Math Review Guide
for
Distribution and
Collection System
Operators

\[ V_{\text{tank}} = (0.785)(D)^2 \times h \]

\[ P = H \times 0.433 \text{Psi/ft} \]

Making Math Work

November 2013 Edition
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This Document is made freely available to anyone needing a basic math review guide. It is designed for use by students studying for the various Collections / Distribution / Meter programs offered by the Schools Committee of the NC AWWA-WEA. For suggestions and corrections, the original source material is maintained by:

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Version 8 - November 2013
Basic Math Operations

Addition
Addition is used to find the sum of two or more quantities. The symbol used to indicate addition is the “+” sign.

Subtraction
Subtraction is used to find the difference between two quantities. The symbol used to indicate subtraction is the “-” sign.

Multiplication
Multiplication is used to find the product of two or more quantities. The symbol used to indicate multiplication is the “x” sign.

Division
Division is used to find the quotient or how many times a number is contained in another number. The mathematical symbol used to indicate division is the “/” or “÷” sign.

Examples of Basic Math Operations
Addition
10 + 2 = 12  
10 - 2 = 8  
10 x 2 = 20  
10 ÷ 2 = 5

Subtraction
10 - 2 = 8
10 x 2 = 20
10 ÷ 2 = 5

Intermediate Math Operations

Using Fractions
- Fractions represent proportions of quantities. For example, if you have a pizza sliced into 8 pieces and someone takes 3 slices from the pie, they have taken 3/8 of the pie.
- Fractions represent partial portions of whole numbers.
- Fractions can be added, subtracted, multiplied, or divided, just like whole numbers.
- Fractions are written as “a/b” or “a ÷ b”.
- Any quantity, divided by itself, is equal to 1. For example 5/5 = 1. This is called a unit fraction.

Adding and Subtracting Fractions
- When adding or subtracting fractions, the number on the bottom of the fractions (denominator) must be the same.

\[
\frac{2}{3} + \frac{4}{5} = \frac{?}{?}
\]

These two fractions cannot be added directly because the denominators are different. The lowest common denominator is found by multiplying the two denominators together to find the lowest common denominator. In this case, it is 15 (3x5). So, multiply each fraction by a unit fraction so that the denominators are the same. For example:

\[
\frac{2(5)}{3(5)} + \frac{4(3)}{5(3)} = \frac{?}{?}
\]

\[
\frac{10}{15} + \frac{12}{15} = \frac{22}{15}
\]

\[
\frac{22}{15} \text{ can further be reduced to } 1\frac{7}{15}
\]
Multiplying Fractions
- Fractions with different denominators can be multiplied directly without the need to find a lowest common denominator. For example:

\[
\frac{2}{4} \times \frac{3}{5} = \frac{6}{20}
\]

Division of Fractions
- To divide fractions, multiply Fraction #1 by the “flipped” Fraction #2. For example:

\[
\frac{1}{3} \div \frac{4}{6} = \frac{1}{3} \times \frac{6}{4} = \frac{6}{12} = \frac{1}{2}
\]

Working with decimals and percentages
- Fractional quantities are sometimes expressed in decimal format or percentage format.

\[
\frac{1}{2} = 0.5 = 50% \\
\frac{2}{3} = 0.666 = 67% \\
\frac{3}{5} = 0.429 = 43%
\]

- The percentages above are calculated by multiplying the “decimal number” such as 0.5 by 100% to get “50%”.

- One thing to note is that you never use “%” in a calculation or equation. 65% is similar to 65¢ in that it must be converted to its decimal form (0.65) to be used in a calculation.

Order of Math Operations
- An equation is two mathematical expressions, separated by an equal sign, that are numerically the same, but expressed differently.

\[Q = V \times A\]

- Equations are mostly seen where you are given 2 knowns and must find an unknown.

- There are several equations used in this syllabus that should be remembered. A partial list is these are:

<table>
<thead>
<tr>
<th>Use of Equation</th>
<th>Equation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full pipe flow</td>
<td>( Q_{cs} = V_{fps} \times A_{it} )</td>
</tr>
<tr>
<td>Time and Distance</td>
<td>dist = speed x time</td>
</tr>
<tr>
<td>Ohm’s Law</td>
<td>( E_{volts} = I_{amps} \times R_{\Omega} )</td>
</tr>
<tr>
<td>Pipe Grade</td>
<td>Slope = Rise/Run</td>
</tr>
</tbody>
</table>

Table of Common Equations

Some people find the following type of diagrams a useful way of remembering equations.

Working with Exponentials
- Exponentials are used to represent numbers raised to a power. The term “power” simply means how many times a number is to be multiplied by itself. For example:

\[
5^2 = 5 \times 5 = 25 \\
4^3 = 4 \times 4 \times 4 = 64 \\
D^2 = D \times D \\
D^3 = D \times D \times D
\]

- When the small number (power) is a 2, the lower number is considered to be “squared”. So when you hear “square feet” that would mean two feet distances have been multiplied to get an area.

- When the small number (power) is a 3, the lower number is considered to be “cubed”. So when you hear “cubic yards” that would mean three yard distances have been multiplied together to get a volume.

- The following illustration is given to help visualize squares and cubes.
Area = 3' x 3' = 9 ft²
Volume = 4' x 4' x 4' = 64 ft³

Conversions, Units, and Constants

Conversions are used to change how we describe quantities. For example, we can describe an area in units of square feet, square yards, acres, etc.

On the last page of this math syllabus is a Conversion Sheet of the most common unit conversions used in water and wastewater.

Another example, we know to convert “yards” to “feet”, you multiply by 3. The conversion in this would be 1 yard = 3 feet.

Question: How many million gallons per day (MGD) is 10,000 gallons per minute (gpm). This is a conversion problem. On the Conversion Sheet we see that 1 MGD = 694 gpm.

To do this problem correctly there are two concepts to understand: conversion as a fraction and unit cancellation.

Conversion as a fraction - All conversions are set up like the one noted above (1 MGD = 694 gpm) and can also be expressed as a fraction. For example, (1 MGD) / (694 gpm) or (694 gpm) / (1 MGD). In fraction form, they can then easily be used for unit cancellation as described herein.

Unit Cancellation – By setting up the conversion as a fraction as above you can verify you have done the multiplication or division correctly by canceling units (i.e. – feet, lbs, gal, etc) . If you have the same units divided by each other in an equation they cancel out whereas if they are multiplied together they are now squared.

So in our example above we want the answer in “MGD” and we want the “gpm” to cancel, so set the equation up as:

$$10,000 \text{ gpm} \times \frac{1 \text{ MGD}}{694 \text{ gpm}}$$, which we can do because the conversion fraction is really a “1” as described above.

This equation can also be written as  \((10,000 \ \text{gpm} \times 1 \ \text{MGD}) / (694 \ \text{gpm})\), since the gpm is on the top and bottom of the equation it cancels itself out and the answer becomes 14.4 MGD.

Units are used to indicate what the numerical quantity represents.

<table>
<thead>
<tr>
<th>Unit</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>Represents just the number &quot;25&quot;</td>
</tr>
<tr>
<td>25 ft</td>
<td>Represents 25 feet</td>
</tr>
<tr>
<td>25 ft²</td>
<td>Represents 25 square feet</td>
</tr>
<tr>
<td>25 miles/hour</td>
<td>Represents 25 miles per hour</td>
</tr>
</tbody>
</table>

Constants represent a paired quantity and unit of measure that is accepted as always being the same.

<table>
<thead>
<tr>
<th>Constant</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.34 lbs/gal</td>
<td>Unit weight of water</td>
</tr>
<tr>
<td>32 ft/s²</td>
<td>Acceleration of gravity</td>
</tr>
<tr>
<td>150 lbs/ft</td>
<td>Unit weight of concrete</td>
</tr>
</tbody>
</table>

Working with Areas, Perimeters & Volumes

For the purpose of this review guide, there are four main shapes that will be studied. These are the rectangle/square; the triangle; and the circle. These shapes are shown below.
A square is a special case of the rectangle where all sides are of equal length. A right triangle is a special triangle where one of the interior angles is a 90 degree angle.

Formulas for Calculating the Properties of Plane Shapes

<table>
<thead>
<tr>
<th>Shape</th>
<th>Area</th>
<th>Perimeter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rectangle</td>
<td>(b \times h)</td>
<td>(2 \times (b + h))</td>
</tr>
<tr>
<td>Square</td>
<td>(b \times b)</td>
<td>(4 \times b)</td>
</tr>
<tr>
<td>Circle</td>
<td>(0.785 \times D^2)</td>
<td>(3.14 \times D)</td>
</tr>
<tr>
<td>Right Triangle</td>
<td>(\frac{1}{2} \times b \times h)</td>
<td></td>
</tr>
</tbody>
</table>

Volumes

For our study of volumes we are interested in the two shapes, cylinders and prisms. Pipes and some tanks are cylinders. Excavated straight sided trenches are prisms.

<table>
<thead>
<tr>
<th>Shape</th>
<th>Volume</th>
<th>Surface Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cylinder</td>
<td>(0.785 \times D^2 \times h)</td>
<td>[2 \times 0.785 \times D^2 ] + (3.14 \times D \times h)</td>
</tr>
<tr>
<td>Prism</td>
<td>(b \times h \times l)</td>
<td>(2 \times [(b \times h) + (b \times l) + (h \times l)])</td>
</tr>
</tbody>
</table>

Construction Stationing

Construction stationing is just a “short-hand” way that distances are represented on engineering drawings. The expression is “00+00”. The numbers to the left of the “+” sign indicate hundreds of feet. The numbers to the right of the “+” sign represent feet. Thus “58+25” is the same as 5,825 feet.

Slope Calculations

Water lines are normally laid a given depth below the surface of the ground without regard to slope. Water is under pressure and doesn’t depend on gravity to make it flow. Sewers, on the other hand are sloped downhill so wastewater flows downhill. Sewers are laid to a slope which means that for every horizontal foot laid out, the sewer drops by some amount. See the following drawing for clarity.

The formula for slope is:

\[
\text{Slope} = \frac{\text{Rise}}{\text{Run}}, \text{ expressed as a percent.}
\]

The slope of the sewer shown is:
Dosing

Dosing refers to the adding of a chemical substance to a carrying medium, usually water, in such a way that the chemical added is dispersed through the medium and doesn’t appreciably react with the carrying medium. In the following discussion, for simplicity, we are going to assume we are always adding chlorine to water or chlorinating water.

Dosage Measurements

Dosage problems are essentially weight problems. Concentrations are usually specified in parts per million (ppm). A chemical concentration of 50 ppm means that there are 50 lbs. of the material present in each 1,000,000 lbs. of water or otherwise proportionally equivalent.

Chemicals added to water can either be added in pure form or in combination with other inert materials. Adding pure chemical is practical on the plant level where the chemical to be added can be contained in a storage tank or pressurized gas cylinder. For portability, chemicals are often combined with inert materials to make it easier and safer to handle. In that case, the purity of the chemical to be added must be known and factored into any dosage problem. Purity refers to the proportion of desired chemical available in the product to be used. For example, a common chemical is calcium hypochlorite, usually in tablet form, that contains a minimum of 65% available chlorine. It’s sometimes referred to as High Test Hypochlorite 65% or HTH_{65%}

Static Dosing

Static dosing is used to add chlorine to a fixed volume of water. Examples are the chlorination of a water main, water tank, swimming pool, and similar.

The formula to determine the amount of HTH to add is:

\[ \text{HTH}_{\text{REQUIRED}} = \frac{\text{MG}_{\text{water}} \times 8.34 \times \text{ppm}}{\text{Purity}} \]

where;

- \( \text{HTH}_{\text{REQUIRED}} \) = Weight of HTH Required (lbs)
- \( \text{MG}_{\text{water}} \) = Volume of water to be treated (million gallons)

Example – How many pounds of HTH_{65%} tablets are needed to disinfect a one million gallon water tank to 25 ppm?

\[ \text{HTH}_{\text{REQUIRED}} = \frac{(1 \text{MG}) \times 8.34 \text{ lbs/gal} \times 25}{0.65} \]

\( \text{HTH}_{\text{REQUIRED}} = 321 \text{ lbs.} \)

Contact Dosing

Contact dosing is used to add chlorine to a constant rate of water flow. Examples are the chlorination of water flowing in a pipe at the rate of 500 gpm such that the chlorine level leaving the chlorination point has an increase in chlorine concentration of 3 ppm.

The formula to determine the amount of HTH to add is:

\[ \text{HTH}_{\text{REQUIRED}} = \frac{\text{MGD}_{\text{water}} \times 8.34 \times \text{ppm}}{\text{Purity}} \]

where;

- \( \text{HTH}_{\text{REQUIRED}} \) = Weight of HTH Required (lbs/day)
- \( \text{MGD}_{\text{water}} \) = Rate of water to be treated (in million gallons per day)
Example – How many pounds of HTH\textsubscript{65\%} tablets are needed, per day, to increase the chlorine level by 2 ppm in a pipe flowing at 1,000 gpm?

\[
\text{HTH}_{\text{required}} = \left( \frac{0.001 \text{ mgal/\text{s}}}{\text{gal}} \right) \times \frac{8.34 \text{ lbs/\text{gal}}}{2} \times 0.65 \\
\text{HTH}_{\text{required}} = 0.0257 \text{ lbs/min}
\]

\[
0.0257 \text{ lbs/min} \times 60 \text{ min/hour} \times 24 \text{ hours/day} = 37 \text{ lbs/day}
\]

Contact Time

**Contact time** refers to the average time a flow is contained in a fixed volume before it is discharged. The drawing below illustrates this concept:

Contact Time Formulas

\[
\frac{V}{Q} = \text{Contact time}
\]

**Example –** What is the detention time for a flow rate of 250 gpm entering a 500,000 gal tank?

\[
T_c = \frac{V}{Q} = \frac{500,000 \text{ gal}}{250 \text{ gpm}} = 2,000 \text{ min}
\]

Water Pressure and Conversions

**Properties of Water**

Important properties of water and conversion factors

- 1 ft\textsuperscript{3} water weighs 62.4 pounds
- 1 gal water weighs 8.34 pounds
- 1 ft\textsuperscript{3} water contains 7.481 gallons

**Examples of Water Pressure Problems**

1. What would be the pressure at the bottom of an elevated tank where the water level is 220\' above the measurement point?

\[
220' \times 0.433 \frac{\text{psis}}{\text{ft}} = 95.26 \text{ psi}
\]

2. The pressure at the fill point of a fill pipe is 25 psi. How many feet of water will enter the tank?

\[
25 \text{ psi} \times 2.31 \frac{\text{ft}}{\text{psi}} = 57.8 \text{ feet}
\]

**Meter Testing**

Refer to the diagram below as a reference to the major components of a **meter test station**.

- a. There is a water supply
- b. There is a meter in the test assembly
- c. There is an inline flow control valve
- d. There is a calibration tank
- e. There is a drain valve on the calibration tank.
- f. There is a **staff gauge** mounted to the tank.
The meter test procedure is basically:

1. Open the drain valve on the calibration tank to empty.
2. Assemble the test station with the meter.
3. Turn on the supply water.
4. Regulate the flow to a predetermined rate (i.e. 2 fps)
5. When the meter needle reached a determined reference point, close the drain valve.
6. When the meter returns to the reference point, shut off the supply.
7. If there’s **MORE** water in the tank than the meter records, the meter is **SLOW**.
8. If there’s **LESS** water in the tank than the meter records, the meter is **FAST**.

**Meter Accuracy**

\[ \text{Accuracy}_{\text{Meter}} = \frac{\text{Meter Reading}}{\text{Actual}} \times 100\% \]

**Electrical Math**

Define: **Ohms Law** – The rate of the flow of the current, **amps** (I) is equal to the electromotive force, **volts** (V) divided by the resistance, **ohms** (R).

The three basic formulas are:

\[ V = I \times R \]
\[ R = \frac{V}{I} \]
\[ I = \frac{V}{R} \]

Another useful formula is \[ \text{Amps} = \frac{\text{Watts}}{\text{Volts}} \]

The diagram below shows a simple circuit that contains a 2000 watt lamp connected to a 120V circuit. If the switch is closed, what will the current flow be? What is the resistance of the circuit?

**Amperage**

\[ \text{Amperage} = \frac{\text{Watts}}{\text{Volts}} = \frac{2000\text{watts}}{120\text{V}} = 16.67\text{A} \]

\[ R = \frac{V}{I} = \frac{120\text{V}}{16.67\text{A}} = 7.2\Omega \]

**Horsepower Calculations**

**Useful Conversions**

1 horsepower = 550 \( \frac{\text{ft} \cdot \text{lb}}{\text{sec}} \)

1 horsepower = 746 watts = 0.746kW

**Definitions**

Power – The quantity of **power** is calculated as **work** divided by time. **Work** is defined as weight x distance.

**Example of Work and Power**

How much power is required to move 2,000 lbs of stone 500’ in 2 minutes? Convert the power to horsepower.

\[ \text{Power} = \frac{2000\text{lb} \times 500’}{120\text{sec}} = 8,333 \text{ft} \cdot \text{lb}/\text{sec} \]

\[ \text{hp} = \frac{8,333 \text{ft} \cdot \text{lb}/\text{sec}}{550 \text{ft} \cdot \text{lb}/\text{sec}} = 15.15\text{hp} \]
Centrifugal Pump Power Calculations

Note that sometimes efficiency is written as $N_{\text{pump}}$ and $N_{\text{motor}}$ instead of $\eta_p$ or $\eta_m$. 

$$WHP = \frac{Q \times H_{\text{TDH}}}{3,960}$$

$$BHP = \frac{WHP}{\eta_p}$$

$$MHP = \frac{BHP}{\eta_m}$$

$$\eta_{\text{overall}} = \frac{WHP}{MHP}$$

$$kW = MHP \times 0.746$$

Example of Pump Power Calculation

A pump discharges 1,250 gpm of water against a total head of 145’. The pump efficiency at this operating point is 80% and the motor efficiency is assumed to be 94%. Calculate the WHP, BHP, MHP, and kW.

WHP = \frac{1,250 \text{gpm} \times 145 \text{ft}}{3,960} = 45.8 \text{whp}

BHP = \frac{45.8 \text{whp}}{0.80} = 57.2 \text{bhp}

MHP = \frac{57.2 \text{bhp}}{0.94} = 60.9 \text{mhp}

\eta_{\text{overall}} = \frac{45.8 \text{whp}}{60.9 \text{mhp}} = 75.2\% 

kW = 60.9\text{mhp} \times 0.746 = 45.4 \text{kw}

Temperature Conversions

To convert °F to °C

$$^\circ C = \left( ^\circ F - 32 \right) \left( \frac{5}{9} \right)$$

To convert °C to °F

$$^\circ F = \left( \frac{^\circ C \times 9}{5} \right) + 32$$
### Conversion Factors & Constants

1. 1 inch (in) = 2.54 centimeters (cm)
2. 1 meter (m) = 3.28 feet (ft)
3. 1 acre = 43,560 square feet (sf)
4. 1 square mile = 640 acres (ac)
5. 1 cubic foot = 7.48 gallons (gal)
6. 1 gallon water = 8.34 pounds (lbs)
7. 1 liter = 1,000 cubic centimeters
8. 1 liter = 1,000 milliliters (ml)
9. 1 gallon = 3.785 liters (l)
10. 1 pound = 7,000 grains
11. 1 pound = 453.5 grams
12. 1 grain/gal = 17.1 parts per million (ppm)
13. 1 grain = 0.0648 grams (g)
14. 1 ppm = 8.34 pounds per MG water
15. 1 ft³ water = 62.4 pounds
16. 1 gram = 15.43 grains
17. 1 ounce = 28.35 grams
18. 1 ounce = 29.57 milliliters (ml)
19. 1 quart = 0.9464 liters
20. 1 foot water = 0.433 pounds per in²
21. 1 psi = 2.31 feet of water
22. 1 inch mercury = 1.13 feet of water
23. 1 horsepower = 33,000 ft-lbs per minute
24. 1 horsepower = 746 watts
25. 1 MGD = 1.55 cubic feet per second
26. 1 MGD = 694 gallons per minute
27. 1 day = 1,440 minutes
28. \( \pi \) (Greek ‘pi’) = 3.14
29. 1 meter = 100 centimeters
30. 1 kilogram = 2.205 pounds
31. 1 mile = 5,280 feet
32. 1,440 min = 1 day
33. 1 cubic yard = 1 day
34. 1 cubic yard = 27 cubic feet
35. 1 square yard = 9 square feet
Putting it to Work

The following problems are designed to utilize everything taught. Working these problems will give the student practice in performing the math problems similar to those found in the exams.

SEWER:

1. If a jetting crew cleans 1,800 feet of sewer in six (6) hours, how many feet are they averaging per hour?
   A. 300 ft/hr
   B. 600 ft/hr
   C. 3000 ft/hr
   D. 60 ft/hr

2. How many cubic yards of dirt would be required to fill a hole 10 feet long, 3 feet wide, and 6 feet deep?
   A. 180 yd$^3$
   B. 6.67 yd$^3$
   C. 66.7 yd$^3$
   D. 18.0 yd$^3$

3. How many square yards of pavement are required to replace a cut 6 feet wide and 9 feet long?
   A. 54 yd$^2$
   B. 60 yd$^2$
   C. 5.4 yd$^2$
   D. 6 yd$^2$

4. A manhole is 96 inches deep, how many feet is this?
   A. 8 ft
   B. 80 ft
   C. 12 ft
   D. 9 ft

5. If a wet well will hold 500 gallons, and the flow into the wet well is 10 gal/min, how long will it take, in minutes, to fill up?
   A. 100 min.
   B. 5 min.
   C. 50 min.
   D. 10 min.

6. If the TV camera travels down the sewer line at a rate of 2 ft/sec, how many minutes will it take to travel through 600 feet of sewer?
   A. 50 min.
   B. 5 min.
   C. 30 min.
   D. 3 min

7. If manhole #1 is at station 0+30 and manhole #2 is at station 2+50, what is the distance between manholes?
   A. 220 ft
   B. 2,200 ft
   C. 22 ft
   D. 50 ft

8. If the sewer line in problem #7 is laid on a 2.0% slope, what is the difference in elevation between the invert in manhole #1 and #2?
   A. 0.44 ft
   B. 44.0 ft
   C. 2.2 ft
   D. 4.4 ft
9. What is the slope in percent of an 8 inch sewer line that is 400 feet long, if the invert elevation of the upstream manhole is 836.00, and the invert elevation of the downstream manhole is 832.50?

A. 1.2%
B. 8.8%
C. 0.88%
D. 10.0%

10. What is the grade in percent (%) of a sewer line which falls 6 feet between station 10+30 and 4+10?

A. 2.0%
B. 1.2%
C. 0.97%
D. 4.0%

11. Estimate the total cost of a sanitary sewer construction project. The project consists of 459 feet of 10 inch sewer, and one manhole.

Costs are estimated as follows:

Excavation and backfill $16/ft
Furnish and install 10" pipe $8/ft
Furnish and install 4' manhole $950/ea

A. $ 974
B. $ 1,190
C. $ 11,966
D. $ 21,200

12. A trench 1.5 feet wide, 8 feet deep, and 100 feet long is to be filled with select backfill. How many cubic yards of backfill are required?

A. 1,200 yd³
B. 44.4 yd³
C. 52.0 yd³
D. 133.3 yd³

13. Using a labor cost of $ 6.50 per man hour, what is the labor cost of a job that requires 2 people 10 hours to complete?

A. $ 13
B. $ 65
C. $ 130
D. $ 68

14. The formula for calculating the volume of a square or rectangle wet well is:

A. V = Length x Width x Circumference
B. V = Width x Area x Perimeter
C. V = Width x Length x Height
D. V = Width x Height x Diameter

15. One cubic foot per second flow is equal to gallons per hour.

A. 2,694
B. 3,615
C. 6,250
D. 26,928

16. A wet well is 10 feet in diameter and 12 feet deep. The pump intake is on the bottom of the wet well. The overflow is 3 feet down from the top. The pump is set to come on when the water level is one foot below the overflow pipe, and cut off 2 feet from the bottom. How many gallons of water will the pump take out before it cuts off? Assume no inflow.

A. 2,350 gals
B. 14,100 gals
C. 3,523 gals
D. 6,110 gals
17. A wet well has these dimensions: 12 feet wide x 12 feet long x 10 feet deep. A pump lowers the water level 4 feet in 6 minutes. How many gallons per minute is the pump pumping?

A. 505 gpm  
B. 718 gpm  
C. 180 gpm  
D. 350 gpm

18. Water is flowing into a wet well at a rate of 300 gpm. The level in the wet well is rising at a rate of 50 gpm. What is the pump capacity under these conditions?

A. 350 gpm  
B. 100 gpm  
C. 200 gpm  
D. 250 gpm

19. Determine the capacity of a pump, if an 8 foot diameter wet well is lowered 5 feet in 3 minutes. Assume no inflow into the wet well. What is the pump’s capacity in MGD?

A. 627 MGD  
B. 205 MGD  
C. 0.9 MGD  
D. 0.6 MGD

20. Wastewater is pumped through an 8 inch force main at the rate of 448 gallons per minute (gpm). What is the velocity of the flow in the line?

A. 2.85 ft/sec  
B. 42.95 ft/sec  
C. 66.40 ft/sec  
D. 100.00 ft/sec

21. What is the overall efficiency of a pumping unit, if the current usage is 75 amperes at 220 volts, and the pump output is 500 gpm at a head of 100 feet?

A. 43%  
B. 57%  
C. 59%  
D. 76%

22. A pump has a capacity of 7,000 gpm and pumps wastewater 22 feet (total head). If the pump efficiency is 85%, what is the brake horsepower required?

A. 30 hp  
B. 40 hp  
C. 50 hp  
D. 60 hp

23. Your town has been receiving complaints about odors in your sewer system. To correct the problem, you have been instructed to use chlorine for odor control. The recommended dose is 15 mg/L, and your flow is 85 gpm. How many pounds 65% HTH chlorine a day will you use?

A. 6.7 lbs  
B. 9.9 lbs  
C. 12.6 lbs  
D. 23.6 lbs.

24. You have a centrifugal pump that delivers 400 gpm against a head of 200 feet, with a combined pump and motor efficiency of 70%. What is the cost for electrical power for operating the pump 12 hours/day for three months of 31 days each? (The electrical cost is 5 cents per kilowatt hour and 1 horsepower = 0.746 kilowatt.)

A. $281  
B. $842  
C. $1,201  
D. $1,682
25. A 10’ x 10’ wetwell contains 8’ of water at the beginning of a pump down test. The pump down time was determined to be 6 minutes and the fill time, after the pump was shutoff was 9 minutes. What was the average pump rate?

A. 1,234 gpm  
B. 1,459 gpm  
C. 1,662 gpm  
D. 1,800 gpm

26. An 8’ circular wetwell containing 6’ of water is equivalent to a 8’ x 8’ square wetwell containing how many inches of water?

A. 41 inches  
B. 51 inches  
C. 57 inches  
D. 64 inches

27. A 12” force main runs 3,000’ uphill from a pump station. It is necessary to drain this force main to perform maintenance on it. How many gallons of sewage must be contained?

A. 2,356 gallons  
B. 17,615 gallons  
C. 19,650 gallons  
D. 25,684 gallons

28. A pump operates at 3,000 gpm at 200’ of head. The pump efficiency is 75% and the motor efficiency is 95%. The pump operates 2000 hours per year. If electricity cost 6 cents per kilowatt-hour used, how much will the power bill be for the year?

A. $13,215  
B. $15,500  
C. $19,037  
D. $23,245

29. A 250’ diameter ground storage tank is 25’ tall. The tank walls and roof must be painted and the paint is known to cover 2,500 square feet per gallon. How many gallons of paint will be required?

A. 10.5 gallons  
B. 19.6 gallons  
C. 27.5 gallons  
D. 42.3 gallons

30. A trench for a sewer line is made in soil that requires a 1.5H : 1V side slope. The trench depth is 14’ and the trench bottom width is 6’. How wide must the top of the excavation be?

A. 20 feet  
B. 32 feet  
C. 48 feet  
D. 60 feet

31. If normal body temperature is 98.6 °F, what is the equivalent temperature in degrees Celsius?

A. 30 °C  
B. 33 °C  
C. 37 °C  
D. 50 °C
WATER

1. What is the volume of water in a 30 inch water line 550 feet long in \( \text{ft}^3 \), and in gallons?
   A. 26.9 \( \text{ft}^3 \) 20.2 gal
   B. 269 \( \text{ft}^3 \) 2,012 gal
   C. 2,698 \( \text{ft}^3 \) 20,184 gal
   D. 26.9 \( \text{ft}^3 \) 202 gal

2. Convert 1/2 to its decimal equivalent.
   A. 50.0
   B. 5.0
   C. 0.5
   D. 0.05

3. How many 18 ft. long sections of 6” ductile iron pipe will be needed for a 600 ft. water main extension?
   A. 34
   B. 200
   C. 20
   D. 333

4. How long will it take a pump which is pumping at 750 gallons per minute (gpm) to empty a tank which contains 75,000 gallons?
   A. 10 min.
   B. 8 min.
   C. 75 min.
   D. 100 min.

5. A water standpipe which is 40 ft. in diameter has 20 ft. of water in it. How much water is it holding?
   A. 1,879,948 gal
   B. 187,898 gal
   C. 46,974 gal
   D. 59,840 gal

6. A water tank pressure guage is reading 40 psi. If the gauge is located at ground level, what is the water surface elevation above the ground?
   A. 40.0 ft
   B. 92.4 ft
   C. 17.3 ft
   D. 23.1 ft

7. If a water plant is discharging finished water at a rate of 10 MGD, how much water is pumped in 20 hours?
   A. 10.0 million gallons
   B. 5.8 million gallons
   C. 6.9 million gallons
   D. 8.3 million gallons

8. Water is pumped from a small town’s well at a rate of 50 gallons per minute (gpm), and the town requires 60,000 gallons of water each day. How many hours must the pump run each day to supply the town with this amount of water?
   A. 2 hrs
   B. 20 hrs
   C. 200 hrs
   D. 10 hrs

9. A 10 inch water main is flowing at 497 gallons per minute (gpm). What is the velocity in feet per second (fps)?
   A. 2.02 fps
   B. 20.3 fps
   C. 0.202 fps
   D. 0.51 fps
10. If the velocity in a 12 inch pipe is 2.5 feet per second (fps), what is the flow in cubic feet per second (cfs)?

A. 19.6 cfs  
B. 282.7 cfs  
C. 2.82 cfs  
D. 1.96 cfs

11. How many pounds of 65% HTH chlorine are required to disinfect a 6 inch water main, 600 feet long with 50 ppm chlorine dosage?

A. 0.57 lbs.  
B. 368 lbs.  
C. 10 lbs.  
D. 5.0 lbs.

12. If 595.7 pounds of 65% HTH chlorine are used to disinfect a 1,000,000 gallon tank, what is the dosage in ppm?

A. 22 ppm  
B. 46 ppm  
C. 103 ppm  
D. 5 ppm

13. How many gallons of paint will it take to cover the outside of a tank (include the top) that is 20 feet in diameter, and 40 feet tall? The paint will cover 900 square feet per gallon. Answer to the nearest whole gallon.

A. 3 gallons  
B. 14 gallons  
C. 6 gallons  
D. 1 gallon

14. Assuming that 16” pipe weighs 90 pounds per foot empty. Estimate the weight of a 20-foot length of pipe filled with water.

A. 2,020 lbs.  
B. 3,040 lbs.  
C. 3,540 lbs.  
D. 4,500 lbs.

15. A plug is installed on the end of a 24” water main. It is anticipated that the maximum line pressure will be 85 psi. Calculate the expected thrust on the plug.

A. 2,040 lbs  
B. 38,433 lbs  
C. 42,250 lbs  
D. 50,250 lbs

16. If the pressure in a water main is 60 psi, what is the static pressure in a faucet located 25 feet above the main?

A. 49.2 psi  
B. 50.5 psi  
C. 70.6 psi  
D. 85.0 psi

17. Five mgd is pumped to a distribution point. Sampling has determined that the chlorine level in the main is 1 mg/l, but, it is desired that the level be 3 mg/l. A tablet chlorinator is specified, using 65% available hypochlorite tablets. Calculate the expected pounds of additional chemical use during a one week period.

A. 52 lb  
B. 512 lb  
C. 625 lb  
D. 898 lb

18. A flow rate of 85 gpm enters a circular tank that is 30 inches in diameter and 5 feet tall, and then overflows out. Calculate the detention time in minutes.

A. 2.2 min  
B. 5.2 min  
C. 10.4 min  
D. 15.5 min
19. Calculate the force, in pounds, on a 36” diameter access hatch on the wet riser of a water tank if the water level is 125’ above the center of the hatch.

A. 4,512 lb  
B. 12,526 lb  
C. 55,041 lb  
D. 80,666 lb 

**METER**

1. When running a flow rate test on a meter you find that in one minute 2.4 cu. ft. of water goes through the meter. What is the rate in GPM?

A. 18 gpm  
B. 3 gpm  
C. 24 gpm  
D. 8 gpm

2. "Meter accuracy" may be defined as the quotient obtained by dividing the meter reading by the actual volume of water. The percentage accuracy of a meter registering 52 cubic feet when 50 cubic feet are run through is?

A. 96%  
B. 102%  
C. 104%  
D. 114%

3. When testing meters in the shop, if the test tank shows 10 cu. ft. and the meter shows 9.6 cu. ft., the meter is?

A. 9.6 % fast  
B. 4.0 % fast  
C. 4.0 % slow  
D. 9.6 % slow

4. A meter in a well discharge line reads 0005678 gallons on one Monday and 0356098 on the following Monday. What is the average daily pumpage?

A. 35,042 gpd  
B. 43,802 gpd  
C. 50,060 gpd  
D. 350,420 gpd

5. When running a flow rate test on a meter you find that in 60 seconds 3.0 cu. ft. of water goes through the meter. What is the rate in GPM?

A. 12.5 GPM  
B. 5.7 GPM  
C. 22.4 GPM  
D. 3.6 GPM

6. While making a flow test on a meter you determine that in 1.5 minutes 4.0 cu. ft. of water goes through the meter. What is the rate in GPM?

A. 20 GPM  
B. 18 GPM  
C. 62 GPM  
D. 27 GPM

7. The percentage accuracy of a test meter registering 90 gallons when 95 gallons are run through it is:

A. 105%  
B. 95%  
C. 80%  
D. 110%

8. While making a flow test on a meter you determine that in 2.3 minutes, 6.2 cu. ft. of water goes through the meter. What is the flow in MGD?

A. 2.0 MGD  
B. 0.5 MGD  
C. 0.03 MGD  
D. 18.0 MGD
9. How much water will a tank 5 feet in diameter and 6 feet tall hold? How much does the water weigh?

A. 8,812 gal. 73,512 lbs.
B. 3,535 gal. 29,405 lbs.
C. 880.8 gal. 7,345.9 lbs.
D. 353.5 gal. 2,947 lbs.
SEWER ANSWERS:

1. If a jetting crew cleans 1,800 feet of sewer in six (6) hours, how many feet are they averaging per hour?

\[
\frac{1,800 \text{ ft}}{6 \text{ hrs}} = 300 \frac{\text{ft}}{\text{hr}}
\]

2. How many cubic yards of dirt would be required to fill a hole 10 feet long, 3 feet wide, and 6 feet deep?

\[
\frac{10' \times 3' \times 6'}{27 \frac{\text{cft}}{\text{cy}}} = 6.67 \text{ cy}
\]

3. How many square yards of pavement are required to replace a cut 6 feet wide and 9 feet long?

\[
\frac{6' \times 9'}{9 \frac{\text{yd}^2}{\text{ft}}} = 6 \text{ yd}^2
\]

4. A manhole is 96 inches deep, how many feet is this?

\[
\frac{96 \text{ in}}{12 \frac{\text{in}}{\text{ft}}} = 8 \text{ ft}
\]

5. If a wet well will hold 500 gallons, and the flow into the wet well is 10 gal/min.: How long will it take, in minutes to fill up?

\[
\frac{500 \text{ gal}}{10 \frac{\text{gal}}{\text{min}}} = 50 \text{ min}
\]

6. If the TV camera travels down the sewer line at a rate of 2 ft/sec, how many minutes will it take to travel through 600 feet of sewer?

\[
\frac{600 \text{ ft}}{2 \frac{\text{ft}}{\text{min}}} = 300 \text{ sec}
\]

\[
\frac{300 \text{ sec}}{60 \frac{\text{sec}}{\text{min}}} = 5 \text{ min}
\]

7. If manhole #1 is at station 0+30 and manhole #2 is at station 2+50, what is the distance between manholes?

\[
\begin{array}{c}
2 + 50 \\
- 30 \\
2 + 20
\end{array}
\]

\[2 + 20 \text{ stations} = 220 \text{ ft}\]

8. If the sewer line in problem #7 is laid on a 2.0% slope, what is the difference in elevation between the invert in manhole #1 and #2?

\[
slope = \frac{\text{rise}}{\text{run}}
\]

\[
\text{rise} = (\text{slope})(\text{run})
\]

\[
\text{rise} = (0.02)(220')
\]

\[
\text{rise} = 4.4'
\]

9. What is the slope in percent of an 8 inch sewer line that is 400 feet long, if the invert elevation of the upstream manhole is 836.00 and the invert elevation of the downstream manhole is 832.50?

\[
\text{Slope} = \frac{\text{rise}}{\text{run}} \times 100\%
\]

\[
\text{Slope} = \frac{836.0 - 832.5}{400} \times 100\%
\]

\[
\text{Slope} = \frac{3.5}{400} \times 100\% = 0.88\%
\]

10. What is the slope in percent (%) of a sewer line which falls 6 feet between station 10+30 and 4+10?

\[
\text{Slope} = \frac{\text{rise}}{\text{run}} \times 100\%
\]

\[
\text{Slope} = \frac{6}{(1,030 - 410)} \times 100\%
\]

\[
\text{Slope} = \frac{6}{620} \times 100\% = 0.97\%
\]
11. Estimate the total cost of a sanitary sewer construction project. The project consists of 459 feet of 10 inch sewer, and one manhole.

Costs are estimated as follows:
- Excavation and backfill: $16/ft
- Furnish and install 10” pipe: $8/ft
- Furnish and install 4’ manhole: $950/ea

\[
\begin{align*}
459' \times $16/ft &= 7,334 \\
459' \times $8/ft &= 3,672 \\
1 \times $950/ea &= 950 \\
\hline
= &\quad 11,966
\end{align*}
\]

12. A trench 1.5 feet wide, 8 feet deep, and 100 feet long is to be filled with select backfill. How many cubic yards of backfill are required?

\[
V = b \times h \times l = 1.5' \times 8' \times 100' = 1,200 \text{ ft}^3
\]

\[
\frac{1,200 \text{ ft}^3}{27 \text{ ft}^3/\text{yd}^3} = 44.4 \text{ yd}^3
\]

13. Using a labor cost of $6.50 per man hour, what is the labor cost of a job that requires 2 people 10 hours to complete?

\[
\frac{$6.50 \text{ per man \cdot hr}}{} \times 2 \text{ men} \times 10 \text{ hrs} = $130
\]

14. The formula for calculating the volume of a square or rectangular wet well is:

\[
V = \text{Width} \times \text{Length} \times \text{Height}
\]

15. One cubic foot per second of flow is equal to gallons per hour.

\[
Q = \frac{1 \text{ ft}^3}{\text{sec}} \times \frac{7.48 \text{ gal}}{\text{ft}^3} \times \frac{3,600 \text{ sec}}{1 \text{ hr}} = 26,928 \text{ ft}^3/\text{hr}
\]

16. A wet well is 10 feet in diameter and 12 feet deep. The pump intake is on the bottom of the wet well. The overflow is 3 feet down from the top. The pump is set to come on when the water level is one foot below the overflow pipe, and cut off 2 feet from the bottom. How many gallons of water will the pump take out before it cuts off? Assume no inflow.

\[
V_{\text{water}} = (12') (12') (4') = 576 \text{ ft}^3
\]

\[
\frac{576 \text{ ft}^3 \times 7.48 \text{ gal}}{1 \text{ ft}^3} = 4308.5 \text{ gal}
\]

\[
Q = \frac{V}{t} = \frac{4308.5 \text{ gal}}{6 \text{ min}} = 718 \text{ gal/min}
\]

17. A wet well has these dimensions: 12 feet wide x 12 feet long x 10 feet deep. A pump lowers the water level 4 feet in 6 minutes. How many gallons per minute is the pump pumping?

\[
V_{\text{water}} = (12') (12') (4') = 576 \text{ ft}^3
\]

\[
\frac{576 \text{ ft}^3 \times 7.48 \text{ gal}}{1 \text{ ft}^3} = 4308.5 \text{ gal}
\]

\[
Q = \frac{V}{t} = \frac{4308.5 \text{ gal}}{6 \text{ min}} = 718 \text{ gal/min}
\]

18. Water is flowing into a wet well at a rate of 300 gpm. The level in the wet well is rising at a rate of 50 gpm. What is the pump capacity under these conditions?

\[
Pump_{\text{Capacity}} = (O_{\text{out}}) - (O_{\text{in}})
\]

\[
Pump_{\text{Capacity}} = (300 \text{ gpm} - 50 \text{ gpm})
\]

\[
Pump_{\text{Capacity}} = 250 \text{ gpm}
\]
19. Determine the capacity of a pump, if an 8 foot diameter wet well is lowered 5 feet in 3 minutes. Assume no inflow into the wet well. What is the pump’s capacity in MGD?

\[
A_{ww} = 0.785(8^2) = 50.24 \text{ ft}^2
\]

\[
V_{ww} = A_{ww} \times D
\]

\[
V_{ww} = 50.24 \text{ ft}^2 \times 5 \text{ ft} = 251.2 \text{ ft}^3
\]

Rate
\[
= \frac{\frac{V_{ww}}{t}}{3 \text{ min}} = \frac{251.2 \text{ ft}^3}{3 \text{ min}} = 83.72 \text{ ft}^3/\text{min}
\]

\[
= \frac{83.72 \text{ ft}^3}{1 \text{ min}} \times \frac{1440 \text{ min}}{1 \text{ day}} \times \frac{7.48 \text{ gal}}{1 \text{ ft}^3} \times \frac{1 \text{ mg}}{10^6 \text{ gal}} = 0.9 \text{ mgd}
\]

20. Wastewater is pumped through an 8 inch force main at the rate of 448 gallons per minute (gpm). What is the velocity of the flow in the line?

\[
A_{pipe} = 0.785(0.67)^2 = 0.35 \text{ ft}^2
\]

\[
Q_{pipe} = \frac{448 \text{ gal}}{\text{min}} \times \frac{1 \text{ min}}{60 \text{ sec}} \times \frac{1 \text{ ft}^3}{7.48 \text{ gal}}
\]

\[
Q_{pipe} = \frac{1 \text{ ft}^3}{\text{sec}}
\]

\[
V_{pipe} = \frac{Q}{A} = \frac{1 \text{ ft}^3/\text{sec}}{0.35 \text{ ft}^2} = 2.85 \text{ fps}
\]

21. What is the overall efficiency of a pumping unit, if the current usage is 75 amperes at 220 volts and the pump output is 500 gpm at a head of 100 feet?

\[
P_{\text{input}} = (75A)(220V)
\]

\[
P_{\text{input}} = 16,500 \text{ watts}
\]

\[
P_{\text{output}} = \frac{(500)(100)}{3960} = 12.63 \text{ hp}
\]

\[
12.63 \text{ hp} \times 746 \text{ watts/\text{hp}} = 9,419 \text{ watts}
\]

\[
\text{Efficiency} = \frac{P_{\text{out}}}{P_{\text{in}}} \times 100\% = \frac{9,419}{16,500} \times 100\% = 57\%
\]

22. A pump has a capacity of 7,000 gpm and pumps wastewater 22 feet (total head). If the pump efficiency is 85%, what is the brake horsepower required?

\[
bhp = \frac{Q_g}{3960 \times E_p}
\]

\[
bhp = \frac{(7,000)(22)}{(3960)(0.85)}
\]

\[
bhp = 46 \text{ hp}
\]

\[
\therefore \text{say 50 hp, since it is closest std. motor available.}
\]
23. Your town has been receiving complaints about odors in your sewer system. To correct the problem, you have been instructed to use chlorine for odor control. The recommended dose is 15 mg/L, and your flow is 85 gpm. How many pounds 65% HTH chlorine a day will you use?

\[
\text{dosage} = \frac{\text{mgd} \times 8.34 \text{ lb/gal} \times \text{ppm}}{\text{purity}} = \frac{0.1224 (8.34) (15)}{0.65} = 23.6 \text{ lb}
\]

24. You have a centrifugal pump that delivers 400 gpm against a head of 200 feet, with a combined pump and motor efficiency of 70%. What is the cost for electrical power for operating the pump 12 hours/day for three months of 31 days each? (The electrical cost is 5 cents per kilowatt hour and 1 horsepower = 0.746 kilowatt.)

\[
\begin{align*}
\text{MHP} &= \frac{Q \times H}{3,960 \times E} = \frac{(400)(200)}{(3960)(0.70)} \\
\text{MHP} &= 28.86 \text{ hp} \\
\text{hp} &= \frac{21.53 \text{ kW}}{12 \text{ hr}} \\
&= \frac{93 \text{ day}}{\text{kW} \times \text{hr}} \\
&= \frac{0.05}{\text{hr}} = \$1,201
\end{align*}
\]

25. A 10’ x 10’ wetwell contains 8’ of water at the beginning of a pump down test. The pump down time was determined to be 6 minutes and the fill time, after the pump was shutoff was 9 minutes. What was the average pump rate?

\[
\begin{align*}
V &= (10')^2 \times 8' \times 7.48 \frac{\text{gal}}{\text{ft}^3} = 5984 \text{ gal} \\
Q_{in} &= \frac{5984 \text{ gal}}{9 \text{ min}} = 664.9 \text{ gpm} \\
Q_{net} &= \frac{5984 \text{ gal}}{6 \text{ min}} = 997.3 \text{ gpm} \\
Q_{out} &= Q_{net} + Q_{in} \\
Q_{out} &= 997.3 + 664.9 = 1662 \text{ gpm}
\end{align*}
\]

26. An 8’ circular wetwell containing 6’ of water is equivalent to a 8’ x 8’ square wetwell containing how many inches of water?

\[
\begin{align*}
V &= 0.785 \times D^2 \times h \\
V &= 0.785 \times 8'^2 \times 6' \\
&= 301.44 \text{ ft}^3 \\
A_w &= \frac{V}{d_w} = \frac{301.44 \text{ ft}^3}{(8')^2} = 4.71' = 57''
\end{align*}
\]

27. A 12” force main runs 3,000’ uphill from a pump station. It is necessary to drain this force main to perform maintenance on it. How many gallons of sewage must be contained?

\[
\begin{align*}
V &= (0.785)(1')^2 (3000') = 2,355 \text{ ft}^3 \\
&= \frac{2,355 \text{ ft}^3 \times 7.48 \text{ gal}}{\text{ft}^3} = 17,615 \text{ gal}
\end{align*}
\]
28. A pump operates at 3,000 gpm at 200’ of head. The pump efficiency is 75% and the motor efficiency is 95%. The pump operates 2000 hours per year. If electricity cost 6 cents per kilowatt-hour used, how much will the power bill be for the year?

\[
\text{MHP} = \frac{Q_{\text{nom}} (H_p)}{(3960)(E_p)(E_m)} = \frac{(3000)(200)}{(3960)(.75)(.95)}
\]

\[
\text{MHP} = 212.65\text{ kW}
\]

\[
\text{kW} = \frac{\text{MHP} \times .746\text{kW/h}}{\text{MHP}} = 158.6\text{kW}
\]

\[
\$ = (158.6 \text{ kW})(2000 \text{ hr})(\frac{.06\text{ cent}}{\text{kWh}}) = \$19,037
\]

29. A 250’ diameter ground storage tank is 25’ tall. The tank walls and roof must be painted and the paint is known to cover 2,500 square feet per gallon. How many gallons of paint will be required?

\[
A_{\text{top}} = (0.785)(250')(25')^2 = 49062\text{ ft}^2
\]

\[
A_{\text{side}} = \text{length} \times \text{height}
\]

\[
A_{\text{side}} = [(250')(\pi)(25')] = 19635\text{ ft}^2
\]

\[
A_{\text{total}} = A_{\text{top}} + A_{\text{side}}
\]

\[
A_{\text{total}} = 49062\text{ ft}^2 + 19635\text{ ft}^2
\]

\[
A_{\text{total}} = 68697\text{ ft}^2
\]

\[
\frac{68697\text{ ft}^2}{2500\text{ gal/ft}^2} = 27.5\text{ gallons}
\]

30. A trench for a sewer line is made in soil that requires a 1.5H : 1V side slope. The trench depth is 14’ and the trench bottom width is 6’. How wide must the top of the excavation be?

\[
14'\text{ deep} \times \frac{1.5H}{1.0V} = 21'
\]

\[
\text{Width} = 2(21') + 6' = 48'
\]

31. If normal body temperature is 98.6 °F, what is the equivalent temperature in degrees Celsius?

\[
\text{°C} = \frac{5(\text{°F} - 32)}{9}
\]

\[
\text{°C} = \frac{5(98.6 - 32)}{9} = 37\text{ °C}
\]

**WATER ANSWERS**

1. What is the volume of water in a 30 inch water line 550 feet long in ft$^3$, and in gallons?

\[
30" = 2.5'
\]

\[
V = 0.785(2.5')^2 \times 550' = 2698\text{ ft}^3
\]

\[
V = 2698\text{ ft}^3 \times \frac{7.48\text{ gal}}{\text{ft}^3} = 20184\text{ gal}
\]

2. Convert 1/2 to its decimal equivalent.

\[
1 ÷ 2 = 0.5
\]

3. How many 18 ft. long sections of 6” ductile iron pipe will be needed for a 600 ft. water main extension?

\[
\text{jo int} = \frac{\text{length}}{\text{length}} = \frac{600\text{ ft}}{18\text{ ft}} = 34
\]

4. How long will it take a pump which is pumping at 750 gallons per minute (gpm) to empty a tank which contains 75,000 gallons?

\[
\text{t} = \frac{V}{Q} = \frac{75,000\text{ gal}}{750\text{ gal/min}} = 100\text{ min}
\]
5. A water standpipe which is 40 ft. in diameter has 20 ft. of water in it. How much water is it holding?

\[ V = A \times h \]

\[ V = \left[ (0.785)(40')^2 \right] (20') \]

\[ V = 25,120 \text{ ft}^3 \]

\[ 25,120 \text{ ft}^3 \times 7.48 \frac{\text{gal}}{\text{ft}^3} = 187,898 \text{ gal} \]

6. A water tank pressure gauge is reading 40 psi. If the gauge is located at ground level, what is the water surface elevation above the ground?

\[ \frac{40 \text{ lb}}{1 \text{ psi}} \times \frac{1 \text{ lb}}{16 \text{ ft}} = 2.31 \text{ ft} \]

7. If a water plant is discharging finished water at a rate of 10 MGD, how much water is pumped in 20 hours?

\[ 10 \text{ mgd} \times \frac{20 \text{ hr}}{24 \text{ hr}} = 8.33 \text{ mgd} \]

8. Water is pumped from a small town's well at a rate of 50 gallons per minute (gpm), and the town requires 60,000 gallons of water each day. How many hours must the pump run each day to supply the town with this amount of water?

\[ t = \frac{V}{Q} = \frac{60,000 \text{ gal}}{50 \text{ gal/min}} = 1200 \text{ min} \]

\[ 1200 \text{ min} \times \frac{1 \text{ hr}}{60 \text{ min}} = 20 \text{ hr} \]

9. A 10 inch water main is flowing at 497 gallons per minute (gpm). What is the velocity in feet per second (fps)?

\[ V_{fps} = \frac{Q}{A} \]

\[ d = \frac{10}{12} = 0.833' \]

\[ Q = \frac{497 \text{ gal} \times 1 \text{ min}}{60 \text{ sec} \times 1 \text{ ft}^3} = 7.48 \text{ gal/ft}^3 \]

\[ Q_{ch} = 1.11 \frac{\text{ft}^3}{\text{sec}} \]

\[ A = (0.785)(0.833')^2 = 0.55 \text{ ft}^2 \]

\[ V_{fps} = \frac{Q}{A} = \frac{1.11}{0.55} = 2.02 \frac{\text{ft}}{\text{sec}} \]

10. If the velocity in a 12 inch pipe is 2.5 feet per second (fps), what is the flow in cubic feet per second (cfs)?

\[ Q = V \times A \]

\[ V = 2.5 \frac{\text{ft}}{\text{sec}} \]

\[ A = 0.785 (1')^2 = 0.785 \text{ ft}^2 \]

\[ Q = \frac{2.5 \frac{\text{ft}}{\text{sec}} \times 0.785 \text{ ft}^2}{0.785 \text{ ft}^2} = 1.96 \frac{\text{ft}^3}{\text{sec}} \]

11. How many pounds of 65% HTH chlorine are required to disinfect a 6 inch water main, 600 feet long with 50 ppm chlorine dosage? 6" = 0.5'

\[ V_{pipe} = 0.785 (0.5')^2 \times 600' = 117.75 \text{ ft}^3 \]

\[ V_{pipe} = 117.75 \frac{\text{ft}^3}{\text{sec}} \times \frac{7.48 \text{ gal}}{\text{ft}^3} = 880.7 \text{ gal} \]

\[ 880.7 \text{ gal} = 0.0008807 	ext{ mg} \]

\[ \text{dosage} = \frac{(0.0008807)(8.34)(50)}{0.65} \]

\[ \text{dosage} = 0.57 \text{ lb} \]
12. If 595.7 pounds of 65% HTH chlorine are used to disinfect a 1,000,000 gallon tank, what is the dosage in ppm?

$$ppm = \frac{(dosage)(purity)}{(mg)(8.34)}$$

$$ppm = \frac{(595.7lb)(0.65)}{(1mg)(8.34 \text{ lb/gal})}$$

$$ppm = 46$$

13. How many gallons of paint will it take to cover the outside of a tank (include the top) that is 20 feet in diameter, and 40 feet tall? The paint will cover 900 square feet per gallon. Answer to the nearest whole gallon.

$$A_{top} = (0.785)(20\text{'})^2 = 314\text{ ft}^2$$

$$A_{side} = \text{length} \times \text{height}$$

$$A_{side} = [(20\text{'})((\pi)(40\text{'})] = 2513\text{ ft}^2$$

$$A_{total} = A_{top} + A_{side}$$

$$A_{total} = 314\text{ ft}^2 + 2513\text{ ft}^2$$

$$A_{total} = 2827\text{ ft}^2$$

$$\frac{2827\text{ ft}^2}{900\text{ gal/ft}^2} = 3\text{ gallons}$$

14. Assuming that 16” pipe weighs 90 pounds per foot empty. Estimate the weight of a 20-foot length of pipe filled with water.

$$\text{Water}_{per\ ft} = 0.785\left(\frac{16}{12}\right)^2(1)(62.4\text{ lb/ft}^3) = 87\text{ lb}$$

$$\left(\frac{90\%}{90\%}\right)(20\text{ ft}) = 1800\text{ lb}$$

$$\left(\frac{87\%}{3540\lb}\right)(20\text{ ft}) = 1740\text{ lb}$$

15. A plug is installed on the end of a 24” water main. It is anticipated that the maximum line pressure will be 85 psi. Calculate the expected thrust on the plug.

$$F = P \times A$$

$$F = \left(\frac{85\text{ lb}}{\text{in}^2}\right)\left[(0.785)(24\text{”})^2\right]$$

$$F = \left(\frac{85\text{ lb}}{\text{in}^2}\right)(452\text{ in}^2) = 38,433\text{ lb}$$

16. If the pressure in a water main is 60 psi, what is the static pressure in a faucet located 25 feet above the main?

$$\frac{25\text{ ft}}{\text{ft}} \times 0.433\text{ psi} = 10.3\text{ psi}$$

$$P_{faucet} = (60 - 10.3)\text{ psi} = 49.2\text{ psi}$$

17. Five mgd is pumped to a distribution point. Sampling has determined that the chlorine level in the main is 1 mg/l, but, it is desired that the level be 3 mg/l. A tablet chlorinator is specified, using 65% available hypochlorite tablets. Calculate the expected pounds of chemical use during a one week period.

$$\text{dosage} = \frac{(mg)(8.34 \text{ lb/gal})(V_{ppm})}{\text{purity}}$$

$$\text{dosage} = \left(5\right)(8.34 \text{ lb/gal})(3 - 1)\times \frac{0.65}{O.65}$$

$$\text{dosage} = 128.3\text{ lb/day}$$

$$128.3\text{ lb/day} \times 7\text{ day} = 898\text{ lb}$$
18. A flow rate of 85 gpm enters a circular tank that is 30 inches in diameter and 5 feet tall, and then overflows out. Calculate the detention time in minutes.

\[ d_t = \frac{V}{Q} \]

\[ = \frac{0.785 \left( \frac{30''}{12''/ft} \right)^2 (5') \left( \frac{7.48 \text{ gal}}{ft^3} \right)}{85 \text{ gal/min}} \]

\[ d_t = 2.2 \text{ minutes} \]

19. Calculate the force, in pounds, on a 36” diameter access hatch on the wet riser of a water tank if the water level is 125’ above the center of the hatch.

\[ F = P \times A; \]

\[ P = \left( \frac{125 \text{ ft}}{0.43 \text{ psi/ft}} \right) = 54.1 \text{ psi} \]

\[ A = 0.785 \left( \frac{36''}{12''/in} \right)^2 = 1017.4 \text{ in}^2 \]

\[ F = \left( \frac{54.1 \text{ lb}}{\text{in}^2} \right) \times 1017.4 \text{ in}^2 = 55,041 \text{ lb} \]

**METER ANSWERS**

1. When running a flow rate test on a meter you find that in one minute 2.4 cu. ft. of water goes through the meter. What is the rate in GPM?

\[ \frac{2.4 \text{ ft}^3}{1 \text{ min}} \times \frac{7.48 \text{ gal}}{\text{ft}^3} = 18 \text{ gal/min} \]

2. "Meter accuracy" may be defined as the quotient obtained by dividing the meter reading by the actual volume of water. The percentage accuracy of a meter registering 52 cubic feet when 50 cubic feet are run through is?

\[ \text{Reading} \times 100\% = \text{Accuracy} \]

\[ \frac{52 \text{ ft}^3}{50 \text{ ft}^3} \times 100\% = 104\% \]

3. When testing meters in the shop, if the test tank shows 10 cu. ft. and the meter shows 9.6 cu. ft., the meter is?

\[ \frac{9.6 \text{ ft}^3}{10 \text{ ft}^3} \times 100\% = 96\% \]

∴ since the reading was less than actual, the meter was slow, or 100% - 96% = 4% slow.

4. A meter in a well discharge line reads 0005678 gallons on one Monday and 0356098 on the following Monday. What is the average daily pumpage?

\[ \Delta(gals) = 0356098 - 0005678 \]

\[ \Delta(gals) = 350,420 \text{ gals} \]

For daily pumpage then.

\[ \frac{350,420 \text{ gal}}{1 \text{ week}} \times \frac{1 \text{ week}}{7 \text{ days}} = 50,060 \text{ gal/day} \]

5. When running a flow rate test on a meter you find that in 60 seconds 3.0 cu. ft. of water goes through the meter. What is the rate in GPM?

\[ Q = \frac{3 \text{ ft}^3}{60 \text{ sec}}; \quad \text{convert to GPM} \]

\[ \frac{3 \text{ ft}^3}{60 \text{ sec}} \times \frac{60 \text{ sec}}{1 \text{ min}} \times \frac{7.48 \text{ gal}}{\text{ft}^3} = 22.4 \text{ gal/min} \]
6. While making a flow test on a meter you determine that in 1.5 minutes 4.0 cu. ft. of water goes through the meter. What is the rate in GPM?

\[ Q = \frac{4 \text{ ft}^3}{1.5 \text{ min}}; \text{ convert to GPM} \]

\[ \frac{4 \text{ ft}^3}{1.5 \text{ min}} \times \frac{7.48 \text{ gal}}{\text{ft}^3} = 20 \text{ gal/min} \]

7. The percentage accuracy of a test meter registering 90 gallons when 95 gallons are run through it is:

\[ \frac{\text{Reading}}{\text{Actual}} \times 100\% = \text{Accuracy} \]

\[ \frac{90 \text{ gal}}{95 \text{ gal}} \times 100\% = 95\% \]

8. While making a flow test on a meter you determine that in 2.3 minutes, 6.2 cu. ft. of water goes through the meter. What is the flow in MGD?

\[ Q = \frac{6.2 \text{ ft}^3}{2.3 \text{ min}}; \text{ convert to mgd} \]

\[ \frac{6.2 \text{ ft}^3}{2.3 \text{ min}} \times \frac{1440 \text{ min}}{\text{day}} \times \frac{7.48 \text{ gal}}{\text{ft}^3} \times \frac{1 \text{ mg}}{1000000 \text{ gal}} \times \frac{0.03}{\text{day}} = 0.03 \text{ mg/day} \]

9. How much water will a tank 5 feet in diameter and 6 feet tall hold? How much does the water weigh?

\[ V = (A)(h); h=6', A=0.785D^2 \]

\[ A = 0.785(5^2) = 19.63 \text{ ft}^2 \]

\[ V = (19.63 \text{ ft}^2)(6') = 117.75 \text{ ft}^3 \]

\[ \frac{117.75 \text{ ft}^3}{1} \times \frac{7.48 \text{ gal}}{\text{ft}^3} = 880.8 \text{ gal} \]

\[ \frac{880.8 \text{ gal}}{1} \times \frac{8.34 \text{ lb}}{\text{gal}} = 7345.9 \text{ lb} \]
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