divide the numerator and denominator by the same number

$$\frac{156}{204} \div \frac{2}{2} = \frac{78}{102}$$

- Simplify fractions by dividing by a common dividend

$$\frac{78}{102} \div \frac{6}{6} = \frac{13}{17}$$

- Fraction is now in its lowest terms (cannot be reduced any further)

Equivalent Fractions

- Verify equivalent fractions by cross multiplying

$$\frac{1}{8} \neq \frac{5}{32}$$

$$1 \times 32 = 32 \qquad 8 \times 5 = 40$$

$$32 \neq 40$$

- Fractions are **not** equivalent

Improper Fractions and Mixed Numbers

- An improper fraction has a numerator equal to or greater than the denominator
  - Represent numbers greater than one

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

- A mixed number is comprised of both whole numbers and fractions

$$3\frac{1}{3}$$

Improper Fractions and Mixed Numbers

- To convert a mixed number into an improper fraction
  - Multiply the denominator by the whole number
  - Add product to numerator

$$4\frac{1}{5}$$

$$5 \times 4 + 1$$

$$\frac{21}{5}$$

Improper Fractions and Mixed Numbers

- To convert an improper fraction to a mixed number
  - Reduce the improper fraction
  - Divide the numerator by the denominator
  - Any remainder becomes the numerator

$$\frac{92}{5}$$

$$92 \div 5 = 18.4$$

$$18\frac{2}{5}$$

$18 \times 5 = 90$
$92 - 90 = 2$

Complex Fractions

$$\frac{25}{\frac{6}{7}}$$

- A fraction whose numerator and/or denominator contains a fraction
- To complete these
  - Simplify the numerator and denominator
  - Restate the original problem
  - Divide as needed

Complex Fractions

$$\frac{\frac{1}{4}}{\frac{3}{8}}$$

- Step 1 – Move bottom fraction to top by inverting (flip) and multiplying

$$\frac{1}{4} \times \frac{8}{3}$$

- Step 2 - Multiply fraction $\frac{1\times8}{4\times3} = \frac{8}{12}$
- Step 3 – Reduce fraction $\frac{8}{12} \div \frac{4}{4} = \frac{2}{3}$

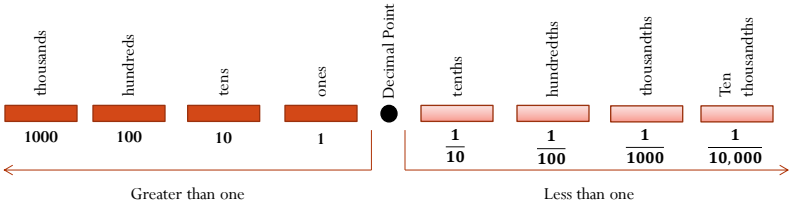
Decimals

Basic Math Concepts for Water and Wastewater Plant Operators

By Joanne Kirkpatrick Price

Decimal System

- The word decimal comes from the Latin word meaning *decem*, meaning ten.
- The decimal system is based on ten and multiples of ten.
- In a place value system the size of any number depends on two things:
  - Which digits are used and
  - Where these digits are placed in relation to the decimal point



Percents and Decimals

- To convert from a decimal to a percent
  - Move the decimal point two places to the right

$$0.46. \rightarrow 46.0\%$$

  - Multiply decimal by 100

$$0.46(100) = 46\%$$

- To convert from a percent to a decimal
  - Move the decimal two points to the left

$$.79.5\% \rightarrow 0.795$$

  - Divide percent by 100

$$\frac{79.5}{100} = 0.795$$

Converting Decimals and Fractions

- To convert a decimal to a fraction
  - The entire number becomes the numerator, disregarding the decimal point
  - The denominator is determined by how many decimal places to the right the number goes
  - Reduce the fraction

$$0.53$$

    - 53 becomes the numerator
    - The number goes 2 places past the decimal, so we will put 2 zeros in the denominator

$$\frac{53}{100}$$

Converting Decimals and Fractions

- To convert a fraction to a decimal
  - Simply divide the numerator by the denominator

$$\frac{1}{2} = 1 \div 2 = 0.5$$

$$\frac{10}{13} = 10 \div 13 = 0.7692$$

Percents and Fractions

- To convert a fraction into a percent
  - Divide the fraction to obtain a decimal number. Then convert the decimal number to a percent.

$$\frac{4}{17}$$

$$4 \div 17 = 0.24$$

$$0.24 \times 100 = 24\%$$

Percents and Fractions

- To convert a percent to a fraction
  - Simply write the number over 100

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

  - If a percent has a decimal, the decimal must be taken out

$$12.5\% = \frac{12.5}{100}$$

$$\frac{12.5}{100} \times \frac{10}{10}$$

$$\frac{125}{1000}$$

  - Reduce fraction to lowest terms

$$\frac{125}{1000} \div \frac{25}{25} = \frac{5}{40}$$

$$\frac{5}{40} \div \frac{5}{5} = \frac{1}{8}$$

AVERAGES

BASIC MATH CONCEPTS FOR WATER AND WASTEWATER PLANT OPERATORS BY JOANNE KIRKPATRICK PRICE

AVERAGES

- By calculating averages, a group of data is represented by a single number

$$Mean = \frac{Sum\ of\ all\ measurements}{Number\ of\ measurements\ used}$$

EXAMPLE

- What is the average temperature for a week given the following data:

$$72°F, 70°F, 79°F, 80°F, 77°F, 77°F, 73°F$$

$$Mean = \frac{Sum\ of\ all\ measurements}{Number\ of\ measurements\ used}$$

$$Mean = \frac{72 + 70 + 79 + 80 + 77 + 77 + 73}{7}$$

$$Mean = \frac{528}{7}$$

$$Mean = 75.4°F$$

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 average 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)

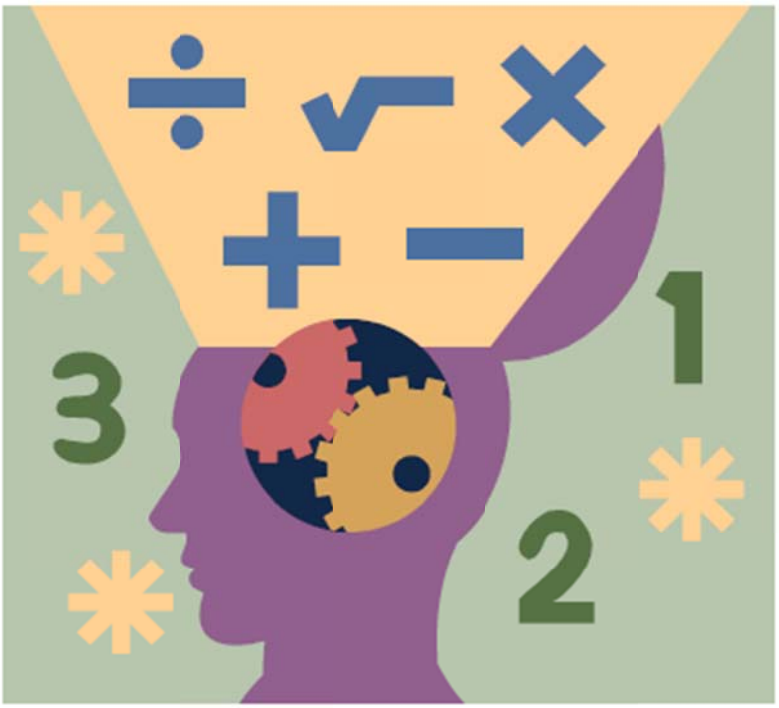
Answers

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

Basic Math Concepts

Solving for X



Basic Math Concepts

For Water and Wastewater Plant Operators
by Joanne Kirkpatrick Price

Difficulties in Math

- A Poor Foundation
  - Mathematics is sequential – concepts build upon concepts
- No Linking or Steps Missing
  - Link new concepts to what you already know
- The "Big Picture" is Missing
  - The skeleton on which all the details can be hung
- "Use It or Lose It" Syndrome
  - The more you practice and use math calculations, the easier they become

Setting Up and Solving Math Problems

- Theoretical Math – concepts such as fractions, decimals, percents, areas, volumes, etc.
  - "Tools" of math - more tools you have, the easier the applied math problems will be
- Applied Math – basic math concepts applied in solving practical problems
  - Applied math calculations have a strategy – a way of approaching every problem that leads them methodically to the answer

Suggested Strategy

- Disregarding all numbers, what type of problem is it?
- What diagram, if any, is associated with the concept identified?
- What information is required to solve the problem and how is it expressed in the problem?
- What is the final answer?
- Does the answer make sense?

Solving for the Unknown Value (X)

Solving for X

- Solve for X

$$(4)(1.5)(x) = 1100$$

  - X must be by itself on one side of equal sign
    - 4 and 1.5 must be moved away from X

$$x = \frac{1100}{(4)(1.5)}$$

$$x = 183.3$$

    - How was this accomplished?

Movement of Terms

- To understand how we move the numbers, we will need to consider more closely the math concepts associated with moving the terms.
- An equation is a mathematical statement in which the terms or calculation on one side equals the terms or calculation on the other side.

Movement of Terms

- To preserve this equality, anything done to one side of the equation must be done to the other side as well.

$$3x = 14$$

- Since X is multiplied by 3, you can get rid of the 3 by using the opposite process: division.

Movement of Terms

- To preserve the equation, you must divide the other side of the equation as well.

$$\frac{\cancel{3}x}{\cancel{3}} = \frac{14}{3}$$

$$x = \frac{14}{3}$$

- Since both sides of the equation are divided by the same number, the value of the equation remains unchanged.

Example 1

$$730 = \frac{x}{3847}$$

What you do to one side of the equation, must be done to the other side.

$$730 = \frac{x}{3847} \times \frac{3847}{1}$$

$$\frac{3847}{1} \times 730 = \frac{x}{\cancel{3847}} \times \frac{\cancel{3847}}{1}$$

$$3847 \times 730 = x$$

$$2{,}808{,}310 = x$$

Example 2

Simplify

What you do to one side of the equation, must be done to the other side.

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

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

$$0.5 = \frac{4128.3}{x} \times \frac{x}{1}$$

$$\frac{x}{1} \times 0.5 = \frac{4128.3}{x} \times \frac{x}{1}$$

$$(x)(0.5) = 4128.3$$

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

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

$$x = 8256.6$$

Solving for X^2

- Follow same procedure as solving for X
- Then take the square root

$$x^2 = 15{,}625$$

$$\sqrt{x^2} = \sqrt{15{,}625}$$

$$x = 125$$

Example 3

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

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

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

$$x^2 = 3600$$

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

$$x = 60$$

Solving for X

- When solving for x involving addition and subtraction, the balance of the equation must still remain.
  - What you do to one side you must do to the other

Example 4

$$115 + 105 + 80 + x = 386$$

$$300 + x = 386$$

$$300 + x - 300 = 386 - 300$$

$$x = 86$$

Example 5

Step 1. Simplify

Step 2. Make x positive

$$17 + 23 + 7 - x = 38$$

$$47 - x = 38$$

$$47 - x + x = 38 + x$$

$$47 = 38 + x$$

$$47 - 38 = 38 + x - 38$$

$$9 = x$$

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

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

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

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

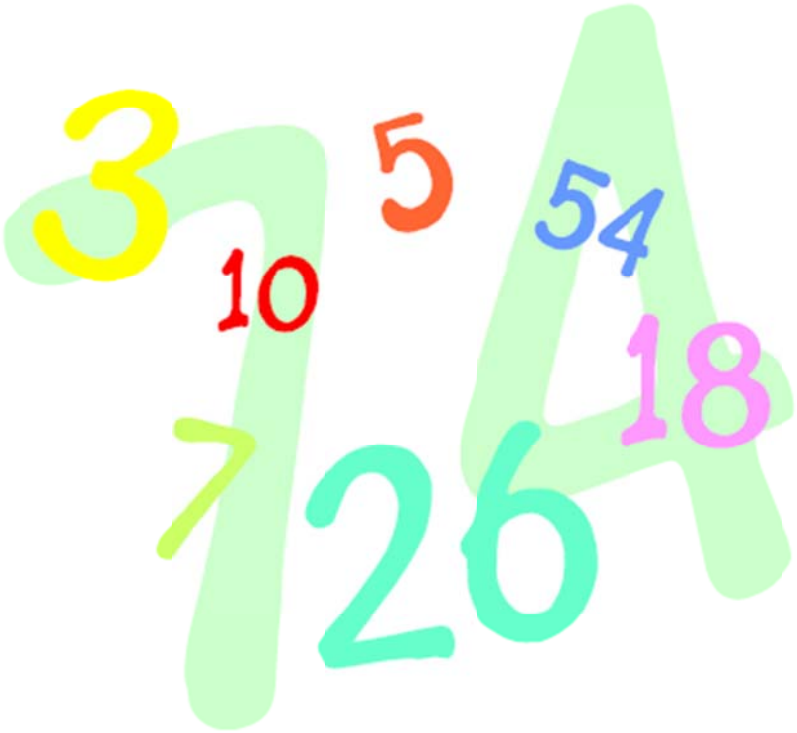
1. 1.8
2. 5.73
3. 5.3
4. 5,976,990
5. 8256.6
6. 8.06
7. 0.005
8. 360
9. 1649.4
10. 244.7
11. 11
12. 4.99
13. 7993.9
14. 590.4
15. 2816.7
16. 4903.5
17. 547,616
18. 117.3
19. 508,000
20. 0.35
21. 10
22. 12
23. 80
24. 12
25. 40
26. 0.83
27. 10.9

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 4

Ratios and Proportions



RATIOS AND PROPORTIONS

For Water and Wastewater Plant Operators

by Joanne Kirkpatrick Price

WHAT ARE RATIOS & PROPORTIONS?

- A **ratio** is the established relationship between two numbers
  - i.e. 3 feet to every yard is a 3:1 ratio
- A **proportion** exists when the value of one ratio is equal to the value of a second ratio

DETERMINING PROPORTIONS

- Three methods to determine if a ratio is proportionate (equal)

$$\frac{1}{4} = \frac{5}{20}$$

  - Division of each ratio

$\frac{1}{4} = 0.25$ $\quad$ $\frac{5}{20} = 0.25$

  - Means and extremes of the ratios

$1 : 4 :: 5 : 20$

$4 \times 5 = 20$

$1 \times 20 = 20$

Since answers are equal, ratio is proportionate

  - Cross multiplication

$\frac{1}{4} \times \frac{5}{20}$

$(4)(5) = 20$

$(1)(20) = 20$

EXAMPLE 1

- Use the division method to determine if the following ratios are proportionate:

$$\frac{3}{5} \text{ and } \frac{15}{20}$$

- First divide each ratio, then compare the answers

$$^3/_5 = 0.6 \qquad ^{15}/_{20} = 0.75$$

Since the answers are **not equal**, the ratios are **not proportionate**

MEANS AND EXTREMES

- If the proportion is written using colons, the product of the means will equal the product of the extremes

Extremes

Means

$2 : 3 = 6 : 9$

$3 \times 6 = 18$

$2 \times 9 = 18$

EXAMPLE 2

- Determine if the following two ratios are proportionate using means & extremes

$24 : 4 :: 18 : 3$

$4 \times 18 = 72$

$24 \times 3 = 72$

Ratios are proportionate

CROSS MULTIPLYING

- If the proportion is written using fractions, cross-multiplied terms will be equal

$$\frac{2}{3} = \frac{6}{9}$$

$$2 \times 9 = 18$$

$$3 \times 6 = 18$$

EXAMPLE 3

- Determine if the following ratio is proportionate using cross multiplying

$$\frac{4}{5} = \frac{72}{95}$$

$$4 \times 95 = 380$$

$$5 \times 72 = 360$$

$$360 \neq 380$$

Ratios are **not** proportionate

SOLVING A PROPORTION

SOLVING PROPORTIONS

- To solve a proportion problem, use the same steps as solving for the unknown value:
  - X must be in the numerator
  - X must be by itself
- There are four terms in every proportion
- In a proportion problem three of the terms are known and one is unknown (X)

EXAMPLE 1

- Solve for X in the proportion problem below

$$\frac{26}{190} = \frac{x}{4750}$$

- 1.) X must be in the numerator
  - YES
- 2.) X by itself
  - 4750 is dividing X, so it will multiply on the other side

$$\frac{(4750)(26)}{190} = x$$

$$650 = x$$

EXAMPLE 2

- Solve for the unknown value X in the problem given below

$$\frac{3.2}{2} = \frac{6}{x}$$

- First, cross multiply terms

$$(3.2)(x) = (2)(6)$$

- Now solve for the unknown

$$x = \frac{(2)(6)}{3.2}$$

$$x = 3.75$$

EXAMPLE 3

- Given the proportion 5:9 :: x:72, solve for the unknown value
- First, rewrite the proportion as a fraction

$$\frac{5}{9} = \frac{x}{72}$$

- Then, solve for the unknown

$$\frac{(72)(5)}{9} = x$$

$$40 = x$$

SETTING UP A PROPORTION PROBLEM

DIRECT PROPORTIONS

- As one unit increases, the other increases as well

As one unit increases the other unit increases

As one unit decreases the other unit decreases

- To set up and solve a direct proportion
  1. Write the two fractions, take care that the location of the units is the same for each fraction
  2. Fill in the given values for both fractions
  3. Solve for the unknown value

EXAMPLE 1

- 0.5 lbs of chlorine are dissolved in 45 gallons of water. To maintain the same concentration, how many pounds of chlorine would have to be dissolved in 100 gallons of water?
- First, write the two fractions

$$\frac{lbs}{gallons} = \frac{lbs}{gallons}$$

- Next, fill in the given information

$$\frac{0.5\ lbs}{45\ gal} = \frac{x\ lbs}{100\ gal}$$

- Now, solve for the unknown

$$(45\ gal)(x) = (0.5lbs)(100gal)$$

$$x\ lbs = \frac{(0.5\ lbs)(100\ gal)}{45\ gal}$$

$$x\ lbs = 1.1\ lbs$$

INDIRECT PROPORTIONS

As one unit increases the other unit decreases

As one unit decreases the other unit increases

- To set up and solve an indirect proportion
  1. Group like units
  2. Place smaller numbers in the numerators and larger numbers in the denominator
  3. Solve for the unknown value

EXAMPLE 2

- In the seeding of a new digester, for every 0.05 lbs of volatile solids entering the digester, 1 lb of volatile solids should be in the digester (in the seed sludge). If 150 lbs of volatile solids enter the digester daily, how many pounds of volatile solids should be under digestion?
- First, group like units

$$\frac{lbs\ VS\ entering}{lbs\ VS\ under\ digestion} = \frac{lbs\ VS\ entering}{lbs\ VS\ under\ digestion}$$

- Next, fill in numbers

$$\frac{0.05\ lbs\ entering}{1\ lb\ VS\ under\ digestion} = \frac{150\ lbs\ entering}{x\ lbs\ under\ digestion}$$

EXAMPLE 2 CONTINUED

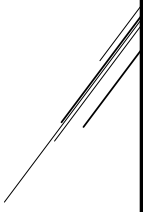
- Now, solve for X

$$\frac{0.05}{1} = \frac{150}{x}$$

$$(0.05)(x) = (1)(150)$$

$$x = \frac{(1)(150)}{0.05}$$

$$x = 3000\ lbs\ VS\ under\ digestion$$



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?

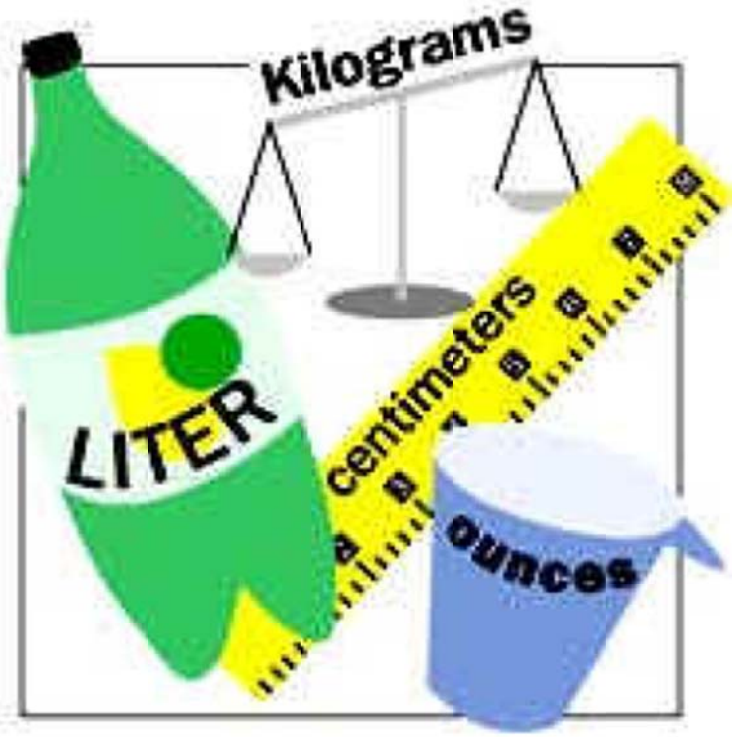
15. A treatment pond is designed for a population loading of 300 persons per acre of pond. If the population to be served is 1240 people, how many acres of treatment pond will be required?

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 5

Metric System and Temperature



Metric System & Temperature

For Water and Wastewater Plant Operators

by Joanne Kirkpatrick Price

Metric Units

Primary Unit

mega	....	kilo	hecto	deka	no	deci	centi	milli	....	micro
(M)		(k)	(h)	(da)	prefix	(d)	(c)	(m)		(μ)
1,000,000		1,000	100	10	1	$^1/_{10}$	$^1/_{100}$	$^1/_{1,000}$		$^1/_{1,000,000}$

↓

meter – linear measurement
liter – volume measurement
gram – weight measurement

Example 1

- Convert 2500 milliliters to liters

Primary Unit

mega	....	kilo	hecto	deka	no	deci	centi	milli	....	micro
(M)		(k)	(h)	(da)	prefix	(d)	(c)	(m)		(μ)
1,000,000		1,000	100	10	1	$^1/_{10}$	$^1/_{100}$	$^1/_{1,000}$		$^1/_{1,000,000}$

- Converting milliliters to liters requires a move of three place values to the left
- Therefore, move the decimal point 3 places to the left

↓

meter – linear measurement
liter – volume measurement
gram – weight measurement

2 5 0 0. = 2.5 Liters

3 2 1

Example 2

- Convert 0.75 km into cm

Primary Unit

mega	....	kilo	hecto	deka	no	deci	centi	milli	....	micro
(M)		(k)	(h)	(da)	prefix	(d)	(c)	(m)		(μ)
1,000,000		1,000	100	10	1	$^1/_{10}$	$^1/_{100}$	$^1/_{1,000}$		$^1/_{1,000,000}$

- From kilometers to centimeters there is a move of 5 value places to the right

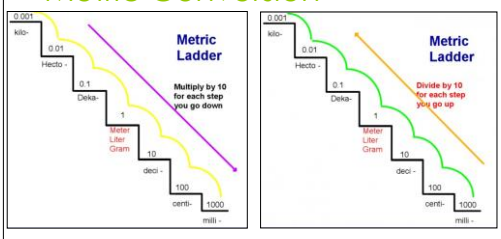
↓

meter – linear measurement
liter – volume measurement
gram – weight measurement

0. 7 5 = 75,000 cm

1 2 3 4 5

Metric Conversion



When converting any type of measures

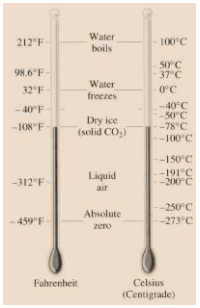
- To convert from a **larger to smaller** metric unit you always **multiply**
- To convert from a **smaller to larger** unit you always **divide**

Temperature

7

Temperature

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 Swedish astronomer Anders Celsius who invented the scale in 1742.

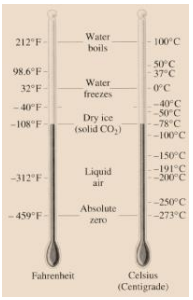
The scale is based on 0 for the freezing point of water and 100 for the boiling point of water.

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

8

Temperature Scales

The conversion formula for a temperature that is expressed on the Celsius (°C) scale to its Fahrenheit (°F) representation is:
F° = (1.8)(°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 = (0.556)(°F- 32).

9

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

10

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

TDEC - Fleming Training Center

Metric Conversion Equations

Linear Measure

1 centimeter	=	0.3937 inches	1 inch	=	2.540 cm
1 meter	=	3.281 feet	1 foot	=	0.3048 m
1 meter	=	1.0936 yards	1 yard	=	0.9144 m
1 kilometer	=	0.6214 miles	1 mile	=	1.609 km

Square Measure

1 cm^2	=	0.155 in^2	1 in^2	=	6.4516 cm^2
1 m^2	=	35.3 ft^2	1 ft^2	=	0.0929 m^2
1 m^2	=	1.196 yd^2	1 yd^2	=	0.8361 m^2

Cubic Measure

1cm^3	=	0.061 in^3	1 in^3	=	16.39 cm^3
1 m^3	=	35.3 ft^3	1 ft^3	=	0.0283 m^3
1 m^3	=	1.308 yd^3	1 yd^3	=	0.7645 m^3

Capacity

1 Liter	=	61.025 in^3	1 in^3	=	0.0164 L
1 Liter	=	0.0353 ft^3	1 ft^3	=	28.32 L
1 Liter	=	0.2642 gal	1 gal	=	3.785 L

Weight

1 gram (g)	=	15.43 grains	1 grain	=	0.0648 g
1 gram	=	0.0353 ounces	1 ounce	=	28.35 g
1 kilogram	=	2.205 pounds	1 pound	=	456.6 g

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_____ kw
6. 0.05 g into _____ μg
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

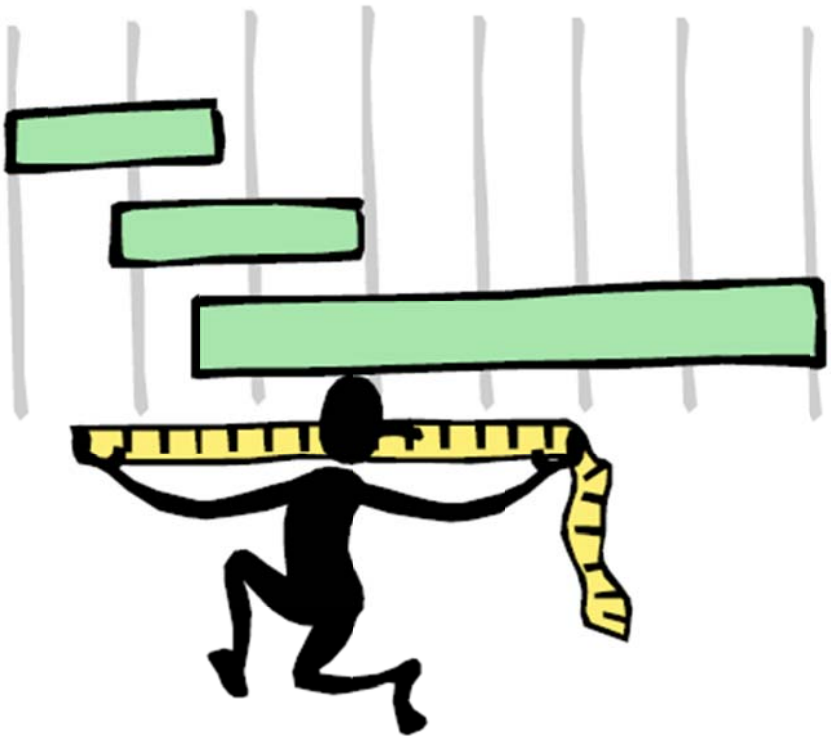
1. 23,000 mg
2. 12.456 km
3. 4.235 L
4. 0.0002 kg
5. 1 kw
6. 500 µg
7. 2000 mL
8. 140,000 g
9. 95 mm
10. 0.1 seconds

Part 2

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

Section 6

Dimensional Analysis



DIMENSIONAL ANALYSIS

MATHEMATICS MANUAL FOR WATER AND WASTEWATER TREATMENT PLANT OPERATORS
BY FRANK R. SPELLMAN

DIMENSIONAL ANALYSIS

- Used to check if a problem is set up correctly
- Work with the units of measure, not the numbers
- Step 1:
  - Express fraction in a vertical format

$$gal/ft^3 \text{ to } \frac{gal}{ft^3}$$

- Step 2:
  - Be able to divide a fraction

$$\frac{\frac{lb}{day}}{\frac{min}{day}} \text{ becomes } \frac{lb}{day} \times \frac{day}{min}$$

DIMENSIONAL ANALYSIS

- Step 3:
  - Know how to divide terms in the numerator and denominator
  - Like terms can cancel each other out
    - For every term that is canceled in the numerator, a similar term must be canceled in the denominator

$$\frac{Kg}{\cancel{day}} \times \frac{\cancel{day}}{min} = \frac{Kg}{min}$$

- Units with exponents should be written in expanded form

$$ft^3 = (ft)(ft)(ft)$$

EXAMPLE 1

- Convert 1800 ft^3 into gallons.
- Use the factor $7.48\ gal/ft^3$
- Would we divide or multiply? Use only the dimensions first to determine the correct setup.
  - Divide

$$\frac{ft^3}{gal/ft^3} = \frac{ft^3}{\frac{gal}{ft^3}}$$

$$ft^3 \times \frac{ft^3}{gal} = \frac{ft^6}{gal}$$ ✗

  - Multiply

$$\cancel{ft^3} \times \frac{gal}{\cancel{ft^3}}$$

$$gal$$ ✓

EXAMPLE 1 CONTINUED

- Plug in numbers
  - Multiply factor to achieve answer

$$1800\ ft^3 \times 7.48\ {}^{gal}/_{ft^3}$$

$$13{,}464\ gal$$

EXAMPLE 2

- Determine the square feet given $70\ ft^3/sec$ and $4.5\ ft/sec$
- Use units to determine set up
  - Multiply

$$\frac{ft^3}{sec} \times \frac{ft}{sec} = \frac{ft^4}{sec^2}$$

  - Divide

$$\frac{\frac{ft^3}{sec}}{\frac{ft}{sec}} = \frac{ft^3}{sec} \times \frac{sec}{ft}$$

$$\frac{(ft)(ft)(ft)}{sec} \times \frac{sec}{ft}$$

$$ft^2$$

EXAMPLE 2 CONTINUED

- Plug in numbers
  - Divide to achieve answer

$$\frac{70\,{ft^3}/{sec}}{4.5\,{ft}/{sec}}$$

$$15.56 ft^2$$

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:

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

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

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

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

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

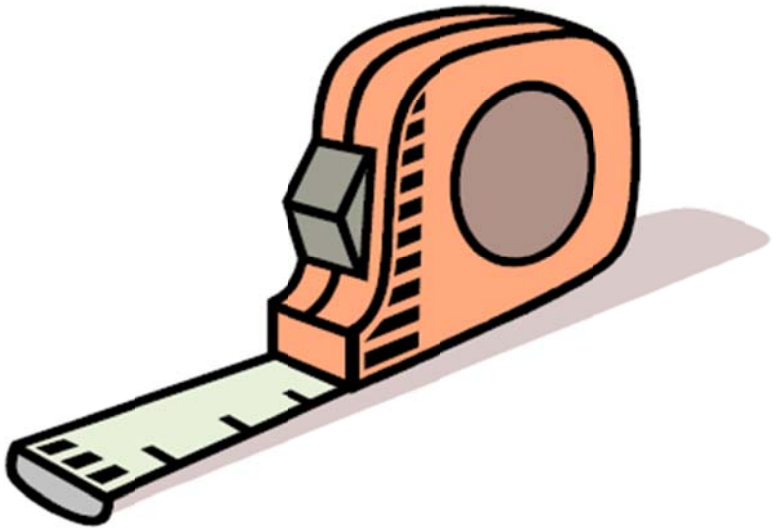
1. 0.034%
2. 6000 mg/L
3. 0.012%
4. 250 mg/L
5. 15,000 mg/L
6. 0.5%
7. 0.68%
8. 0.0195 %
9. 6.10 meters
10. 13.21 gal
11. 27.56 in
12. 105 ft
13. 0.16 gal
14. 453,600 mg
15. 1 L
16. 10,219.5 mL
17. 1320 ft
18. 0.80 mi
19. 5.67 yds
20. 10.17 ft
21. 1080 in
22. 7.2 in
23. 41 feet
24. 142.58 feet
25. 660 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 7

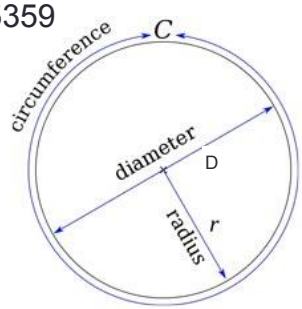
Circumference, Area and Volume



CIRCUMFERENCE AND AREA

Parts of a Circle

- Diameter is distance across the center of circle
- Radius is distance from circle's center to the edge
- Circumference is the distance around a circle or a circular object
- Pi (π) is a mathematical constant
  - $\pi = 3.14159265359$



Circumference & Perimeter

- Circumference of a Circle

$$Circumference = (\pi)(Diameter) \quad \text{OR}$$
$$Circumference = 2(\pi)(radius)$$

- Perimeter is obtained by adding the lengths of the four sides of a square or rectangle

$$Perimeter = 2(length) + 2(width)$$

Example 1

- Find the circumference of a 6 inch diameter pipe.

$$Circumference = 2(\pi)(radius)$$

$$r = \frac{1}{2}D$$

$$C = 2(\pi)(3\ inches)$$

$$C = 18.85\ inches$$

- Find the perimeter of a rectangular tank that is 15 ft by 22 ft.

$$Perimeter = 2(length) + 2(width)$$

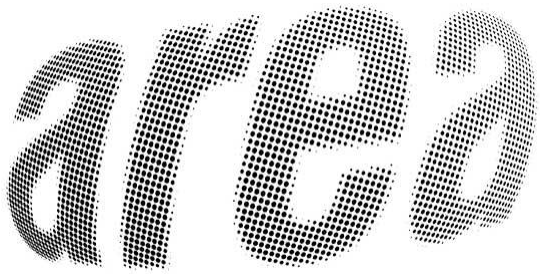
$$P = 2(15\ ft) + 2(22\ ft)$$

$$P = 30\ ft + 44\ ft$$

$$P = 74\ ft$$

Area

- Area is the measurement of the amount of space on the surface of an object
- Two dimensional measurement
- Measured in: in^2, ft^2, acres, etc.

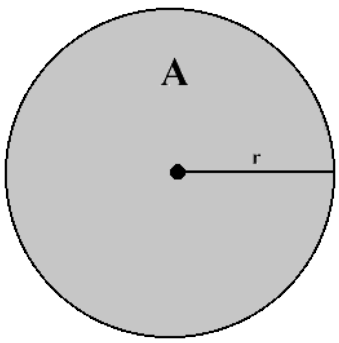


Area

- Area of Circle

$$Area = \pi(radius^2)$$

$$A = \pi r^2$$



Example 2

- Find the area of the cross section of a pipe in ft² that has a diameter of 2 feet.

$$Area = \pi(radius^2)$$

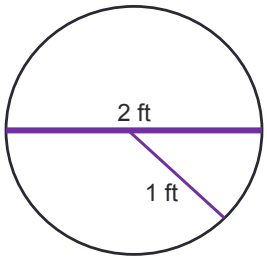
$r = \frac{1}{2}D$

$r = \frac{1}{2}(2ft)$

$r = 1ft$

$A = \pi(1ft)(1ft)$

$A = 3.14\ ft^2$

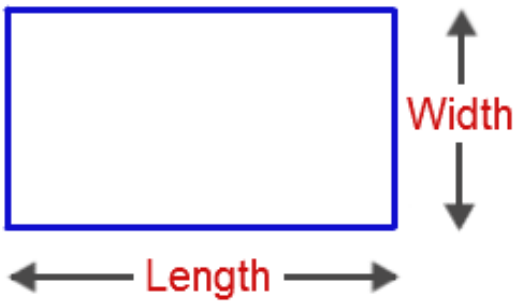


Area

- Area of Rectangle

$$Area = (length)(width)$$

$$A = (L)(W)$$



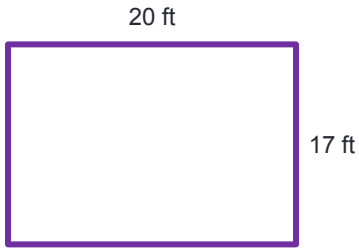
Example 3

- Find the area in ft² of a rectangular basin that is 20 feet long and 17 feet wide.

$$A = (L)(W)$$

$$A = (20ft)(17ft)$$

$$A = 340ft^2$$

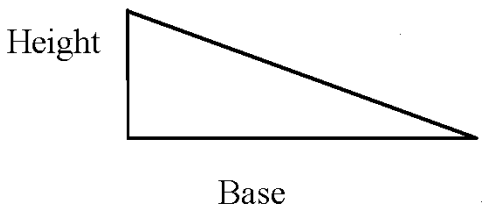


Area

- Area of Right Triangle

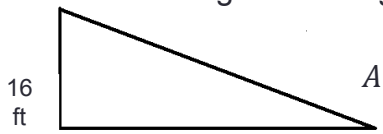
$$Area = \frac{(base)(height)}{2}$$

$$A = \frac{(b)(h)}{2}$$



Example 4

- Determine the area in ft² of a right triangle where the base is 23 feet long with a height of 16 feet.



$$A = \frac{(b)(h)}{2}$$

$$A = \frac{(23ft)(16ft)}{2}$$

$$A = \frac{368ft^2}{2}$$

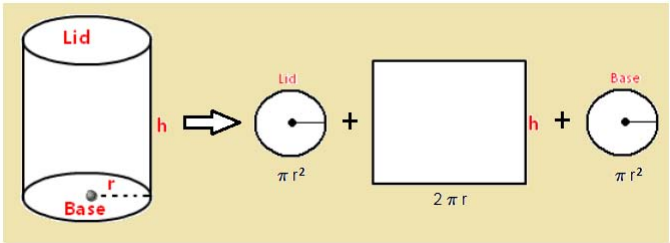
$$A = 184ft^2$$

Area

- Area of Cylinder (total exterior surface area)

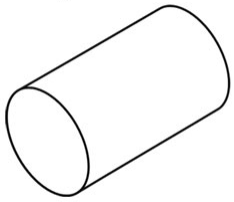
$$Area = [surface\ area\ of\ end\ \#1] + [surface\ area\ of\ end\ \#2] + [(\pi)(Diameter)(height)]$$

$$A = A_1 + A_2 + [(\pi)(D)(h)]$$



Example 5

- Find the total surface area in ft² of a pipeline that is 12 inches in diameter and 20 feet long.



$$A = A_1 + A_2 + [(\pi)(D)(h)]$$

$$A_1 = \pi r^2$$

$$A_1 = \pi(0.5ft)^2$$

$$A_1 = \pi(0.25ft^2)$$

$$A_1 = 0.7854ft^2$$

$$A = 0.7854ft^2 + 0.7854ft^2 + [(\pi)(1ft)(20ft)]$$

$$A = 0.7854ft^2 + 0.7854ft^2 + 62.8319ft^2$$

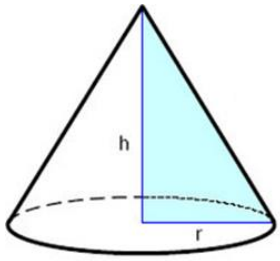
$$A = 64.40ft^2$$

Area

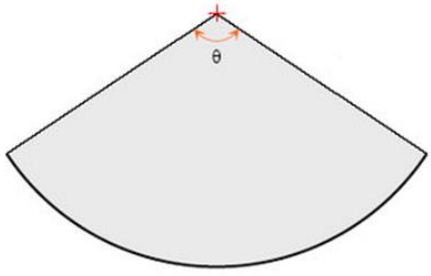
- Area of Cone (lateral area)

$$Area = (\pi)(radius)\sqrt{radius^2 + height^2}$$

$$A = (\pi)(r)\sqrt{r^2 + h^2}$$



Right Circular Cone



Unrolled Lateral Area

Example 6

- Find the lateral area (in ft²) of a cone that is 3 feet tall and has a radius of 1.5 feet.

$$A = (\pi)(r)\sqrt{r^2 + h^2}$$

$$A = (\pi)(1.5ft)\sqrt{(1.5ft)^2+(3ft)^2}$$

$$A = (\pi)(1.5ft)\sqrt{2.25ft^2 + 9ft^2}$$

$$A = (\pi)(1.5ft)\sqrt{11.25ft^2}$$

$$A = (\pi)(1.5ft)(3.35ft)$$

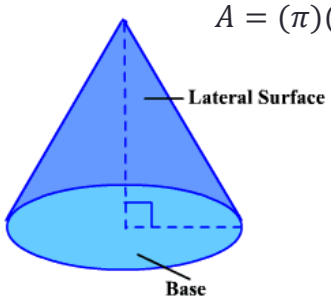
$$A = 15.81ft^2$$

Area

- Area of Cone (total surface area)

$$Area = (\pi)(radius)(radius + \sqrt{radius^2 + height^2}\ )$$

$$A = (\pi)(r)(r + \sqrt{r^2 + h^2}\ )$$



Example 7

- Find the total surface area in ft^2 of a cone that is 4.5 feet deep with a diameter of 6 feet.

$$A = (\pi)(r)(r + \sqrt{r^2 + h^2}\ )$$

$$A = (\pi)(3ft)(3ft + \sqrt{(3ft)^2 + (4.5ft)^2}\ )$$

$$A = (\pi)(3ft)(3ft + \sqrt{9ft^2 + 20.25ft^2}\ )$$

$$A = (\pi)(3ft)(3ft + \sqrt{29.25ft^2}\ )$$

$$A = (\pi)(3ft)(3ft + 5.4ft)$$

$$A = (\pi)(3ft)(8.4ft)$$

$$A = 79.17ft^2$$

Volume

Volume

- Volume is the capacity of a unit or how much it will hold
- Measured in
  - cubic units (ft^3, m^3, yd^3) or
  - liquid volume units (gallons, liters, million gallons)
- The answer will come out in cubic units
  - You must then convert it to liquid volume units

Volume of a Cylinder

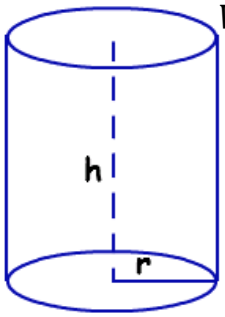
$$Volume = (0.785)(Diameter^2)(height)$$

$$Vol = (0.785)(D^2)(h)$$

OR

$$Volume = (\pi)(radius^2)(height)$$

$$Vol = (\pi)(r^2)(h)$$



Example 8

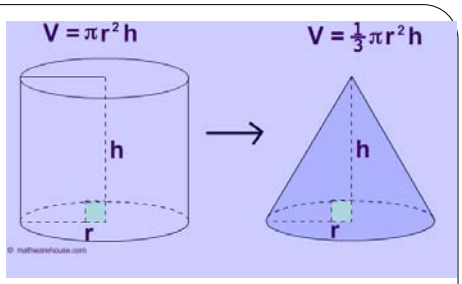
- Determine the volume in ft^3 for a tank that is 20 feet tall with a radius of 7.5 ft.

$$Vol = (\pi)(r^2)(h)$$

$$Vol = (\pi)(7.5ft)(7.5ft)(20ft)$$

$$Vol = 3534.29\ ft^3$$

Volume of a Cone



$$Volume = (1/3)(0.785)(Diameter^2)(height)$$

$$Vol = (1/3)(0.785)(D^2)(h)$$

OR

$$Volume = (1/3)[(\pi)(radius^2)(height)]$$

$$Vol = (1/3)[(\pi)(r^2)(h)]$$

Example 9

- Determine the volume in gallons of a conical tank that is 8 feet wide and 15 feet tall.

$$Vol = (1/3)(0.785)(D^2)(h)$$

$$Vol = (1/3)(0.785)(8ft)(8ft)(15ft)$$

$$Vol = 251.2\ ft^3$$

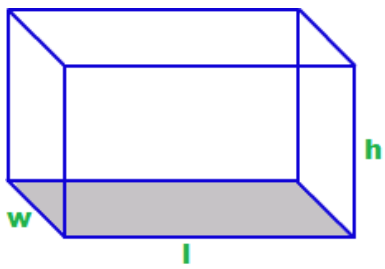
$$Vol, gal = (251.2\ \cancel{ft^3})(7.48\ \frac{gal}{\cancel{ft^3}})$$

$$Vol, gal = 1878.98\ gallons$$

Volume of a Rectangle

$$Volume = (length)(width)(height)$$

$$Vol = (l)(w)(h)$$



Example 10

- Determine the volume in m^3 for a tank that measures 30 meters by 15 meters by 25 meters.

$$Vol = (l)(w)(h)$$

$$Vol = (30m)(15m)(25m)$$

$$Vol = 11250m^3$$

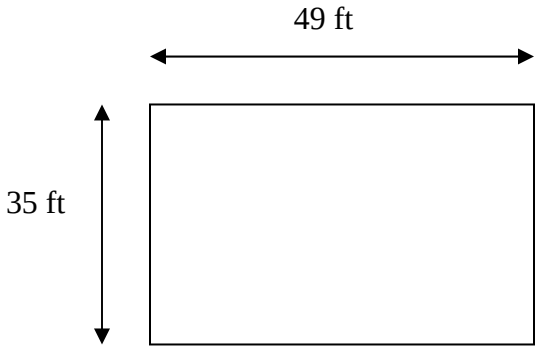
Math Problem Strategies

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		**Unknown**
Length = 35 ft Width = 49 ft	A = (l)(w) A = (35 ft)(49 ft) A = 1715 ft^2	Area = ?

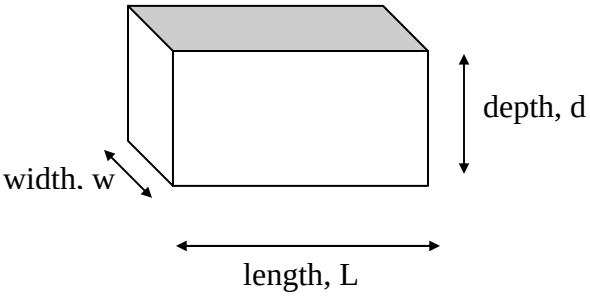


*****Remember: make sure measurements agree; if diameter of pipe is in inches then change to feet; if flow is in MGD and you need feet or feet/sec then change to ft^3/sec before you plug values into formula.***

mega (M)	..	kilo (k)	hecto (h)	deka (da)	no prefix	deci (d)	centi (c)	milli (m)	..	micro (μ)
1,000,000		1,000	100	10	1	$^1/_{10}$	$^1/_{100}$	$^1/_{1,000}$		$^1/_{1,000,000}$

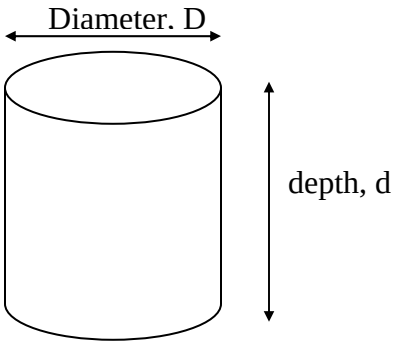
Tank Volume Calculations: Most tank volumes calculations are for tanks that are either rectangular or cylindrical in shape.

Rectangular Tank



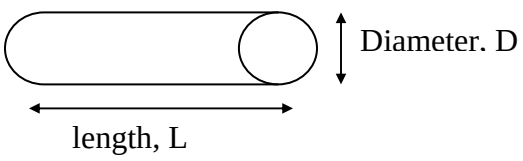
Volume = (L)(W)(d)

Cylindrical Tank



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

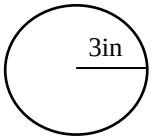
Portion of a Pipeline

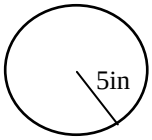


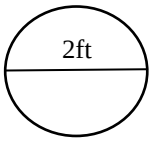
Volume = $(0.785)\ (D)^2\ (L)$

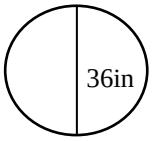
Basic Math for Water and Wastewater
CIRCUMFERENCE, AREA, AND VOLUME

Circumference

1. 

2. 

3. 

4. 

5. A chemical holding tank has a diameter of 24 feet. What is the circumference of the tank in feet?

6. An influent pipe inlet opening has a diameter of 4 feet. What is the circumference of the inlet opening in inches?

7. What is the length (in feet) of the notched weir of a circular clarifier that has a diameter of 32 feet?

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 lateral surface area (in ft^2) of a cone with a radius of 3 feet and a height of 9 feet.

3. Calculate the surface area (in ft^2) of a basin which is 90 feet long, 25 feet wide, and 10 feet deep.

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

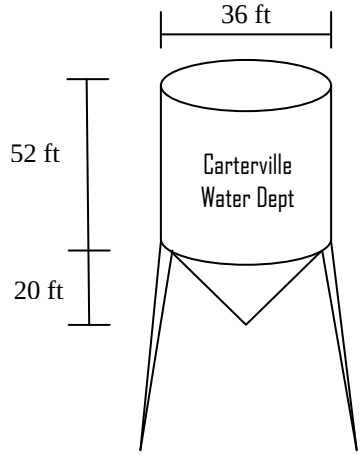
5. A chemical hopper is cone shaped and covered. It has a diameter of 4 feet and a depth of 7 feet. Calculate the total surface area of the hopper (in ft^2).

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

7. Determine the surface area in square feet for a triangle that has a base of 10 feet and a height of 15 ft.

8. A cylindrical storage tank is used to hold the day's supply of chemical. If the tank is 3 feet wide and 8 feet deep, what is the total exterior surface area of the cylinder in square feet?

9. A circular water tower that is tapered at the bottom has a diameter of 36 feet and a height of 52 feet from the top to the beginning of the taper. The cone created by the taper has a height of 20 feet. Calculate the total exterior surface area of the water tower.



Volume

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

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

3. 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.

4. Calculate the volume (in ft^3) of a cone shaped chemical hopper with a diameter of 12 feet and a depth of 18 feet.

5. 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?

6. 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?

7. Refer back to the water tower in Carterville in problem 7 of the last section. Calculate the total volume (in gallons) when the tower is full.

DON'T THINK TOO HARD ON THIS ONE...

8. 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:

Circumference	Area	Volume
1. 18.85 in	1. 540 ft^2	1. 1000 ft^3
2. 31.42 in	2. 89.41 ft^2	2. 9050.8 gal
3. 6.28 ft	3. 2250 ft^2	3. 359.04 gal
4. 113.10 in	4. 3.14 ft^2	4. 678.58 ft^3
5. 75.40 ft	5. 58.31 ft^2	5. 48442.35 gal
6. 150.80 in	6. 1.77 ft^2	6. 150000 gal
7. 100.53 ft	7. 7.0 ft^2	7. 446671.14 gal
	8. 89.53 ft^2	8. No, it quadruples it (4X)
	9. 8420.51 ft^2	

Basic Math for Water and Wastewater
Circumference, Area, and Volume

1. A rectangle has a length of 5 feet and a width of 3 feet. What is the area (in ft^2) of the rectangle?

2. Calculate the volume (in gal) of a water tank that is 19 feet in diameter with a height of 25 feet.

3. What is the area (in ft^2) of a rectangle 5 ft by 4 ft?

4. The diameter of a circle is 5 feet. What is its area (in ft^2)?

5. What is the lateral surface area (in in^2) of a cone with a diameter of 42 inches and a height of 26 inches?

6. What is the cross-sectional area (in ft^2) of a pipe with a diameter of 7 inches?

7. The dimensions of a tank are 60 feet wide, 10 feet deep and 15 feet long. Calculate the volume of the tank in cubic feet.

8. Calculate the volume of water (in ft^3) in a section of rectangular channel that is 4 feet deep, 5 feet wide, and 500 feet long.

9. A tank is 25 ft wide, 75 ft long and can hold water to a depth of 10 ft. What is the volume of the tank, in gallons?

10. The diameter of a tank is 60 ft. When the water depth is 25 ft, what is the volume of the water in the tank, in gallons?

11. A tank is 12 ft wide, 20 ft long and 15 deep. If the depth of the water is 11 ft, how many gallons of water are in the tank?

12. A new section of 12-inch diameter pipe is to be disinfected before it is put into service. If the length of the pipe is 2000 ft, how many gallons of water will be needed to fill the pipeline?

13. A section of 6 inch diameter pipeline is to be filled with chlorinated water for disinfection. If ¼ mile of pipeline is to be disinfected, how many gallons of water will be required?

14. A circular clarifier has a diameter of 40 ft. What is the surface area (in ft^2) of the clarifier?

15. Calculate the total surface area (in ft^2) of a cone that has a diameter of 48 inches and a height of 36 inches.

16. The surface area of a tank is 2000 ft^2. If the width of the tank is 25 feet, what is the length of the tank?

17. What is the cubic yard volume of a trench 500 ft long, 2.25 ft wide and 4 ft deep?

18. What is the diameter of a pipe (in feet) that is 750 feet long and holds 1324 ft^3 of water?

19. The top of a tank has a surface area of 3150 ft^2. If the width of the tank is 35 ft, what is the length of the tank?

20. Calculate the volume of water in gallons in a 6 foot deep channel holding 4 feet of water. The channel is 5 feet wide and 1200 feet long.

21. A tank is 12 ft wide and 20 feet long. If the depth of water is 11 feet, what is the volume of water in the tank in gallons?

22. Determine the amount of water, in gallons, to be disinfected in a new 36 inch water main that is 2 miles long.

23. A tank will hold 7500 gallons. What is the volume of water in the tank if the depth is 12.5 feet, width is 20, and length is 25 ft?

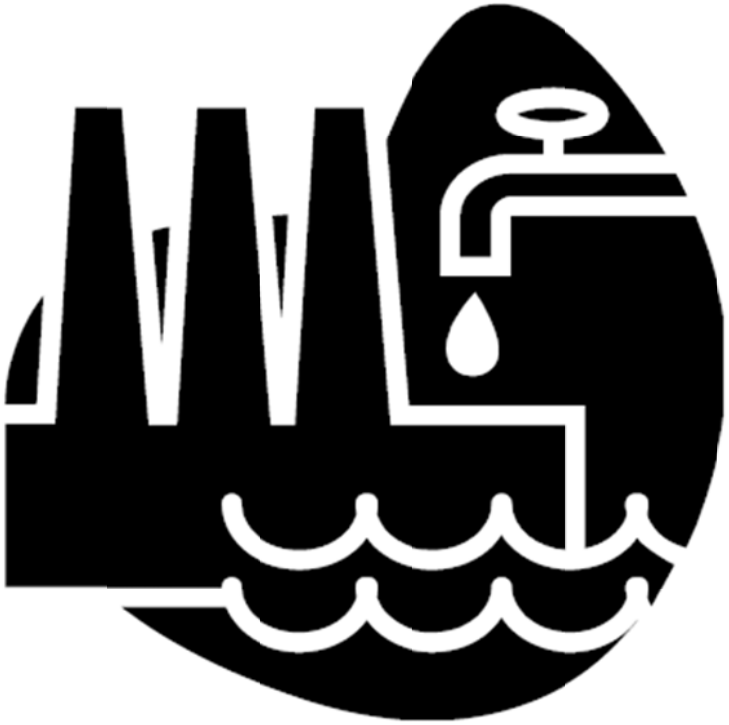
24. A 55 gallon steel drum with a diameter of 24 inches and a height of 42 inches needs to be painted. Calculate how many square feet of paint you would need to paint the entire outside of the barrel.

Answers

1. 15 ft
2. 53019.87 gal
3. 20 ft^2
4. 19.6 ft^2
5. 2204.93 in^2
6. 0.27 ft^2
7. 9,000 ft^3
8. 10,000 ft^3
9. 140,250 gal
10. 528,462 gal
11. 19,747.2 gal
12. 11,743.6 gal
13. 1,937.7 gal
14. 1256 ft^2
15. 35.22 ft^2
16. 80 ft
17. 166.67 yd^3
18. 1.5 ft
19. 90 ft
20. 179,520 gal
21. 79,747.2 gal
22. 558,055.9 gal
23. 46,750 gal
24. 28.27 ft^2

Section 8

Flow and Velocity



Velocity & Flow

Velocity

- The speed at which something is moving
- Measured in
  - $^{ft}/_{min}$ $^{ft}/_{sec}$ $^{miles}/_{hr}$ etc

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

Example 1

- Blue dye is placed in a sewer line at a manhole. Three (3) minutes later, the dye appears in a manhole 125 feet down stream. What is the velocity of the flow in ft/min?

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

$$Vel = \frac{125\ ft}{3\ min}$$

$$Vel = 41.67\ {}^{ft}/_{min}$$

Flow

- The volume of water that flows over a period of time
- Measured in
  - ${}^{ft^3}/_{sec}$ ${}^{ft^3}/_{min}$ ${}^{gal}/_{day}$ ${}^{MG}/_{D}$

$$Flow = (Area)(Velocity)$$

$$Q = AV$$

Example 2

- Water is flowing at velocity 3 ft/sec through a channel that is 2 feet wide and 1.5 feet deep. What is the flow in cubic feet per second?

$$Q = AV$$

$$Q = (l)(w)(velocity)$$

$$Q = (2ft)(1.5ft)\left(3\ {}^{ft}/_{sec}\right)$$

$$Q = 9\ {}^{ft^3}/_{sec}$$

Example 3

- Determine the flow in ft^3/sec through a 6 inch pipe that is flowing full at a velocity of 4.5 ft/sec.

$6in \div 12\frac{in}{ft}$
$D = 0.5ft$

$$Q = AV \qquad A = (0.785)(D^2)$$

$$Q = (0.785)(D^2)(vel)$$

$$Q = (0.785)(0.5ft)(0.5ft)\left(4.5\ {}^{ft}/_{sec}\right)$$

$$Q = 0.88\ {}^{ft^3}/_{sec}$$

Velocity

$$Velocity = \frac{Flow\ rate, {}^{ft^3}/_{sec}}{Area, ft^2}$$

- Use this formula when given the flow and area or dimensions

Example 4

- The flow through a 1.5 foot pipeline is 9.7 gallons per minute. What is the velocity of the water in ft/minute?

$$Velocity = \frac{Flow\ rate, {}^{ft^3}/_{sec}}{Area, ft^2}$$

$$\frac{9.7\frac{gal}{min}}{7.48\frac{gal}{ft^3}}$$

$$= 1.30\ {}^{ft^3}/_{min}$$

$$Vel = \frac{1.30\ {}^{ft^3}/_{sec}}{(0.785)(1.5ft)(1.5ft)}$$

$$Vel = \frac{1.30\ {}^{ft^3}/_{sec}}{1.7663\ ft^2}$$

$$Vel = 0.74\ {}^{ft}/_{sec}$$

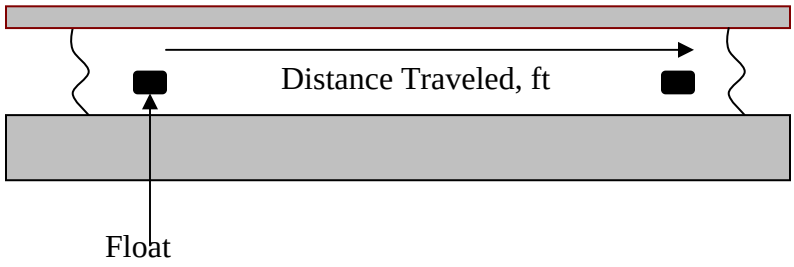
Basic Math for Water and Wastewater
Flow and Velocity

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?

2. A float travels 300 feet in a channel in 2 minutes and 14 seconds. What is the velocity in the channel, ft/sec?

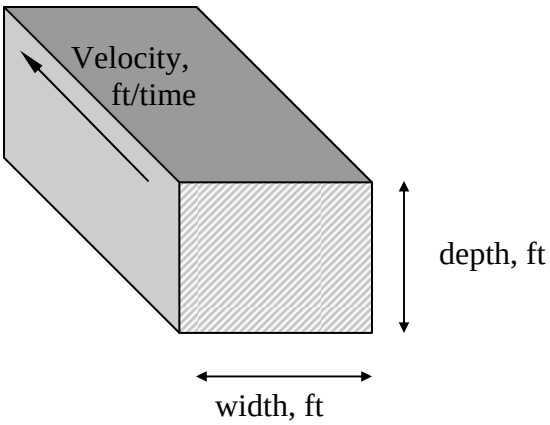
3. The distance between manhole #1 and manhole #2 is 105 feet. A fishing bobber is dropped into manhole #1 and enters manhole #2 in 30 seconds. What is the velocity of the wastewater in the sewer in ft/min?



$$\text{Velocity} = \frac{\text{Distance Traveled, ft}}{\text{Duration of Test, min}}$$

$$= \text{ft/min}$$

1.) 185 ft/min 2.) 2.2 ft/sec 3.) 210 ft/min



$$\underset{ft^3/time}{Q} = \underset{(ft)(ft)}{(A)} \quad \underset{(ft/time)}{(V)}$$

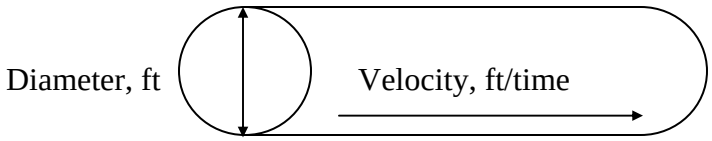
Flow in a channel

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?

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?

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?

4.) 16.8 ft^3/sec 5.) 900 ft^3/min; 9.7 MGD 6.) 1.8 ft



$$\underset{ft^3/time}{Q} = \underset{ft^2}{(A)} \quad \underset{(ft/time)}{(V)}$$

$$\underset{ft^3/time}{Q} = (0.785)\,(D)^2\,(vel)$$
$$(ft)(ft)\ (ft/time)$$

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?

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?

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?

10. An 8 inch diameter pipeline has water flowing at a velocity of 3.4 ft/sec. What is the flow rate in gpm?

7.) 10.05 ft3/sec 8.) 0.59 ft3/sec 9.) 6 in 10.) 532.4 gpm

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.)

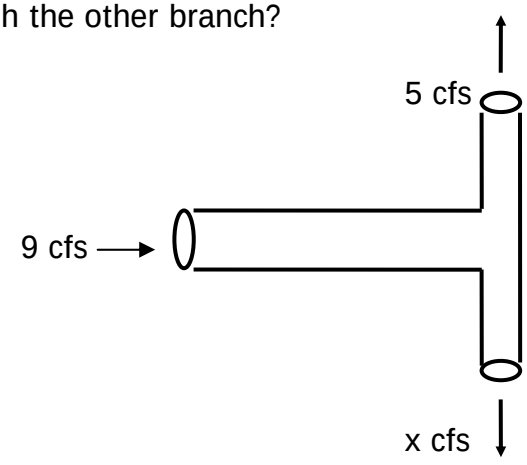
10. A cork placed in a channel travels 30 feet in 20 seconds. What is the velocity of the cork in feet per second?

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?



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. 2,404.50 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. 8.8 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. 465,046.56 gpd
20. 9.09 ft/sec
21. 6 in
22. 1,173,420 gpd