MATHEMATICS FOR WATER OPERATORS

The understanding of the mathematics of water hydraulics (flows, pressures, volumes, horsepower, velocities) and water treatment (detention time, chemical dosage) is an important tool for all water system operators. This chapter covers most of the major categories of math calculations that are important to know for both certification and daily operations of water systems. The examples range from basic problems, that might appear on a Class 1 or 2 exam, to more complex problems that could be found on a Class 3 or 4 exam. The advanced levels will also have more problems related to water treatment processes like dosage problems and detention time problems.

PRESSURE

Water pressure is measured in terms of pounds per square inch (psi) and feet of head (height of a water column in feet). A column of water 2.31 feet high creates a pressure of 1 psi. The water pressure at the bottom of a storage tank can be used to determine the water level in the tank. Centrifugal pumps are rated in feet of Total Dynamic Head (TDH) but system pressures are measured in psi. All water system operators must be able to convert from one pressure unit to the other.

If the pressure (psi) is known, The height of the water column can be determined by multiplying the psi by 2.31.

psi X 2.31 = Feet of Head

Example:

1. A pressure gauge at the bottom of a storage tank reads 30 psi. What is the water level in the tank?

   A. Convert psi to feet of head

   30 psi x 2.31 = **69.3 feet of water above the gauge**

If the height of a column of water is known, the pressure it exerts can be determined by dividing the feet of head by 2.31.

$$\frac{\text{Feet of Head}}{2.31} = \text{psi}$$

Example:

2. The reservoir level is 115 feet above the pump discharge. What is the discharge pressure on the pump?

   A Convert feet of head to psi.

   $$\frac{115\text{ feet}}{2.31} = \mathbf{49.8\ psi}$$

Advanced questions may require you to calculate the feet of head or psi before it can be converted.

Examples:

3. A pump is installed at 5320 feet above sea level. The overflow of the reservoir is at 5460 feet above sea level. What is the discharge pressure on the pump in psi?

A. Find the difference in elevation

5460 feet – 5320 feet = 140 feet of head

B. Convert feet of head to psi

$\frac{140 \text{ feet}}{2.31}$ = **60.6 psi**

4. A discharge pressure gauge on a pump reads 72 psi when the pump is running. The pressure gauge at the top of a hill 40 feet above the pump reads 45 psi. What is the friction loss in the pipe in feet of head?

A. Find the difference in the pressures

72 psi – 45 psi = 27 psi

B. Convert psi to feet of head

27 psi x 2.31 = 62.4 feet of head

C. Subtract the difference in elevation to find the friction loss

62.4 feet – 40 feet = **22.4 feet of head**

FLOW

The amount of water moving through the system can be measured in one of three different units. They are gpm (gallons per minute), mgd (millions of gallons per day), and cfs (cubic feet per second). The conversions are listed below.

mgd x 700 = gpm $\frac{\text{gpm}}{700}$ = mgd

cfs x 449 = gpm $\frac{\text{gpm}}{449}$ = cfs

Examples:

1. A system uses 2 mgd. How many gallons per minute does it use?

A. Convert mgd to gpm

2 mgd x 700 = **1400 gpm**

2. A pipeline has a carrying capacity of 3 cfs. How many gpm can it handle?

A. Convert cfs to gpm

3 cfs x 449 = **1347 gpm**

3. A well pumps 350 gpm. How many mgd will it pump?

A. Convert gpm to mgd

$\frac{350 \text{ gpm}}{700}$ = **0.5 mgd**

AREAS

In order to calculate volumes of circular tanks and velocities in pipes, the area of the circle must first be determined. There are two basic formulae used to calculate the area of a circle.

Area = 3.1416 x r^2 | Area = d^2 x 0.785
r = radius | d = diameter

Examples:

1. A sedimentation basin is 60 feet in diameter. What is the surface area of the tank?

A. Calculate the area

3.1416 x 30' x 30' = **2830 square feet**

60' x 60' x 0.785 = **2830 square feet**

2. A pipeline has diameter of 12 inches. What is the area of the pipe?

A. Calculate the area

3.1416 x 6" x 6" = **113 square inches**

12" x 12" x 0.785 = **113 square inches**

VOLUMES

The volume of a rectangular tank can be determined by multiplying the length, height, and width together.

Volume of rectangular tank (ft^3) = L' x H' x W'

Example:

1. A sedimentation basin is 60' long by 40' wide and 10' deep. What is the volume of the tank in cubic feet?

A. Calculate the volume

60' x 40' x10' = **24,000 cubic feet (ft^3)**

The volume of a circular tank can be determined by multiplying the area of the by the height (or depth) of the tank.

$$\text{Volume of circular tank } (ft^3) = 3.1416 \times r'^2 \times H'$$

Or

$$\text{Volume of circular tank } (ft^3) = d'^2 \times 0.785 \times H'$$

Example:

1. A sedimentation basin is 60'in diameter and 12' deep. What is the volume of the tank?

A. Calculate the volume

3.1416 x 30' x 30' x 12' = **33,900 cubic feet (ft^3)**

or 60' x 60' x 0.785 x 12' = **33,900 cubic feet (ft^3)**

VOLUMES IN GALLONS

It is often necessary to calculate a volume of a tank or pipe in gallons rather than cubic feet. In most cases the volume must be calculated in cubic feet and then converted into gallons. This is determined by multiplying cubic feet by 7.48.

Cubic feet x 7.48 = gallons

Example:

1. A sedimentation basin is 60' long by 40' wide and 10' deep. What is the volume of the tank in cubic feet?

A. Calculate the volume

60' x 40' x10' = 24,000 ft^3

B. Convert cubic feet to gallons

24,000 ft^3 x 7.48 = **179,500 gallons**

2. A circular tank has a diameter of 40 feet and is 10 feet deep. How many gallons will it hold?

A. Calculate the volume

3.1416 x 20' x 20' x 10' = 12,600 ft^3

or 40' x 40' x 0.785 x 10' = 12,600 ft^3

B. Convert cubic feet to gallons

12,600 ft^3 x 7.48 = **94,200 gallons**

VOLUMES OF PIPES

The number of gallons contained in a one-foot section of pipe can be determined by squaring the diameter (in inches) and then multiplying by 0.0408. To determine the number of gallons in a particular length of pipe multiply the gallons per foot by the number of feet of pipe.

$$\text{Volume (gal)} = D''^2 \text{x } 0.0408 \text{ x Length}'$$

Examples:

1. A 12" line is 1100 ft long. How many gallons does the pipe hold?

    A. Find the volume of the pipe in gallons
    12" x 12" x 0.0408 x 1100 = **6460 gallons**

2. A 6" line is 654 ft long. How many gallons does the pipe hold?

    A. Find the volume of the pipe in gallons
    6" x 6" x 0.0408 x 654 = **960 gallons**

VELOCITY

The velocity of the water moving through a pipe can be determined if the flow in cubic feet per second (cfs) and the diameter of the pipe (inches) are known. The area of the pipe must be calculated in square feet (ft^2) and the flow is then divided by the area.

$$\text{Velocity (fps)} = \frac{\text{Flow (cfs)}}{\text{Area (ft}^2\text{)}}$$

Example:

1. A 24" pipe carries a flow of 11 cfs. What is the velocity in the pipe?

    A. Change diameter in inches to feet
    24"/12" per ft = 2 ft.
    B. Find area of the pipe in sq.ft.
    1 x 1 x 3.1416 = 3.14 sq.ft.
    C. Find the velocity in fps
    $\frac{\text{11 cfs}}{\text{3.14 sq.ft.}}$ = **3.5 fps**

The flow through a pipe (cfs) can be determined if the velocity and pipe diameter are known. The area of the pipe must be calculated in square feet and then multiplied by the velocity (fps.)

Examples:

2. A 12'" pipe carries water at a velocity of 5.0 fps. What is the flow in cfs?

A. Change inches to ft.
12"/12" per ft = 1 ft.
B. Find area of the pipe in sq.ft.
0.5 x 0.5 x 3.1416 = 0.785 sq.ft.
C. Find the flow in cfs
5.0 fps x 0.785 sq.ft. = **3.9 cfs**

3. A 12" pipe carries 1400 gpm at 4.0 fps velocity and reduces to a 6" pipe. What is the velocity in the 6" pipe?

A. Convert flow to cfs
$\frac{\text{1400 gpm}}{\text{449 gpm/cfs}}$ = 3.12 cfs
B. Change inches to ft.
6"/12" per ft = 0.5 ft.
C. Find area of the pipe in sq.ft.
0.25' x 0.25' x 3.1416 = 0.196 sq.ft.
D. Find the velocity in fps
$\frac{\text{3.12 cfs}}{\text{0.196 sq.ft.}}$ = **16 fps**

DETENTION TIME

Detention time is the length of time in minutes or hours for one gallon of water to pass through a tank. To calculate detention time, the capacity of a tank in gallons is divided by the flow in gallons per minute (gpm) or gallons per day (gpd). If gpm is used, the answer will be in minutes and must be divided by 60 minutes to get hours. If gpd is used, the answer will be in days and must be multiplied by 24 hours. The detention time formula can also be used to calculate how long it will take to fill a tank.

Examples:

1. A 50,000 gallon tank receives 250,000 gpd flow. What is the detention time in hours?

A. Find detention time in days
$\frac{\text{50,000 gal.}}{\text{250,000 gal/day}}$ = 0.2 days
B. Change days to hours
0.2 days x 24 hrs/day = **4.8 hours**

2. A tank is 60' x 80' x 10' and the flow is 2.0 mgd? What is the detention time in hours?

A. Find Volume in cubic feet
60' x 80' X 10' = 48,000 cu.ft.
B. Change cubic feet to gallons
48,000 cu.ft. X 7.48 gal/cu.ft. = 359,000 gal.
C. Change mgd to gal/day
2.0 mgd = 2,000,000 gal/day
D. Find D.T. in days
$\frac{359{,}000 \text{ gal.}}{2{,}000{,}000 \text{ gal/day}} = 0.18$ days
E. Change days to hours
0.18 days x 24 hrs/day = **4.3 hours**

3. A tank is 100' in diameter and 22 feet deep. If the flow into the tank is 1500 gpm and the flow out of the tank is 300 gpm, how many hours will it take to fill the tank?

A. Calculate the volume in cubic feet
3.1416 x 50' x 50' x 22' = 173,000 ft^3
or 100' x 100' x 0.785 x 22' = 173,000 ft^3
B. Change cubic feet to gallons
172,800 ft^3 x 7.48 = 1,290,000 gallons
C. Calculate the net inflow
1500 gpm – 300 gpm = 1200 gpm
D. Calculate how long until full (detention time)
$\frac{1{,}290{,}000 \text{ gal}}{1200 \text{ gpm}} = 1075$ minutes
E. Change minutes to hours
$\frac{1075 \text{ min}}{60 \text{ min/hr}} =$ **17.9 hours**

DOSAGE

Chemical dosages are measured in ppm (parts per million) or mg/l (milligrams per liter.) Parts per million (ppm) is always a comparison of weight (pounds per million pounds). One pound of chemical added to one million pounds of water would be a dosage of 1 ppm. Since each gallon of water weighs 8.34 pounds, one million gallons of water weighs 8.34 million pounds and would require 8.34 pounds of chemical to obtain a dosage of l ppm. Milligrams per liter (mg/l) is the metric term for a dosage equal to ppm.

1 gallon = 8.34 lbs. 1 ppm = 1 mg/l

The number of pounds of chemical needed to achieve a certain dosage can be determined by multiplying the ppm by the number of millions of gallons treated and then by 8.34 lbs/gal. The amount of water to be treated must always be in terms of millions of gallons (mgd).

mg/l x mgd x 8.34 = pounds per day

Examples:

1. How many lbs/day of chlorine are needed to provide a dosage of 2.2 mg/l in 800,000 gal/day?

   A. Change gal/day to mgd
      800,000 gpd = 0.8 mgd
   B. Calculate lbs/day
      2.2 mg/l x 0.8 mgd x 8.34 =**14.7 lbs/day**

If HTH is used, instead of chlorine gas, only 65-70% of each pound will be chlorine. Therefore, the amount of HTH must be calculated by dividing the pounds of chlorine needed by 0.65 or 0.70.

2. A tank is 44' in diameter and 22' high and is dosed with 50 ppm of chlorine. How many pound of 70% HTH is needed?

   A. Find the volume of the tank in cubic feet
      22' x 22' x 3.1416 x 22' = 33,450 cu.ft.
   B. Change cu.ft. to gallons
      33,450 x 7.48 = 250,000 gallons
   C. Change gallons to mgd
      250,000 gallons = 0.250 mgd
   D. Find lbs of chlorine
      50 ppm x 0.25 mg x 8.34 = 104.25 lbs of chlorine
   E. Change percent available to a decimal equivalent
      70% = 0.70
   F. Find lbs of HTH
      $\frac{104.25 \text{ lbs Cl}}{0.70}$ = **149 lbs of HTH**

3. A 12" pipe is 1880' long and must be disinfected with 50 ppm of 65% HTH. How many pounds of HTH are needed?

A. Find the volume of the pipe in gallons
  12" x 12" x .0408 x 1880' = 11, 045 gallons
B. Change gallons to mgd
  11,045 gallons = 0.011 mgd
C. Find lbs of chlorine
  50 ppm x 0.011 mgd x 8.34 = 4.6 lbs of Chlorine
D. Change percent available to a decimal equivalent
  65%= 0.65
E. Find lbs of HTH
  $\frac{4.6 \text{ lbs Cl}}{0.65}$ = **7.1 lbs of HTH**

When chemical solutions are used the weight of the solution will be more than the weight of a gallon of water. The weight of a gallon of liquid is determined by multiplying the weight of a gallon of water (8.34 lbs) by the Specific Gravity of the solution. The S.G. of the solution can be found on the shipping container label. Some exams do not provide the specific gravity of the liquid chemical in the math problems. If S.G. is not given then you should assume the weight of the solution is 8.34 lbs/gallon.

Example:

1. A chlorine pump is feeding 10% bleach at a dosage of 5 mg/l. The specific gravity of the bleach is 1.14. If 2,200,000 gallons are treated in 16 hours, how many gallons per hour is the pump feeding?

A. Change gallons to mg
  2,200,000 gallons = 2.2 mg
B. Find lbs of chlorine
  5 ppm x 2.2 mg x 8.34 = 91.7 lbs of Chlorine
C. Change percent available to a decimal equivalent
  10% = 0.10
D. Find lbs of Bleach
  $\frac{91.7 \text{ lbs Cl}}{0.10}$ = 917 lbs of Bleach
E. Find the weight of a gallon of bleach
  S.G. of 1.14 x 8.34 lbs/gal = 9.5 lb/gal of Bleach
F. Find gallons of Bleach
  $\frac{917 \text{ lbs Bleach}}{9.5 \text{ lbs/gal}}$ = 96.5 gallons of Bleach
G. Find gallons per hour
  $\frac{96.5 \text{ gal.}}{16 \text{ hr}}$ = **6.0 gal/hr**

Here is the same problem worked without knowing the S.G. of the solution. Note the difference in the answers.

2. A chlorine pump is feeding 10% bleach at a dosage of 5 mg/l. If 2,200,000 gallons are treated in 16 hours, how many gallons per hour is the pump feeding?

A. Change gallons to mg
   2,200,000 gallons = 2.2 mg
B. Find lbs of chlorine
   5 ppm x 2.2 mg x 8.34 = 91.7 lbs of Chlorine
C. Change percent available to a decimal equivalent
   10% = 0.10
D. Find lbs of Bleach
   $\frac{91.7 \text{ lbs Cl}}{0.10}$ = 917 lbs of Bleach
E. Find gallons of Bleach
   $\frac{917 \text{ lbs Bleachl}}{8.34 \text{ lbs/gal}}$ = 110 gallons of Bleach
F. Find gallons per hour
   $\frac{110 \text{ gal}}{16 \text{ hr}}$. = **6.9 gal/hr**

3. A chlorine pump is feeding 12% bleach at a dosage of 2.4 mg/L. If the flow is 1,250,000 gpd, how many gallons per hour is the pump feeding? S.G. = 1.14

A. Change gpd to mgd
   1,250,000 gpd = 1.25 mgd
B. Find lbs of chlorine
   2.4 ppm x 1.25 mgd x 8.34 = 25 lbs of Chlorine
C. Change percent available to a decimal equivalent
   12% = 0.12
D. Find lbs of Bleach
   $\frac{25 \text{ lbs Cl}}{0.12}$ = 208 lbs of Bleach solution
E. Find the weight of a gallon of bleach
   1.14 S.G. x 8.34 = 9.5 lbs/gal
F. Find gallons of Bleach
   $\frac{25 \text{ lbs Bleachl}}{9.5 \text{ lbs/gal}}$ = 2.63 gpd of Bleach
G. Find gallons per hour
   $\frac{2.63 \text{ gpd}}{24 \text{ hr/day}}$. = **0.108 gph**

Liquid chemical dosages can be calculated to determine the gallons per day. Chemical feed pumps are calibrated using ml/min. If you take 3785 ml/gal and divide it by 1440 min/day, the conversion for gal/day to ml/min can be determined.

$$\frac{3785 \text{ ml/gal}}{1440 \text{ min/day}} = 2.6 \text{ ml/min /gal/day}$$

Gal/day x 2.6 = ml/min

Examples:

5. A 20% available Fluoride solution is used to dose 2,000,000 gpd at 450 ppb (parts per billion). The S.G. is 1.26. How many ml/min is the pump feeding?

A. Change 450 ppb to ppm
   450 ppb = 0.45 ppm (mg/l)

B. Change 2,000,000 gpd to mgd
   2,000,000 gpd = 2.0 mgd

C. Find lbs of Fluoride
   0.45 ppm x 2.0 mgd x 8.34 = 7.5 lbs/day

D. Change percent available to a decimal equivalent
   20%= 0.2

E. Find lbs of Fluoride solution
   $$\frac{7.5 \text{lbs F}}{0.2} = 37.5 \text{ lbs of F solution}$$

F. Find the weight of a gallon of solution
   1.26 x 8.34 = 10.5 lbs/gallon of solution

G. Find gallons of fluoride
   $$\frac{37.5 \text{ lbs solution}}{10.5 \text{ lbs/gal}} = 3.6 \text{ gpd}$$

H. Change gallon/day to ml/min
   3.6 gpd x 2.6 = **9.3 ml/min**

6. An 18% available Alum solution is used to dose 600,000 gpd at 25 mg/l. How many ml/min is the pump feeding? (No S.G. given: Use 8.34 lb/gal)

A. Change 600,000 gpd to mgd
600,000 gpd = 0.6 mgd
B. Find lbs of Alum
25 mg/l x 0.6 mgd x 8.34 = 125 lbs/day
C. Change percent available to a decimal equivalent
18%= 0.18
D. Find lbs of Alum solution
$\frac{\text{125 lbs Alum}}{0.18}$ = 695 lbs of Alum solution
E. Find gallons of Alum
$\frac{\text{695 lbs solution}}{\text{8.34 lbs/gal}}$ = 83.3 gpd
F. Change gallon/day to ml/min
83.3 gpd x 2.6 = **217 ml/min**

5. A chlorine pump is feeding 12% bleach at a dosage of 2.4 mg/L. If the flow is 1,250,000 gpd, how many milliliters per minute is the pump feeding? S.G. = 1.14

A. Change gpd to mgd
1,250,000 gpd = 1.25 mgd
B. Find lbs of chlorine
2.4 ppm x 1.25 mgd x 8.34 = 25 lbs of Chlorine
C. Change percent available to a decimal equivalent
12% = 0.12
D. Find lbs of Bleach
$\frac{\text{25 lbs Cl}}{0.12}$ = 208 lbs of Bleach solution
E. Find the weight of a gallon of bleach
1.14 S.G. x 8.34 = 9.5 lbs/gal
F. Find gallons of Bleach per day
$\frac{\text{25 lbs Bleach}}{\text{9.5 lbs/gal}}$ = 2.63 gpd of Bleach
G. Find milliliters per minute
2.63 gpd x 2.6 = 6.8 ml/min

Sometimes there is too much information in the question. The example below has too much information. The well flow and storage tank data are not needed to work the problem.

Example:

7. A system has a well that produces 200 gpm and a 1500 gallon storage tank. There are 120 homes on the systems and the average daily consumption is 350 gallons/home. A chlorine dosage of 1.3 ppm is maintained using 65% HTH. How many pounds of HTH must be purchased each year?

A. Find system consumption
    120 homes x 350 gallons/day/home = 42,000 gpd
B. Change gallons/day to mgd
    42,000 gallons/day = 0.042 mgd
C. Find lbs/day of chlorine
    1.3 ppm x 0.042 mg x 8.34 = 0.45 lbs/day of Chlorine
D. Change percent available to a decimal equivalent
    65% = 0.65
E. Find lbs/day of HTH
    $\frac{0.45 \text{ lbs Cl}}{0.65}$ = 0.7 lbs/day of HTH
F. Find lbs/year of HTH
    0.7 lbs/day x 365 days/year = **255.5 lbs/year**

WIRE-TO-WATER CALCULATIONS

The term wire-to-water refers to the conversion of electrical horsepower to water horsepower. The motor takes electrical energy and converts it into mechanical energy. The pump turns mechanical energy into hydraulic energy. The electrical energy is measured as motor horsepower (MHp.) The mechanical energy is measured as brake horsepower (BHp.) And the hydraulic energy is measured as water horsepower (WHp.)

Horsepower is measured by lifting a weight a given distance in a specific time period. One horsepower is the amount of energy required to produce 33,000 ft-lbs of work per minute. That means that lifting 33,000 pounds one foot in one minute or lifting one pound 33,000 feet in the air in one minute would both require one horsepower worth of energy.

When water is pumped, performance is measured in flow (gallons/minute) and pressure (feet of head). If you multiply gallons per minute and feet of head the resulting units would be gallon-feet per minute. Multiply gallon-feet per minute by 8.34 pounds/gallon and the units become foot-pounds (of water) per minute. This can now be converted to water horsepower by dividing by 33,000 ft-lbs/min per horsepower.

$$\frac{\text{Gpm} \times 8.34 \times \text{Feet of Head}}{33{,}000 \text{ ft-lbs/min/Hp}} = \text{Water Horsepower (WHp)}$$

This equation can be further simplified to:

$$\frac{\text{Gpm} \times \text{Feet of Head}}{3960} = \text{Water Horsepower (WHp)}$$

Brake horsepower is the amount of energy that must go into the pump to produce the required WHp. Loses due to friction and heat in the pump reduce the pump's efficiency and require more energy in than goes out. If a pump is 80% efficient, it requires 10 BHp to generate 8 WHp.

$$\text{BrakeHp} = \frac{\text{WaterHp}}{\text{Pump Efficiency}}$$

Motor horsepower is the amount of electrical energy that must go into the motor to produce the required BHp. Loses due to friction and heat in the motor reduce the motor's efficiency and require more energy in than goes out. If a motor is 88% efficient, it requires 10 BHp to generate 8.8 BHp

$$\text{MotorHp} = \frac{\text{BrakeHp}}{\text{Motor Eff}}$$

OR

$$\text{MotorHp} = \frac{\text{WaterHp}}{\text{Motor Eff} \times \text{Pump Eff}}$$

Motor horsepower can be converted into kilowatts by multiplying by 0.746 Kw/Hp. Kilowatt-hours can be determined by multiplying kilowatts by run time in hours.

$$\text{MotorHp} \times 0.746 \text{ Kw/Hp} \times \text{Hours} = \text{Kw-Hours of electricity}$$

The following example has seven problems that relate to wire-to-water calculations. Each problem will take the calculation one step further. It is intended to show how the steps are linked, not to represent an example of a set of exam questions. An actual exam question would possibly require the calculation of Water horsepower (Problems 1-3) or calculation of cost of operation (Problems 1-7)

Pump Data:
- 6 Feet - Negative Suction Head
- 96 Feet - Discharge Head
- 17 Feet - Friction Loss
- 400 gpm - Flow
- Motor Efficiency - 90%
- Pump Efficiency - 80%

1. What is the static head on the pump?

   96 ft + 6 ft = **102 ft**

2. What is the total dynamic head?

   96 ft + 6 ft + 17 ft = **119 ft TDH**

3. What is the Water Horsepower that the pump delivers?

   $$\frac{400 \text{ gpm} \times 119 \text{ ft}}{3960} = \mathbf{12\ WHp}$$

4. What is the Brake Horsepower?

   A. Change 80% to a decimal
   80% = 0.80
   B. Find Brake Horsepower

   $$\frac{12 \text{ Whp}}{0.80 \text{ Pump Eff}} = \mathbf{15\ BHp}$$

5. What is the Motor Horsepower?

   A. Change 90% to a decimal
   90% = 0.90
   B. Find Motor Horsepower

   $$\frac{15 \text{ BHp}}{0.90 \text{ Motor Eff}} = \mathbf{16.7\ MHp}$$

6. How many Kilowatts of electricity does the motor require?

   16.7 MHp x 0.746 Kw/Hp = **12.5 Kw**

7. If the pump runs 13 hours a day and electric rates are $0.09/Kw-Hour, How much does it cost to run the pump for a month (30 days)?

A. Find Kw-Hours per day
12.5 Kw x 13 hours/day = 162 Kw-Hours/day
B. Find cost per day
162 Kw-Hours x $0.09/KwHour = $14.58/day
C. Find cost for the month
14.58/day x 30 days/month = **$437.40/month**

BASIC SAMPLE PROBLEMS

1. A pressure gauge reading is 80 psi. How many feet of head is this?

A. 173 feet
B. 185 feet
C. 200 feet
D. 212 Feet

2. The pump is 150 feet below the reservoir level. What is the pressure reading on the gauge in psi?

A. 52 psi
B. 60 psi
C. 65 psi
D. 75 psi

3. A tank is 20' x 60' by 15' deep. What is the volume in gallons?

A. 115, 000 gallons
B. 128,000 gallons
C. 135,000 gallons
D. 154,000 gallons

4. A tank is 60' in diameter and 22' high. How many gallons will it hold?

A. 465,000 gallons
B. 528,000 gallons
C. 640,000 gallons
D. 710,000 gallons

5. A dosage of 2.4 mg/l of chlorine gas is added to 3.8 mgd. How many pounds per day of chlorine are needed?

A. 68 lbs/day
B. 76 lbs/day
C. 82 lbs/day
D. 88 lbs/day

6. How many gallons are in a 6" pipe 950 feet long?

A. 1108 gallons
B. 1253 gallons
C. 1308 gallons
D. 1395 gallons

7. A 12" pipe is carrying water at a velocity of 5.8 fps. What is the flow?

A. 4.55 cfs
B. 5.36 cfs
C. 5.67 cfs
D. 6.04 cfs

ADVANCED SAMPLE PROBLEMS

1. The pressure at the top of the hill is 62 psi. The pressure at the bottom of the hill, 60 feet below, is 100 psi. The water is flowing uphill at 120 gpm. What is the friction loss, in feet, in the pipe?

   A. 24.6 feet
   B. 27.8 feet
   C. 31.2 feet
   D. 33.8 feet

2. A tank is 82' in diameter and 31 feet high. The flow is 1600 gpm. What is the detention time in hours?

   A. 12.75 hours
   B. 14.80 hours
   C. 16.00 hours
   D. 18.25 hours

3. A tank is 120' x 50' x 14' deep. The flow is 2.8 mgd. What is the detention time in hours?

   A. 3.8 hours
   B. 4.4 hours
   C. 5.3 hours
   D. 6.2 hours

4. A 16" pipe is 1250 feet long. How much 65% HTH is needed to dose it with 50 mg/l of chlorine?

   A. 6.50 lbs
   B. 7.25 lbs
   C. 7.96 lbs
   D. 8.34 lbs

5. A solution of hydrofluosilisic acid is 22% fluoride. The S.G. is 1.28. If 750 ppb are added to 5,600,000 gallons/day, how many ml/min should the pump be feeding?

   A. 26 ml/min
   B. 39 ml/min
   C. 48 ml/min
   D. 55 ml/min

6. A bleach system feeds 12% bleach. The dosage is 1.4 mg/l for 8.2 mgd. How many ml/min should the pump feed?

   A. 200 ml/min
   B. 250 ml/min
   C. 300 ml/min
   D. 350 ml/min

7. Pump Data:

   18 Feet - Positive Suction Head
   158 Feet - Discharge Head
   26 Feet - Friction Loss
   1200 gpm - Flow
   Motor Efficiency - 86%
   Pump Efficiency - 78%

What is the motor horsepower?

   A. 60 MHp
   B. 65 MHp
   C. 70 MHp
   D. 75 MHp

8. Pump Data:

20 Feet - Positive Suction Head
185 Feet - Discharge Head
18 Feet - Friction Loss
300 gpm - Flow
Motor Efficiency - 90%
Pump Efficiency - 80%
Kw-Hour Cost = $0.11/Kw-Hr
Average Run Time – 6 Hours/day

What is the cost to run the pump for 30 days?

A. $245.08
B. $284.34
C. $410.50
D. $463.82

9. A chlorine pump is feeding 12% bleach at a dosage of 1.0 mg/l. The specific gravity of the bleach is 1.18. The well flow is 1.7 mgd, how many ml/min is the pump feeding?

A. 22 ml/min
B. 31 ml/min
C. 46 ml/min
D. 53 ml/min

10. A 10-inch pipe is 1200' long and must be dosed at 200 mg/L of 12.5% bleach. The S.G. of the bleach is 1.2. How many gallons of bleach are needed?

A. 3.48 gallons
B. 4.72 gallons
C. 6.54 gallons
D. 8.35 gallons