Surface Water Math Study Guide

Kentucky Division of Compliance Assistance
Certification and Licensing Branch

This study guide is intended to help students become more familiar with the variety of math equations within the Surface Water Treatment manual and exam.

Below is a chart of where math can be found in the training manual.

Chapter	Name	Page	Concept
4	Coagulation	66	Conversions
6	Sedimentation	90	Area/ volume
7	Alternative Treatment	105	Weir Overflow Rate
7	Alternative Treatment	105	Detention Time
7	Alternative Treatment	106	Surface Overflow Rate
7	Alternative Treatment	106	Lbs of Chemical
8	Filtration	147	Flow Q =AxV
8	Filtration	148	Filtration and Backwash Rate
8	Filtration	149	Alternative Filtration Rate
9	Disinfection	196	Dosage = Demand - Residual
9	Disinfection	203	lbs formula and % purity
9	Disinfection	208	Specific Gravity
9	Disinfection	209	Strength of Solution
14	Stabilization	248	Langelier Saturation Index

Work through each problem introduced in each chapter and the math questions (if any) at the end of each chapter.

Class I & II

1. What is the flow rate of wastewater, in gallons per minute, through a plant that treats 1.5 million gallons of water per day?

A. 2.3 gpm
B. 11.22 gpm
C. 673 gpm
D. 1042 gpm

2. What is the flow rate of wastewater, in gallons per minute, through a plant that treats 2 million gallons of water during an 8 hour shift?

A. 1389 gpm
B. 2693 gpm
C. 4167 gpm
D. 5987 gpm

3. What is the volume of pipe that has an inside diameter of 8 inches and is 1,500 feet long?

A. 50.24 ft^3
B. 528.6 ft^3
C. 673.3 ft^3
D. 788.9 ft^3

4. What volume in gallons would this pipe hold?

5. What is the weir overflow rate of a circular sedimentation basin that has a circumference at the weir of 300 feet? Assume that flow into the basin is at 400 gpm and the basin is full.

A. 0.75 gpm/ft
B. 1.33 gpm/ft
C. 1.5 gpm/ft
D. 2.6 gpm/ft

6. What is the weir overflow rate of a circular sedimentation basin that has a radius of 30 feet? Assume that flow into the basin is at 150 gpm and the basin is full.

A. 0.8 gpm/ft
B. 4.77 gpm/ft
C. 0.32 gpm/ft
D. 3.75 gpm/ft

7. What is the detention time of a rectangular settling basin which measures 15' wide by 25' long by 10' deep and receives a flow of 250 gpm?

A. 11.2 minutes
B. 15 minutes
C. 112.2 minutes
D. 900 minutes

8. How would you solve the previous question if the answers were in hours instead of minutes ?

9. How would you solve the previous question if the flow was 0.4 MGD?

10. What is the surface overflow rate of a sedimentation basin if the basin measures 10 feet by 12 feet and is 8 ft deep and the flow rate into it is 700 gpm?

A. 0.73 gpm/ft^2
B. 5.8 gpm/ft^2
C. 14.5 gpm/ft^2
D. 20.2 gpm/ft^2

11. What would be surface overflow rate of the above basin if the inflow was given as 2 ft^3/sec?

12. A water treatment plant used 32 pounds of alum to treat 1.2 million gallons of water during a 24 hour period. What is the polymer dosage?

A. 0.32 mg/L
B. 3.2 mg/L
C. 26.6 mg/L
D. 38.4 mg/L

13. Water flows through a 10" inside diameter pipe at a rate of 1.3 ft^3/s. What is the velocity of the water flowing through this pipe?

A. 2.4 ft/s
B. 1.99 ft/s
C. 0.79 ft/s
D. 0.1 ft/s

14. What would the velocity of the water be in the above pipe if the flow rate was 400 gpm?

15. The hydraulic grade line is located 150 feet above a point in the pipeline. What is the pressure at that point in the pipeline?

A. 17.9 psi
B. 20 psi
C. 65 psi
D. 351 psi

16. If your standpipe is 95 feet tall and 35 feet in diameter, what would a pressure gauge read if the gauge was 5 feet above grade?

A. 37 psi
B. 39 psi
C. 41 psi
D. 43 psi

17. A filter has a surface area of 240 square feet and filters 900 gpm. What is the filtration rate?

A. 3.75 gpm/ft^2
B. 7.5 gpm/ft^2
C. 0.26 gpm/ft^2
D. 0.1 gpm/ft^2

18. What would be the filtration rate in Question #15 if the flow was given as 2.1 MGD?

19. The chlorine demand of a certain water system is 3.0 mg/L. The plant treats 250,000 gallons of water with 10 pounds of chlorine gas per day. What will the chlorine residual be?

A. 4.7 mg/L
B. 7.7 mg/L
C. 0.9 mg/L
D. 1.8 mg/L

20. How many pounds of 5.25% bleach would be needed to treat 900,000 gallons of water at a dosage of 3 ppm?

A. 428.9 pounds
B. 42.8 pounds
C. 22.5 pounds
D. 11.25 pounds

Answer Key

1. D
2. C
3. B
4. 3953.9 gallons
5. B
6. A
7. C
8. 1.87 hrs
9. 101 minutes
10. B
11. 7.48 gallons/ft^2
12. B
13. A
14. 1.65 ft/s
15. C
16. B
17. A
18. 6.07 gpm/ft^2
19. D
20. A

Class III & IV

21. If the water during your backwash cycle rises at a rate of 6 inches in 3 minutes, what is the backwash rate?

A. 0.8 gpm/ft^2
B. 1.25 gpm/ft^2
C. 3.2 gpm/ft^2
D. 3.6 gpm/ft^2

22. Calculate the theoretical detention time through a treatment plant having a flow rate of 5.2 MGD and the following basin sizes:
flocculator = 20' X 60' X 15'
sedimentation = 40' X 90' X 15'

A. 149 minutes
B. 220 minutes
C. 298 minutes
D. 356 minutes

23. A water treatment plant used 110 pounds of cationic polymer to treat 6.9 million gallons of water during a 24 hour period. Specific gravity of the polymer is 2.47. What is the polymer dosage?

A. 0.77 mg/L
B. 1.2 mg/L
C. 1.5 mg/L
D. 1.9 mg/L

24. In the new chemical catalogue for 2020, Alum that was $0.08 a pound has the price increased by 12%. Polymer was $0.22 a pound but has just undergone a 37% increase and electrical energy got a 41% increase from it's current $0.08 kWh. What are the new prices of alum, polymer and electricity?

A. $0.06, $0.07, $0.03
B. $0.09, $0.30, $0.11
C. $0.47, $0.58, $0.23
D. $0.015, $0.07, $0.03

Do you have to calculate all three?

25. A water treatment facility has 2 filters that each measure 16 feet wide, 16 feet long, and 12 feet deep. The plant treats 6.0 MGD. Under normal conditions (all filters in service) what is the plant's filtration rate?

A. 8.1 gpm/ft^2
B. 10 gpm/ft^2
C. 21 gpm/ft^2
D. 29 gpm/ft^2

26. A jar test indicates that 50 ppm of liquid alum will provide an optimum coagulant dosage. The alum solution has a S.G. of 1.2. If the water plant treats, on average 1.8 MGD, how many pounds of alum will be used every 30 days?

A. 27,021 lbs
B. 22,518 lbs
C. 19,027 lbs
D. 14, 899 lbs

27. A water plant treats on average 6.5 MGD, and has an average incoming concentration of iron of 0.07 ppm. If 85% of the iron is removed, how many lbs. of iron will be removed in a year's time?

A. 206 lbs
B. 512 lbs
C. 1177 lbs
D. 1383 lbs

28. The chlorine demand is calculated to be 2.8 mg/l. The flow through the plant is 5000 gpm and the chlorinator was set to feed 160 lbs/day. If the desired chlorine residual leaving the plant is 0.8 ppm, what will be the new setting of the chlorinator?

A. 100 lbs/day
B. 120 lbs/day
C. 160 lbs/day
D. 216 lbs/day

29. What is the water horsepower for a pump station with the following parameters?

A. 45 WHP
B. 52.6 WHP
C. 65.7 WHP
D. 74 WHP

Flow 1.5 MGD
Pump efficiency 80%
Total head 200 ft
Motor Efficiency 90%

30. What is the brake horsepower for a pump station with the above parameters?

A. 65.7 BHP
B. 72 BHP
C. 80 BHP
D. 85.2 BHP

31. What is the motor horsepower for a pump station with parameters from question #30?

A. 65.7 MHP
B. 73 MHP
C. 80 MHP
D. 85.2 MHP

Answer Key

21. B
22. A
23. D
24. B
25. A
26. A
27. C
28. D
29. B
30. A
31. B

Class I & II Solved Equations

1. Conversion used: 1 MGD = 694.5 gpm You multiple because you are going from left to right on the conversion sheet.
   1.5 MGD x 694.5 gpm = 1041.8 or 1042 gpm

2. First calculate the number of minutes in 8 hours – 8 hrs. x 60 min/hr. = 480 minutes
   Next take the flow in gallons in the 8 hour period and divide by the number of minutes in 8 hours
   2,000,000 gallons ÷ 480 minutes = 4167 gpm

3. Formula used: Volume, ft^3 = 0.785 x dia, ft x dia, ft x length, ft
   Calculate the diameter of the pipe in feet – 8 inches/12 inches/ft = 0.67 feet
   Now calculate the volume of the pipe – 0.785 x 0.67 ft x 0.67 ft x 1,500 ft = 528.6 ft^3

4. Conversion used: 1 ft^3 = 7.48 gal. You multiply because you are going from left
   to right on the conversion sheet.
   528.6 ft^3 x 7.48 gal/ft^3 = 3,953.9 gallons

5. Formula used: Weir Overflow Rate = Flow (gpm) ÷ Feet of Weir
   A circular sedimentation tank has a weir all along the outer edge of the tank. The length of weir is equal to the tank's circumference. In this problem you are given the circumference is 300 feet.
   Calculate the weir overflow rate – 400 gpm ÷ 300 feet of weir = 1.33 gpm/ft

6. Formula used: Weir Overflow Rate = Flow (gpm) ÷ Feet of Weir
   Also needed: Diameter (D) = 2 x radius & Circumference = 3.14 x Diameter (D)
   Diameter = 2 x 30 feet = 60 feet
   Circumference = 3.14 x 60 feet = 188.4 feet
   Weir Overflow Rate = 150 gpm ÷ 188.4 ft = 0.8 gpm/ft

7. Formula used: Detention Time = Volume (gals) ÷ Flow (gpm)
   Calculate the volume of the tank
   Volume (gal) = 15 ft x 25 ft x 10 ft x 7.48 gal/ft^3=28,050 gal
   Detention Time = 28,050 gal ÷ 250 gpm = 112.2 minutes

8. To solve for detention time in hours, take detention time in minutes and divide by 60 minutes/hour
   Detention time (hr) = 112.2 min ÷ 60 min/hr = 1.87 hours

9. Conversion used: MGD to gpm – 0.4 MGD x 604.5 gpm = 277.8 gpm
   Detention time = 28,050 gal ÷ 277.8 gpm = 199.97 minutes

10. Formula used: Surface Overflow Rate = Flow (gpm) ÷Area (ft^2)
    Surface area of tank – 10 ft x 12 ft = 120 ft^2 (Don't use depth for ft^2)
    Surface Overflow Rate = 700 gpm ÷ 120 ft^2 = 5.8 gpm/ft^2

11. Conversion used: flow to gpm
    2 ft^3/s x 448.8 gpm/ft^3/s = 897.6 gpm
    Surface Overflow Rate = 897.6 gpm ÷ 120 ft^2= 7.48 gpm/ft^2

12. Formula used: ppm = lbs of chemical ÷ (flow, MGD x 8.34)
    ppm = 32 lbs ÷ (1.2 MGD x 8.34) = 32 ÷ 10.008 = 3.2 ppm

13. Formula used: Velocity (V) = Flow (Q) ÷ Area, ft^2 (A)
    Find the area of the 10 in pipe – 10 in ÷ 12 in = 0.83 ft
    Area = 0.785 x 0.83 x 0.83 = 0.54 ft^2
    Velocity – 1.3 ft^3/s ÷ 0.54 ft^2 = 2.4 ft/s

14. Conversion used: flow from gpm to ft^3/s – 400 gpm 448.8 gpm/ft^3 = 0.89 ft^3/s
    Velocity – 0.89 ft^3/s ÷ 0.54 ft^2 = 1.65 ft/s

15. Conversion used: psi = ft of head x 0.433
    psi = 150 feet x 0.433 = 65 psi

16. Conversion used: psi = feet of head x 0.433
    psi = (95 ft – 5 ft) x 0.433 Subtract 5 feet because gauge is 5 feet off the ground
    psi = 90 ft x 0.433 = 39 psi

17. Formula used: Filtration Rate = Flow (gpm) ÷ Surface Area (ft^2)
    Calculate the filtration rate – 900 gpm ÷ 240 ft^2 = 3.75 gpm/ft^2

18. Conversion used: flow to MGD to gpm – 2.1 MGD x 694.5 gpm/MGD = 1,458.45 gpm
    Filtration Rate = 1,458.45 gpm ÷ 240 ft^2 = 6.07 gpm/ft^2

19. Formulas used: ppm = pounds ÷ (Flow, MGD x 8.34) and
    Residual = Dosage - Demand
    Calculate ppm – 10 pounds ÷ (0.25 MGD x 8.34) = 10 ÷ 2.085 = 4.8 mg/L
    Calculate Residual - Residual = 4.8 mg/L – 3.0 mg/L = 1.8 mg/L

20. Formula used: Pounds = (ppm x 8.34 x Flow, MGD) ÷ % purity
    Convert 900,000 gal/day to MGD – 900,000 ÷ 1,000,000 = 0.9 MGD
    Convert %purity to decimal – 5.25% ÷100 = 0.0525
    Calculate pounds – (3 ppm x 8.34 x 0.9 MGD) ÷ 0.0525 = 22.52 ÷ 0.0525 = 428.9 pounds

Class III & IV Solved Equations

21. Formula used: Filtration Rate : For every 1.6 in./min. of rise or fall = 1gpm/ft^2
    Backwash cycle raises the water level 6 in. in 3 min.
    Rise per min. = 6 in. ÷ 3 min. = 2 in./min 2in/min ÷1.6 = 1.25 x 1 gpm/ft^2 = 1.25 gpm/ft^2

22. Formula used: Detention Time = Volume of basin (gal) ÷ Flow (gpm)
    First calculate the volume in gallons for the two basins
    Flocculator volume (gal) = 20’ x 60’ x 15’ x 7.48 gal/ft^3 = 134,640 gallons
    Sedimentation basin (gal) = 40’ x 90’ x 15’ x 7.48 gal/ft^3 = 403,920 gallons
    Total Basin volume – 134,640 + 403,920 = 538,560 gallons
    Convert flow to gpm – 5.2 MGD x 694.5 gpm/MGD = 3,611.4 gpm
    Divide tank volume (gal) by flow in gpm = 538,560 gal ÷ 3,611.4 = 149.1 or 149 minutes

23. Formula used: ppm = pounds ÷ (flow, MGD x 8.34)
    Since you have pounds already you do not have to use SP.GR. in the calculation.
    ppm = 110 lbs. ÷ (6.9 MGD x 8.34) = 110 ÷ 57.546 = 1.9

24. Formula used: Formula not on sheet. Take the old price x (1 + the percent change in decimal format)
Alum price = $0.08 x 1.12 = $0.09/lb
Polymer price = $0.22 x 1.37 = $0.30/lb
Electrical cost = $0.08 x 1.41 = $0.11/kWh

25. Formula used: Filtration rate = Flow (gpm) ÷ Filter surface area (ft^2)
Convert flow from MGD to gpm – Flow = 6.0 MGD x 694.5 gpm/MGD = 4,167 gpm
Calculate area of filters – Area (ft^2) = 2 filters x 16' x 16' = 512 ft^2
Calculate Filtration Rate = 4,167 gpm ÷ 512 ft^2 = 8.1 gpm/ft^2

26. Formula used: Pounds = ppm x 8.34 x flow, MGD x Sp.gr. x # of days
Pound = 50 ppm x 8.34 x 1.8 MGD x 1.2 x 30 days
Pounds = 27,021 pounds

27. Formula used: pounds = ppm x 8.34 x MGD x % removal x days in a year
Pounds removed = 0.07 x 8.34 x 6.5 MGD x 0.85 x 365 days = 1,177 pounds removed in 1 year

28. Formulas used: Dosage = Demand + Residual Pounds = ppm x 8.34 x flow, MGD
Calculate Dosage- Dosage, mg/L = 2.8 mg/L + 0.8 mg/L = 3.6 mg/L
Convert flow from gpm to MGD – flow, MGD = 5000 gpm ÷ 694.5 gpm/MGD = 7.19 MGD
Calculate Pounds = 3.6 mg/L x 8.34 x 7.19 MGD = 215.87 pounds
The chlorinator must be set to 216 lbs/day.

Given the following:
Flow = 1.5 MGD Total Head = 200 ft
Pump efficiency = 80% Motor efficiency = 90%

29. Formula used: Water horsepower = (flow, gpm x total head, ft) ÷3960
    Convert flow to gpm – Flow, gpm = 1.5 MGD x 694.5 gpm/MGD = 1,041.75 gpm
    WHP = (1,041.75 gpm x 200 ft) ÷ 3960 = 208,350 ÷ 3960 = 52.6 WHP

30. Brake Horsepower = (flow, gpm x Total head, ft) ÷ (3960 x Pump Efficiency)
    BHP = (1,041.75 x 200 ft) ÷ (3960 x 0.80) = 208,350 ÷ 3,168 = 65.7 BHP

31. Motor Horse Power = (flow, gpm x Totalvhead, ft) ÷ (3960 x Pump Efficiency x Motor Efficiency)
    MHP = (1,041.75 gpm x 200 ft) ÷ (3960 x 0.80 x 0.90) = 208,350 ÷ 2,851.2 = 73 MHP

Questions or Concerns?

The Kentucky Operator Certification Program provides training and issues certifications to ensure that individuals engaged in performing many of Kentucky's critical environmental activities are qualified and capable to perform their duties. DCA staff are available to provide on-site assistance and training.

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