Distribution Math

Study Guide

Kentucky Certification and Licensing Branch

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

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

Chapter	Name	Page	Concept
3	Storage	34	Conversions
3	Storage	38	Demand
4	Disinfection	42	Demand/Dosage/Residual
4	Disinfection	50	lbs formula and % purity
4	Disinfection	50	Strength of Solution
4	Disinfection	53	Lbs formula % and Specific Gravity
9	Meters	126	Water Loss and meter error
10	Hydraulics	133	Q = A x V
10	Hydraulics	138	Head vs psi conversion
10	Hydraulics	148	C-factor (need chart)
10	Hydraulics	154	Equivalent Flow rate
10	Hydraulics	155	Rule of continuity (includes velocity)
10	Hydraulics	171	Static Discharge Head; Total Static Head
10	Hydraulics	175	Electrical Cost
12	Corrosion	189	Langeliers 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. If your distribution system is serving 1,000 people who are using an average of 125 gallons per day per person, what would your daily demand be?

A. 1000 gallons
B. 8,340 gallons
C. 12,500 gallons
D. 125,000 gallons

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. 694.5 gpm
B. 1389 gpm
C. 2880 gpm
D. 4167 gpm

3. What is the flow rate if it takes a pump 1 minute and 15 seconds to fill a rectangular tank 3 feet wide and 4 feet long to a depth of 5 feet?

A. 359 gpm
B. 390 gpm
C. 420 gpm
D. 480 gpm

4. How many 24 ft section of pipe will be needed to replace 2 miles of 8” pipe?

A. 110
B. 220
C. 440
D. 880

5. How many lbs of 65% available calcium hypochlorite would be needed to treat 50,000 gallons of water at a rate of 200 gpm to the desired dosage of 3.0 mg/L?

A. 1.25 lbs
B. 1.92 lbs
C. 12.5 lbs
D. 19.2 lbs

6. How many pounds of calcium hypochlorite (70% available chlorine) will it take to disinfect a new 8 inch pipe that is 1.5 miles long?

A. 4.3 lbs
B. 5.6 lbs
C. 12.51 lbs
D. 18.35 lbs

7. What is the amount of chlorine required to treat 900,000 gallons of water to provide a 0.9 ppm residual and satisfy a 3.0 ppm chlorine demand?

A. 6.75 lbs
B. 15.79 lbs
C. 22.5 lbs
D. 29.27 lbs

8. Water flows through a 10" pipe at a rate of 3.5 cubic feet per second. What is the velocity of the water flowing through this pipe?

A. 3.5 f/s
B. 6.5 f/s
C. 7.8 f/s
D. 9.1 fps

9. Water flows through a 12" pipe at a rate of 6.0 ft/second. What is the flow in ft^3/s?

A. 4.71 ft^3/s
B. 7.61 ft^3/s
C. 448.8 ft^3/s
D. 2113.8 ft^3/s

10. You have been pumping water to a neighborhood water system for 90 days. The beginning master meter reading was 5,750,000 and 90 days later the same meter read 14,350,500. What was the average flow in gallons per day?

A. 15,945 gpd
B. 95,561 gpd
C. 223,339 gpd
D. 575,000 gpd

11. How many gallons of water are in a tank 72 inches in diameter by 30 feet high when the water is 16 feet deep?

A. 564 gallons
B. 785 gallons
C. 3382 gallons
D. 3771 gallons

12. How many pounds of 65% HTH powder will be required to disinfect a 20,000 gallon tank?

A. 12.8 lbs
B. 8.34 lbs
C. 5.4 lbs
D. 0.6 lbs

13. A reservoir is an average of 65 feet deep and when full, holds 220 million gallons. One pump draws 9,000 gpm for 8 hours per day while another pump drew 12,500 gpm for 4 hours per day. At 8:00 AM Monday morning, the reservoir level was at 55 feet, at 8:00 AM Tuesday morning, what was the water level in the reservoir? Assume no rain or other inflow or outflow.

A. 55 ft
B. 53 ft
C. 57 ft
D. 35 ft

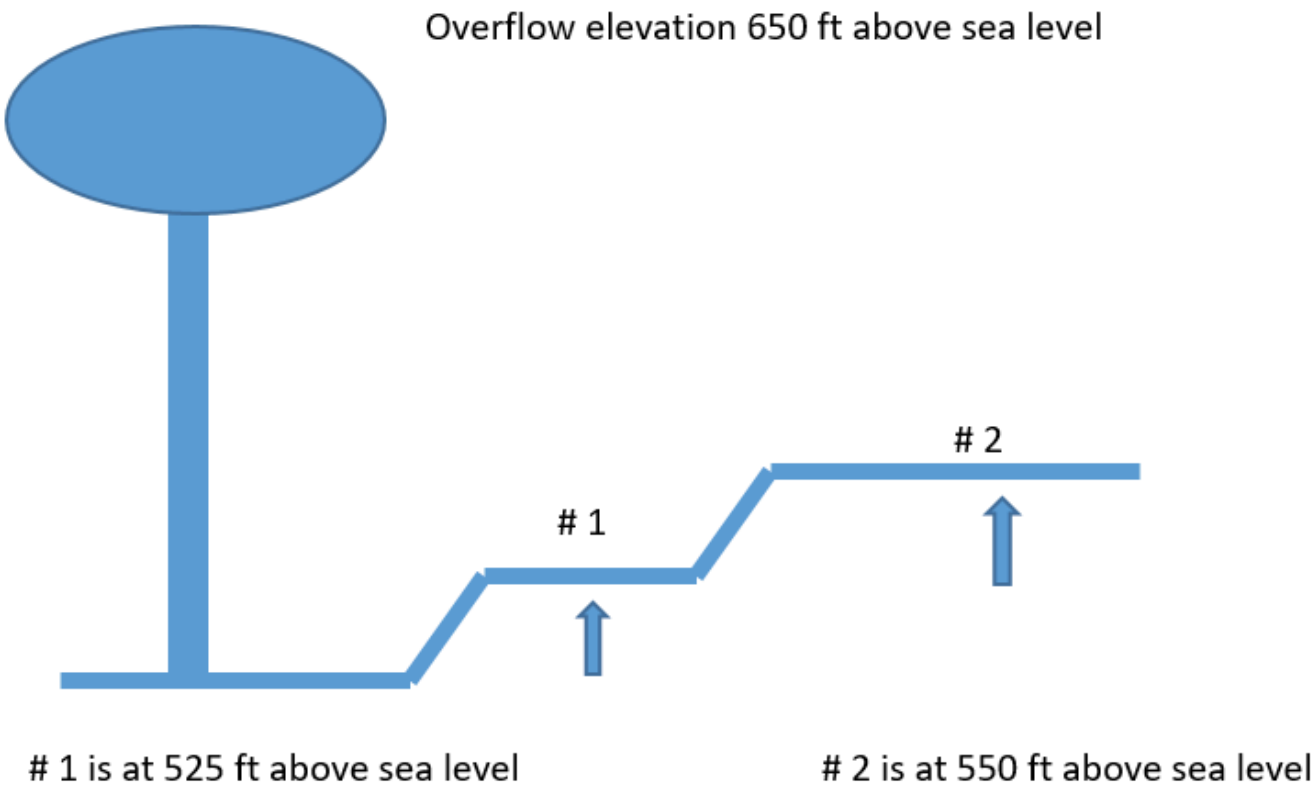
14. A new waterline 8 inches in diameter must be disinfected with 5.25% bleach with a specific gravity of 1.2. Since the pipeline is 8,000 feet long, how many gallons of bleach will be needed?

A. 9 gallons
B. 14 gallons
C. 17 gallons
D. 19 gallons

15. You are going to clean and disinfect a water tank. After you have cleaned the tank, you will prepare a 250 ppm solution of water and chlorine bleach that will be used to swab the sides of the tank. To prepare the solution, you mix 5.25% chlorine bleach with water for a final volume of 40 gallons of disinfectant. 1 gallon of the bleach weighs 8.5 lbs. How much bleach will be required for this solution?

A. 0.19 gallons
B. 0.8 gallons
C. 1.9 gallons
D. 2.7 gallons

Refer to the following figure for questions 16 and 17.



16. What will the static water pressure be at location #1?

A. 50 psi
B. 54 psi
C. 60 psi
D. 70 psi

17. What is the difference in pressure between location # 1 and location #2?

A. 0.psi
B. 5 psi
C. 10.8 psi
D. 25 psi

18. Water flows through a 18" pipe at a rate of 900 gpm. What is the velocity of the water flowing through this pipe?

A. 0.05 f/s
B. 0.75 f/s
C. 0.9 fps
D. 1.1 fps

19. Calculate the water horsepower of a pump required to move 850 gpm against a head of 210 feet?

A. 45 WHP
B. 50 WHP
C. 55 WHP
D. 60 WHP

20. What would be the BHP of the pump in question 19 if the pump efficiency was 90%?

A. 45 BHP
B. 50 BHP
C. 55 BHP
D. 60 BHP

Answer Key

1. D
2. D
3. A
4. C
5. B
6. C
7. D
8. B
9. A
10. B
11. C
12. B
13. A
14. C
15. A
16. B
17. C
18. D
19. A
20. B

Class III & IV

21. A reservoir has a capacity of 70 million gallons and can hold 35 feet of water when full. The plant treats water at the rate of 100 MGD for 24 hours into the reservoir. A pumping station delivers water from the reservoir to the distribution system at the rate of 36 MGD for 8 hours and 90 MGD for 16 hours. At the beginning of a day the water was 4 ft deep. At the end of the 24 hour period, how deep would the water be in the reservoir?

A. 10 ft
B. 18 ft
C. 24 ft
D. 35 ft

22. A water main is 1600 ft long and has an inside diameter of 12 inches. The flow through the main is 700 gpm. The main is 10 year-old DIP with a known C-Value of 100. What is the loss in feet of head per 100 ft? Use the Friction Loss of Water chart on page 148 of the Distribution System Operator Certification Manual.

A. 0.22 ft
B. 1.99 ft
C. 2.12 ft
D. 3.52 ft

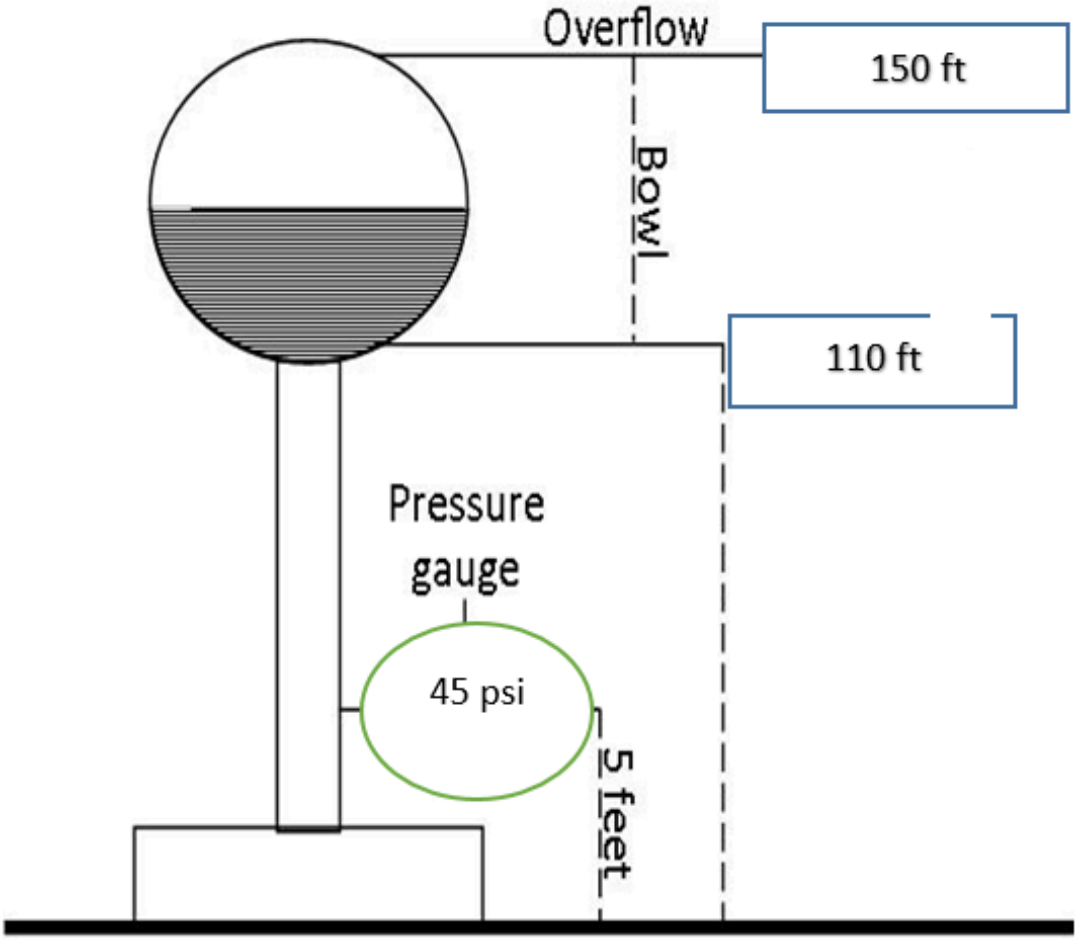
23. From the previous question. There is no elevation change throughout this section of pipe. If the system pressure is 60 psi at the beginning of this section, what should the pressure be at the end of the section?

A. 26 psi
B. 58.5 psi
C. 60 psi
D. 61.5 psi

24. If water flow past any given point is at the rate of 2.4 ft^3/sec, how many gallons will flow past this point in 1.5 minutes?

A. 1615 gallons
B. 2455 gallons
C. 3300 gallons
D. 4566 gallons

Refer to the following Figure for question 25.



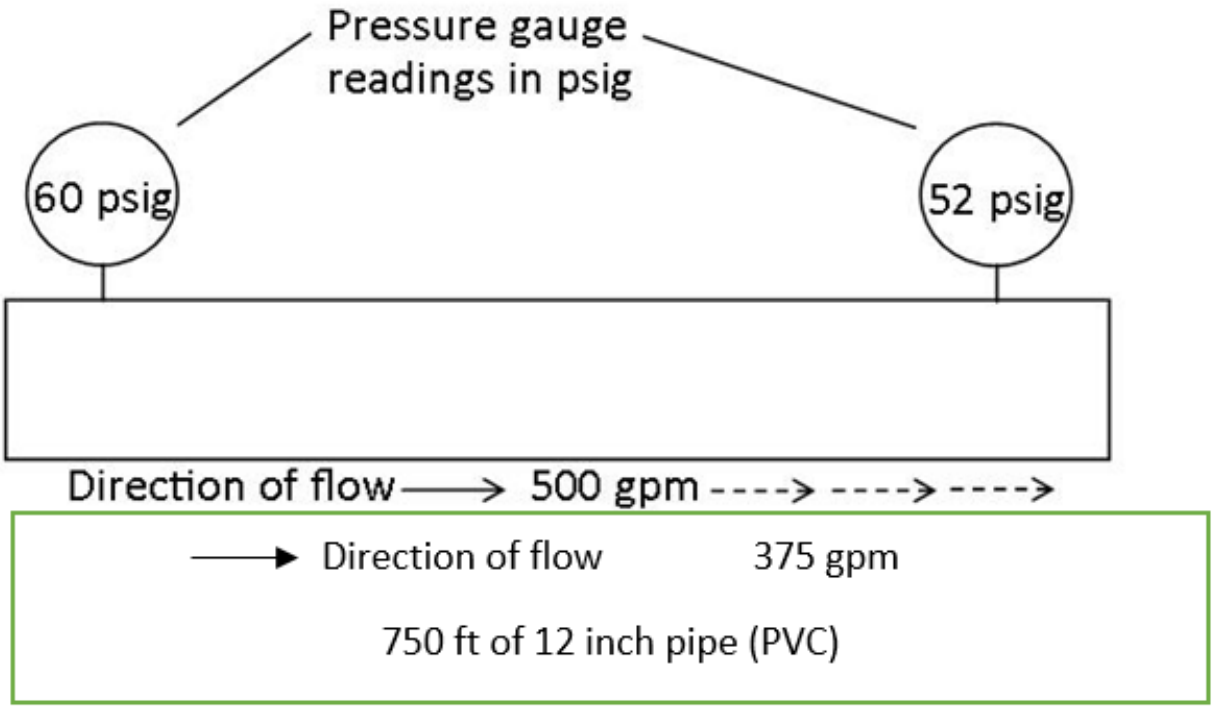
25. What will the pressure gauge read when the water level rises to the overflow?

A. 18 psi
B. 65 psi
C. 63 psi
D. 108 psi

26. How much would it cost to run a 65 MHP pump for two off-peak 8 hr shifts if the charge for power is $0.08/kWhr?

A. $31.04
B. $42.00
C. $55.86
D. $62.06

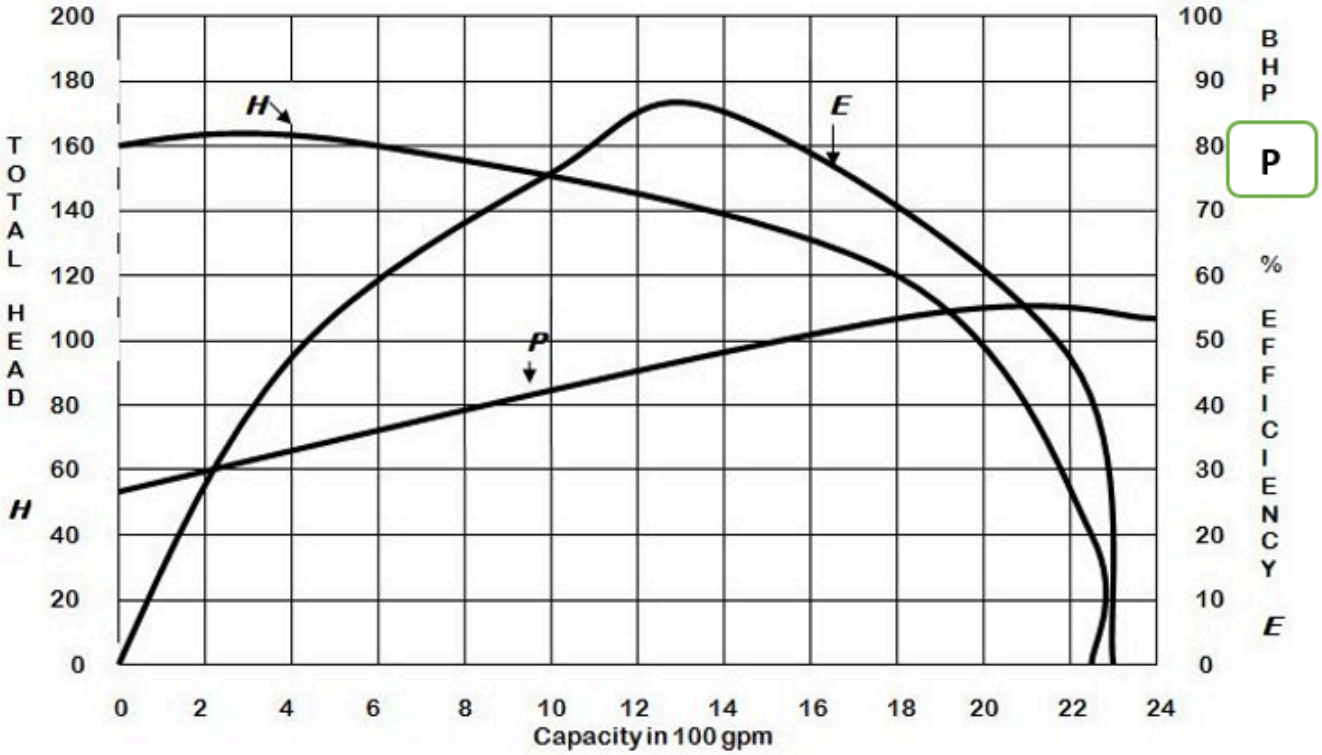
Refer to the following Figure for question 27.



27. Determine the head loss across the pipeline.

A. 9 ft
B. 18.5 ft
C. 27 ft
D. 36 ft

Refer to the following Figure for questions 28, 29 and 30.



28. What is the capacity of the pump in gpm when the pump is operating at its highest efficiency?

A. 13 gpm
B. 200 gpm
C. 1300 gpm
D. 2000 gpm

29. Which of the following statements is correct based on the data presented in the graph?

A. Loss of pressure head is constant throughout the range of capacity of the pump.
B. The most efficient pump operation occurs when pumping 1000 gpm.
C. Power needed decreases with increasing capacity
D. The pump would not be running efficiently when the capacity exceeds 2000 gpm

30. The greatest efficiency of the pump is when it is pumping between

A. 600 - 2000gpm
B. 1200 - 1400 gpm
C. 400 - 1000 gpm
D. 1800 - 2200 gpm

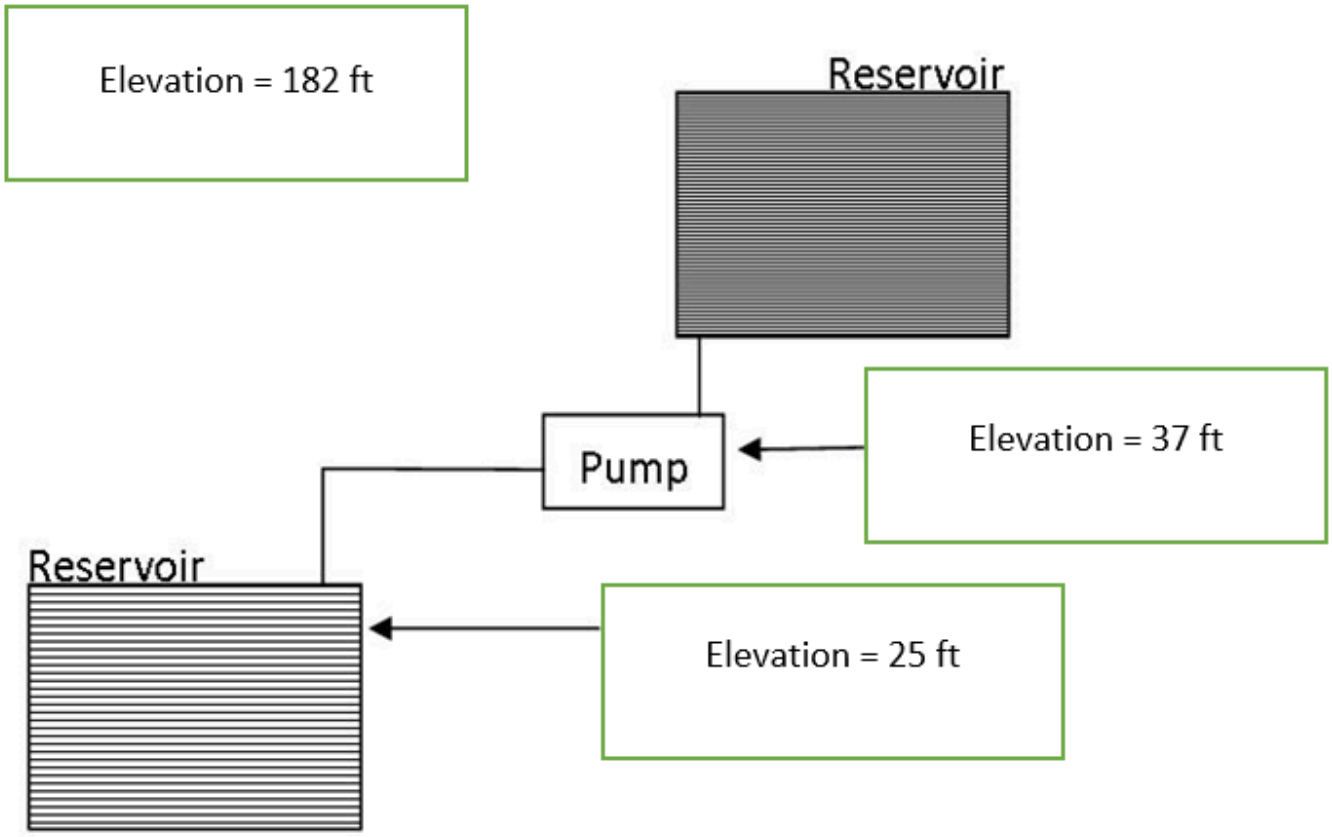
31. What water horsepower is required to lift water from a reservoir that is 20 feet below the centerline of the pump and then raise it to an elevated storage tank that is 90 feet above the centerline of the pump? The pump will need to deliver water at a rate of 3.5 ft^3/s.

A. 43.6 WHP
B. 57.8 WHP
C. 62.1 WHP
D. Pumps cannot lift water 20 ft.

32. You are flushing an 8 inch pipe. Flow from the hydrant is 350 gpm. What is the velocity of water in this pipe?

A. 0.35 f/s
B. 0.79 f/s
C. 2.23 f/s
D. 7 f/s

Refer to the following Figure for questions 33, 34 and 35.



33. For the arrangement of water source, pump and reservoir what is the total static head in feet?

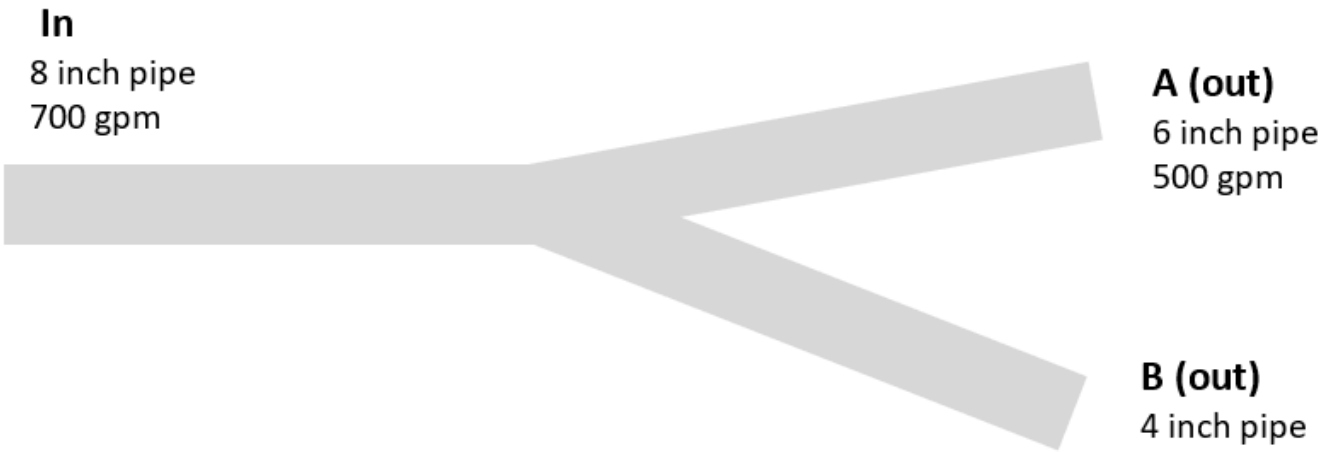
A. 157 ft
B. 145 ft
C. 62 ft
D. 12 ft

34. For the arrangement of water source, pump and reservoir what is the static discharge head in feet?

A. 157 ft
B. 145 ft
C. 62 ft
D. 12 ft

35. For the arrangement of water source, pump and reservoir what is the total static suction lift in feet?

A. 157 ft
B. 145 ft
C. 62 ft
D. 12 ft



36. From information in the above diagram, what will be the velocity in f/s of water in pipe B?

A. 1.4 fps
B. 4.4 fps
C. 5.2 fps
D. 5.8 fps

37. A 10 inch line is flowing at 1440 gpm and has a starting pressure of 85 psi. The pipe is estimated to have a C-Factor of 120. The pipe system is 1,600 feet long through flat terrain. What will be the approximate ending pressure of the line discounting any valves or restrictive appurtenances in the line? Use the Friction Loss of Water chart on page 148 of the Distribution System Operator Certification Manual.

A. 51 psi
B. 67 psi
C. 75 psi
D. 81 psi

Answer Key

21. B
22. A
23. B
24. A
25. C
26. D
27. B
28. C
29. D
30. B
31. A
32. C
33. A
34. B
35. D
36. C
37. C

Class I & II Solved Equations

1. Formula used: *No Formula on Sheet*
   Take the number of people times the amount of water each person uses each day.
   Daily demand = 1000 people x 125 gal/person = 125,000 gallons/day

2. Conversion
   2,000,000 gallons produced in 8 hours
   8 hours x 60 min/hr = 480 min
   2,000,000 gal ÷ 480 min = 4,167 gpm

3. Formula used: *No Formula on Sheet*
   First calculate how many gallons are in the tank then divide by the number of minutes it took to fill the tank.
   Volume, gal: 3 ft x 4 ft x 5 ft x 7.48 gal/ft^3 = 448.8 gallons
   1 min 15 seconds = 1.25 minutes
   Flow rate, gpm: 448.8 gal ÷ 1.25 min = 359 gpm

4. Find total number of feet in 2 miles and divide it by the length of pipe.
   Total length needed: 2 mile x 5,280 ft/mile = 10,560 ft ÷ 24 ft = 440 sections needed

5. Formula used: *Pounds = mg/L x 8.34 X MG ÷ % purity*
   Convert gallons to MG: 50,000 ÷1,000,000 = 0.050 MG
   Pounds: 3.0 mg/L x 8.34 x 0.050 MG = 1.25 lbs ÷ 0.65 = 1.92 lbs

6. Formula used: *Pounds formula.*
   Dosage will be 50 ppm because it is new pipe.
   Find volume of the pipe:
   0.785 x (8/12) x (8/12) x (1.5 x 5,280) =
   0.785 x 0.67 x 0.67 x 7,920 = 2,790 ft^3 x 7.48 = 20,896 gal
   20,896 ÷ 1,000,000 = 0.021 MG
   Pounds: 50 mg/L x 8.34 x 0.021 MG = 8.76 lbs ÷ 0.70 = 12.51 lbs

7. Formula used: *Pounds formula and Dosage = Demand + Residual*
   Dosage, mg/L: 3.0 mg/L + 0.9 mg/L = 3.9 mg/L
   Pounds: 3.9 mg/L x 8.34 X 0.9 MG = 29.27 lbs

8. Formula used: *Velocity (V) = Flow (Q) ÷ Area (A)*
   Calculate area of pipe: 0.785 x (10/12) x (10/12) = 0.785 x 0.83 x 0.83 = 0.54 ft^2
   Calculate Velocity: V = 3.5 ft^3 ÷ 0.54 ft^2 = 6.48 or 6.5 ft/s

9. Formula used: *Q = A x V*
   Calculate A: 0.785 x (12/12) x (12/12) = 0.785 x 1 x 1 = 0.785
   Calculate Q: Flow = 0.785 x 6.0 ft/s = 4.71 ft^3/s

10. Formula used: *No formula on sheet*.
    Divide total gallons used in the time period divided by number of days in period to get average water use per day.
    Water used: 14,350,500 – 5,750.000 = 8,600,500 gallons
    Avg. Flow/day: 8,600,500 ÷ 90 = 95,561 gpd

11. Formula used: *Volume of a cylinder and converting inches to feet*
    Diameter, ft: 72 in/12 in = 6 ft
    Volume, gal = 0.785 x 6 ft x 6 ft x 16 ft = 452.16 ft^3 x 7.48 gal/ft^3 =
    3,382 gallons

12. Formula used: *No formula on sheet*
    Calculate gallons per foot of reservoir: 220,000,000 ÷ 65 ft = 3,384,615 gal/ft
    Reservoir level at start 55 feet or 186,153,846 gallons
    Withdrawals:
    Pump 1 – 9,000 gpm for 8 hours = 9000 x 8 hr x 60 min = 4,320,000 gallons
    Pump 2 – 12,500 gpm for 4 hours/day = 12,500 x 4 hr x 60 min = 3,000,000 gallons
    Total withdrawn: 4,320,000 + 3,000,000 = 7,320,000 gallons
    Feet lost in reservoir: 7,320,000 gal÷ 3,384,615 gal/ft = 2.1 or 2 feet
    Depth in reservoir: 55 ft – 2 ft = 53 ft

13. Formula used: *Pounds formula and dosage of 50 ppm for new tank*
    20,000 gal = 0.020 MG
    lbs = 50 ppm x 8.34 x 0.020 = 8.34 lbs ÷ 0.65 = 12.8 lbs

14. Formula used: *Pounds formula then divide pounds by weight of a gallon of the bleach*
    Calculate volume of pipe in MG: 8 inches = 0.67 feet
    Volume, MG = 0.785 x 0.67 x 0.67 x 8,000 x 7.48 gal/ft^3 = 21,086 ÷1,000,000 = 0.021 MG
    lbs = 50 x 8.34 x 0.021 = 8.76 ÷ 0.0525 = 166.8 lbs ÷ (8.34 x 1.2) = 166.8 ÷ 10.008 = 16.7 or 17 gal

15. Formula used: *Pounds formula then divide pounds by weight of a gallon of the bleach*
    Convert 40 gallons to MG: 40 ÷ 1,000,000 = 0.00004 MG
    Calculate pounds needed: 250 ppm x 8.34 x 0.00004 MG = 0.0834 lbs ÷ 0.0525 = 1.59 lbs
    Calculate gallons needed: 1.59 lbs ÷ 8.5 lbs/gal = 0.19 gallons

16. Conversion: 1 foot of head = 0.433 psi
    Calculate feet of head at Position #1: 650 ft – 525 ft = 125 feet of head
    Convert to psi: 125 feet of head x 0.433 = 54 psi

17. Conversion: 1 foot of head = 0.433 psi
    Calculate difference in elevation between site #1 and site #2:
    550 ft = 525 ft = 25 feet
    Convert feet of head to psi: 25 feet of head x 0.433 = 10.8 psi

18. Formula used: *Velocity (V) = Flow (Q) ÷ Area (A)*
    Convert flow from gpm to ft^3 /s: 900 gpm ÷ 448.8 gpm/ft^3 /s = 2.0 ft^3 /s
    Convert pipe diameter from inches to feet: 18 in /12 in/ft = 1.5 ft
    Calculate area: 0.785 x 1.5 ft x 1.5 ft = 1.77 ft^2
    Calculate Velocity: V = 2.0 ft^3 ft/s ÷ 1.77 ft^2 = 1.1 ft/s

19. Formula used: *WHP = (Flow (gpm) x Head (ft)) ÷ 3960*
    Calculate WHP: (850 gpm x 210 ft) ÷ 3960 = 178,500 ÷ 3960 = 45 WHP

20. Formula used: *BHP = (Flow (gpm) x Head (ft)) ÷ (3960 x %pE)*
Calculate BHP: (850 gpm x 210 ft) ÷ (3960 x 0.90) = 178,500 ÷ 3564 = 50 BHP

Class III & IV Solved Equations

21. Formula used: *No Formula on Sheet*
    Track the flow in and out of tank and convert to feet at the end
    Calculate MG per foot of reservoir – 70 MG ÷ 35 feet deep = 2MG/ft
    At start of day water was 4 ft deep – 4 ft x 2 MG = 8MG
    Water Plant treats 100 MG
    Pump Station removes 36 MGD for 8 hours – 36 MG x 0.33 days = 12 MG
    Pump Station removes 90 MGD for 16 hours – 90 MG x 0.66 days = 60 MG
    Total water pumped out – 12 + 60 = 72 MG
    Water in reservoir 1t start - 8 MG + 100 MG -12 MG – 60 MG = 36 MG ÷ 2 MG/ft = 18 ft of water

22. Formula used: *Hazen – Williams chart*
    From Chart for a 12“ pipe at 700 gpm, head loss is 0.22 ft/100 ft of pipe

23. Head loss for 1600 ft at 0.22 feet lost per 100 ft of pipe – 16 x 0.22 = 3.52 feet of head
    Convert feet of head to psi – 3.52 feet x 0.433 = 1.5 psi
    Subtract psi lost from starting psi – 60 psi – 1.5 psi = 58.5 psi

24. Convert 2.4 ft^3/s to gpm – 2.4 ft^3/s x 448.8 = 1077 gpm
    Calculate flow for 1.5 minutes – 1077 x 1.5 = 1615 gallons

25. Pressure at overflow = (Elevation at overflow –elevation of gauge) x 0.433
    Pressure at overflow = (150 – 5) x 0.433 – 145 x 0.433 = 63 psi

26. Formula used: *HP x 0.746 x hours x Electrical cost/kWh (Not on formula sheet)*
    Calculate cost – 65 MHP x 0.746 x (2 x 8 hr) x $0.08/kWh = $62.06

27. Conversion used: psi to feet of head – 1 psi = 2.31 feet of head
    Change in pressure – 60 psi – 62 psi = 8 psi x 2.31 ft/psi = 18.5 feet of head

28. Find where efficiency is highest on graph and read gpm off Capacity axis – 1300 gpm

29. Look at graph to determine which is correct. The only one that is correct is that the pump would not be running efficiently when the capacity exceeds 2000 gpm

30. The same question as #28. Answer is B. 1200-1300 gpm

31. Formula used: *WHP = (flow, gpm x head , ft) ÷ 3960*
    Convert flow to gpm – 3.5 ft^3/s x 448.8 gpm = 1,570.8 gpm
    Find total head to overcome – 20 + 90 = 110 ft.
    Calculate WHP – (1,570.8 gpm x 110 ft) ÷ 3960 = 172,788 ÷ 3960 = 43.6 WHP

32. Formula used: *Velocity (V) = Flow (Q) ÷ Area (A)*
    Calculate Area of pipe – 0.785 x (8in/12in) x 8in/12in) = 0.785 x 0.67 x 0.67 = 0.35 ft^2
    Convert flow to ft^3/s – 350 gpm ÷ 448.8 $gpm/ft^3/s$ = 0.78 ft^3/s
    Calculate velocity – V = 0.78 ft^3/s ÷ 0.35 ft^2 = 2.23 ft/s

33. Total Static Head = Distance from source to where it is being pumped to.
From drawing – 182 ft – 25 ft = 157 ft.

34. Static discharge head is from the pump centerline to where it is being pumped to
From Drawing – 182 ft – 37 ft = 145 ft.

35. Total suction lift is from source to the pump centerline
From drawing, 37ft - 25ft = 12 ft

36. Formula used: V = Q ÷ A
First calculate the flow in Pipe B – 700 gpm – 500 gpm = 200 gpm
Convert the flow from gpm to ft^3/s – 200 gpm ÷ 448.8 gpm/ft^3/s = 0.45 ft^3/s
Calculate the area of the 4 inch pipe (4 in = 0.33 ft) – 0.785 x 0.33 ft x 0.33 ft = 0.085 ft^2
Calculate the velocity – 0.45 ft^3/s ÷ 0.085 ft^2 = 5.2 ft/s

37. Formula used: Flow, gpm x 100 ÷ Actual C-Factor = Equivalent Flow
Calculate Equivalent flow – 1440 x 100 ÷120 = 144,000 ÷ 120 = 1,200 gpm

Use Hazen- Williams chart to determine head loss at equivalent flow –
10 inch pipe at 1,200 gpm = 1.40 head loss per 100 feet
1600 ft ÷100 = 16 sections x 1.4 = 22.4 feet of head loss x 0.433 = 9.7 or 10 psi loss
Starting pressure was 85 psi – 10 psi lost = 75 psi.

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. Operator Certification staff are available to provide on-site assistance and training.

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