

## Advanced Math Problems

1. A water plant clearwell is 40 feet wide, 50 feet long, and 12 feet deep. If water is flowing into the clearwell at a rate of 8 cfs and being pumped out at a constant rate of 3 cfs, how many hours will it take to fill the clear well if there were 2 feet of water in the clear well?

$$\text{Width} = 40 \text{ ft} \quad \text{Length} = 50 \text{ ft} \quad \text{Depth} = 12 \text{ ft} - 2 \text{ ft} = 10 \text{ ft}$$

$$\text{Filling Flow Rate} = 8 \text{ cfs} - 3 \text{ cfs} = 5 \text{ cfs}$$

$$\text{Step 1: } V = 50 \text{ ft} \times 40 \text{ ft} \times 10 \text{ ft} = 20,000 \text{ ft}^3$$

$$\text{Step 2: } 20,000 \text{ ft}^3 \times \frac{1 \text{ sec}}{5 \text{ ft}^3} \times \frac{1 \text{ min.}}{60 \text{ sec}} \times \frac{1 \text{ hr}}{60 \text{ min}} = 1.1 \text{ hrs}$$

2. The overflow of a water tower is 100 feet above ground. The water line is 10 feet below ground level. If the water tower is filled to a level 2 feet below the overflow point, what is the pressure in the water line?

$$\text{Step 1 (Water Height): } 100 \text{ ft} - 2 \text{ ft} = 98 \text{ ft} + 10 \text{ ft} = 108 \text{ ft}$$

$$\text{Step 2: } 108 \text{ ft} \times \frac{1 \text{ psi}}{2.31 \text{ ft}} = 46.75 \text{ psi}$$

3. A cylindrical rapid mix tank is 8 feet in diameter and 10 feet high. The flow rate through the plant is 8,000,000 gallons per day. What is the detention time (in seconds) of the rapid mix tank?

$$V = \pi R^2 \times h \quad \text{Diameter} = 8 \text{ ft} \quad \text{Height} = 10 \text{ ft} \quad \text{Flow Rate} = 8,000,000 \text{ gal/day}$$

$$\text{Step 1: } 3.14(4 \text{ ft})^2 \times 10 \text{ ft} = 502.4 \text{ ft}^3 \times \frac{7.48 \text{ gal}}{1 \text{ ft}^3} = 3,758 \text{ gal}$$

$$\text{Step 2: } 3,758 \text{ gal} \times \frac{1 \text{ day}}{8,000,000 \text{ gal}} = 0.0004697 \text{ day}$$

$$\text{Step 3: } 0.0004697 \text{ day} \times \frac{24 \text{ hours}}{1 \text{ day}} \times \frac{60 \text{ min}}{1 \text{ hr}} \times \frac{60 \text{ sec}}{1 \text{ min}} = 40.6 \text{ seconds}$$

4. A pretreatment basin is 80 feet in diameter and 30 feet deep. The water flow is 7.0 MGD. Calculate: A) basin volume in gallons, B) detention time in hours, and C) how many pounds of alum must be fed per day to give a dosage of 3 mg/L.

Diameter= 80 ft Depth= 30 ft Water Flow= 7.0 MGD

$$A) \text{ Volume} = \pi R^2 \times h = 3.14(40 \text{ ft})^2 \times 30 \text{ ft} = 150,720 \text{ ft}^3 \times \frac{7.48 \text{ gal}}{\text{ft}^3} =$$

**1,127,385.6 gallons**

$$B) \text{ Step 1: } \frac{7,000,000 \text{ gal}}{1 \text{ day}} \times \frac{1 \text{ day}}{24 \text{ hrs}} = 291,667 \text{ gal/day}$$

$$\text{Step 2: } 1,127,285.6 \text{ gal} \times \frac{1 \text{ hr}}{291,667 \text{ gal}} = \text{3.86 hours}$$

$$C) 7,000,000 \text{ gal} \times \frac{8.34 \text{ lbs}}{1 \text{ gal}} = 58,380,000 \text{ lbs} = 58.38 \text{ ppm}(\text{lbs}) \times 3 = \text{175.14 lbs}$$

5. A filter has a sand area of 18 feet by 18 feet. When the influent valve is shut, the water level drops 5 inches per minute. What is the rate of filtration in million gallons per day?

$$\text{Filter Area} = 18 \text{ ft} \times 18 \text{ ft} = 324 \text{ ft}^2 \quad \text{Drop rate} = \frac{5 \text{ in}}{1 \text{ min}} \times \frac{1 \text{ ft}}{12 \text{ in}} = 0.417 \text{ ft/min}$$

$$\text{Step 1: } 324 \text{ ft}^2 \times \frac{0.417 \text{ ft}}{1 \text{ min}} = 135 \text{ ft}^3/\text{min}$$

$$\text{Step 2: } \frac{135 \text{ ft}^3}{1 \text{ min}} \times \frac{7.48 \text{ gal}}{1 \text{ ft}^3} \times \frac{60 \text{ min}}{1 \text{ hr}} \times \frac{24 \text{ hrs}}{1 \text{ day}} = 1,454,112 \frac{\text{gal}}{\text{day}} = \text{1.45 MGD}$$

6. A pipe has a diameter of 3.0 feet and is full of water. If the flow velocity through the pipe is 100 feet per minute, what is the flow rate through the pipe in cubic feet per second?

$$Q = V \times A \quad A = \pi R^2 \quad \text{Diameter} = 3.0 \text{ ft} \quad \text{Velocity} = 100 \text{ ft/min}$$

$$\text{Step 1: } \text{Area} = 3.14(1.5)^2 = 7.065 \text{ ft}^2$$

$$\text{Step 2: } Q = \frac{100 \text{ ft}}{\text{min}} \times 7.065 \text{ ft}^2 = \frac{706.5 \text{ ft}^3}{\text{min}} \times \frac{1 \text{ min}}{60 \text{ sec}} = \text{11.8 ft}^3/\text{sec}$$

7. A pump discharges into a 4.0-foot diameter barrel. If the water level in the barrel rises 30 inches in 30 seconds, what is the flow into the barrel in gallons per minute?

$$Q = V \times A \quad A = \pi R^2 \quad \text{Diameter} = 4.0 \text{ ft} \quad \text{Water Rises } 30 \text{ in}/30 \text{ sec}$$

$$\text{Step 1: } A = 3.14(2)^2 = 12.56 \text{ ft}^2$$

$$\text{Step 2: } \frac{30 \text{ in}}{30 \text{ sec}} \times \frac{1 \text{ ft}}{12 \text{ in}} \times \frac{60 \text{ sec}}{1 \text{ min}} = 5 \text{ ft/min}$$

$$\text{Step 3: } \frac{5 \text{ ft}}{1 \text{ min}} \times 12.56 \text{ ft}^2 = \frac{62.8 \text{ ft}^3}{1 \text{ min}} \times \frac{7.48 \text{ gal}}{1 \text{ ft}^3} = \text{469.7 gal/min}$$

8. If a stabilization pond is 8 feet deep and 6.0 acres in area, and is filled to the top, how many gallons does it hold? Assuming a discharge rate of 2 cfs, how many hours would it take to bring the level down to 4 feet?

$$\text{Depth} = 8 \text{ ft} \quad A = 6 \text{ acres} \times \frac{43,560 \text{ ft}^2}{1 \text{ acre}} = 261,360 \text{ ft}^2 \quad \text{Discharge rate} = 2 \text{ cfs}$$

$$\text{Gallons the pond holds: } 261,360 \text{ ft}^2 \times 8 \text{ ft} = 2,090,880 \text{ ft}^3 \times \frac{7.48 \text{ gal}}{1 \text{ ft}^3} = 15,639,782 \text{ gal}$$

$$\text{Hours: Step 1 (Gallons of 4 ft of discharge): } 261,360 \text{ ft}^2 \times 4 \text{ ft} = 1,045,440 \text{ ft}^3$$

$$\text{Step 2 (time): } 1,045,440 \text{ ft}^3 \times \frac{1 \text{ sec}}{2 \text{ ft}^3} \times \frac{1 \text{ min}}{60 \text{ sec}} \times \frac{1 \text{ hr}}{60 \text{ min}} = 145.2 \text{ hrs}$$

9. The wet well of a lift station is in the form of a cylinder with a diameter of 8 feet and a depth of 24 feet. One pump starts up when the wastewater is 9 feet deep and pumps at a rate of 420 gpm. When the wastewater is 1 foot deep the pump shuts off.
- A) If wastewater is entering the wet well at an average rate of 180 gpm, how long will the pump run?
- B) What is the rest period between pump shut down and start up?

$$\text{A) Vol. of discharge: } V = 3.14(4 \text{ ft})^2 \times 8 \text{ ft} = 401.92 \text{ ft}^3 \times \frac{7.48 \text{ gal}}{1 \text{ ft}^3} = 3,006.4 \text{ gal}$$

$$\text{Rate of water level decrease: } 420 \text{ gpm} - 180 \text{ gpm} = 240 \text{ gpm}$$

$$\text{Pump running time: } 3,006.4 \text{ gal} \times \frac{1 \text{ min}}{240 \text{ gal}} = 12.53 \text{ minutes}$$

$$\text{B) Pump rest time: } 3,006.4 \text{ gal} \times \frac{1 \text{ min}}{180 \text{ gal}} = 16.7 \text{ minutes}$$

10. A turbine pump set at a rate of 500 gpm is pumping water through a 12-inch main. How fast is the water traveling through the pump in feet per second?

$$Q = V \times A \rightarrow V = \frac{Q}{A} \quad A = \pi r^2 \quad \text{Flow Rate} = 500 \text{ gpm} \quad \text{Diameter} = 12 \text{ in}$$

$$\text{Step 1: } 3.14(0.5 \text{ ft})^2 = 0.785 \text{ ft}^2$$

$$\text{Step 2: } \frac{500 \text{ gal}}{1 \text{ min}} \times \frac{1 \text{ ft}^3}{7.48 \text{ gal}} = 66.8 \text{ ft}^3/\text{min}$$

$$\text{Step 3: } V = \frac{66.8 \text{ ft}^3/\text{min}}{0.785 \text{ ft}^2} = \frac{85.1 \text{ ft}}{\text{min}} \times \frac{1 \text{ min}}{60 \text{ sec}} = 1.42 \text{ ft/sec}$$

11. A storage tank contains 50,000 gallons. How much HTH (at 65% chlorine) in pounds must be added to chlorinate the water to 12 mg/L if the water already contains 1 mg/L?

$$\text{Chemical Feed} = \text{flow rate/storage (MGD)} \times \text{dosage (mg/L)} \times 8.34 \text{ lbs/gal}$$

$$\text{Step 1: } 0.05 \text{ MG} \times 11 \frac{\text{mg}}{\text{L}} \times 8.34 \frac{\text{lbs}}{\text{gal}} = 4.587 \text{ lbs @ 100\% chlorine}$$

$$\text{Step 2: } 4.587 \text{ lbs} \div 0.65 = 7 \text{ lbs HTH}$$

12. You are to disinfect a water storage tank by maintaining a 50 mg/L chlorine solution in the tank for 24 hours. If the tank is 40 feet in diameter and 70 feet high, how many pounds of HTH (65% chlorine) are needed?

$$V = \pi R^2 \times h \quad \text{Height} = 70 \text{ ft} \quad \text{Diameter} = 40 \text{ ft} \quad \text{Chlorine conc. for 24 hr} = 50 \text{ mg/L}$$

$$\text{Step 1: } V = 3.14(20 \text{ ft})^2 \times 70 \text{ ft} = 87,920 \text{ ft}^3 \times \frac{7.48 \text{ gal}}{1 \text{ ft}^3} = 657,642 \text{ gal}$$

$$\text{Step 2: } 0.657642 \text{ MG} \times 50 \frac{\text{mg}}{\text{L}} \times 8.34 \frac{\text{lbs}}{\text{gal}} = 274 \text{ lbs @ 100\% Chlorine conc.}$$

$$\text{Step 3: } 274 \text{ lbs} \div 0.65 = 422 \text{ lbs HTH}$$

13. A water plant is treating 1,000,000 gallons in 8 hours. A test for free chlorine residual of the plant indicates a level of 0.5 mg/L. Based on experience, the operator knows they must bring the free chlorine residual up to 2.0 mg/L at the plant in order to maintain a level of 1.0 mg/L free residual in the distribution system. If the rotameter on the chlorinator is set at 45, what must the new setting be?

$$1 \text{ MG per 8 hr period} = 3 \text{ MG per 24 hours} \quad \text{Starting free chlorine residual} = 0.5 \text{ mg/L} \\ \text{Rotameter setting} = 45$$

$$\text{Step 1 (Amount increase needed): } 2.0 \text{ mg/L} - 0.5 \text{ mg/L} = 1.5 \text{ mg/L}$$

$$\text{Step 2 (chlorine needed): } 3 \text{ MG} \times 1.5 \frac{\text{mg}}{\text{L}} \times 8.34 \frac{\text{lbs}}{\text{gal}} = 37.5 \text{ lbs}$$

$$\text{Step 3 (rotameter setting): } 37.5 \text{ lbs} + 45 = 82.5 \text{ lbs/day}$$

14. A filter bed is 20 feet wide and 30 feet long. The operator backwashes the filter for 20 minutes and the backwash meter reads 130,000 gallons. What is the backwash rate in gpm/ft<sup>2</sup>?

$$\text{Step 1: Area of Filter} = 20 \text{ ft} \times 30 \text{ ft} = 600 \text{ ft}^2$$

$$\text{Step 2: Backwash rate} = \frac{130,000 \text{ gal}}{20 \text{ min}} = \frac{6,500 \text{ gal}}{1 \text{ min}} \div 600 \text{ ft}^2 = 10.83 \text{ gpm/ft}^2$$

15. Calculate the volatile solids in mg/L for a 50 ml sample based on the following information:

Tared weight of crucible = 13.24 grams

Sample and crucible weight after drying = 13.68 grams

Sample and crucible weight after ignition = 13.38 grams

$$\text{Step 1: } 13.68 \text{ g} - 13.38 \text{ g} = 0.3 \text{ g/50 mL}$$

$$\text{Sep 2: } \frac{0.3 \text{ g}}{50 \text{ mL}} \times \frac{1,000 \text{ mg}}{1 \text{ g}} \times \frac{1,000 \text{ mL}}{1 \text{ L}} = 6,000 \text{ mg/L}$$

16. The total suspended solids in a raw wastewater sample is 500 mg/L. At a mechanical treatment plant, the primary clarifier removes 60% of the suspended solids. How many pounds of dry solids are removed each day if the flow into the plant is 1,300,000 gallons per day?

$$\text{Step 1: } 1.3 \text{ MGD} \times 500 \frac{\text{mg}}{\text{L}} \times 8.34 \frac{\text{lbs}}{\text{gal}} = 5,421 \text{ lbs @ 100\% solids}$$

$$\text{Step 2: } 5,421 \text{ lbs} \times 0.6 \text{ lbs} = 3,252.6 \text{ lbs}$$

17. A lagoon system has a primary cell of 7.8 acres and one secondary cell of 7.4 acres. Assume the cells are 8 feet deep, there are 2 feet of dead storage at the bottom of the cells, and there are 3 feet of freeboard. If the population in the community is 1,464, and the daily flow is 75 gallons/capita, how many days storage does this system have?

$$\text{Step 1: } 7.8 \text{ acres} + 7.4 \text{ acres} = 15.2 \text{ acres} \times \frac{43,560 \text{ ft}^2}{1 \text{ acres}} = 662,112 \text{ ft}^2$$

$$\text{Step 2: } 662,112 \text{ ft}^2 \times 3 \text{ ft} = 1,986,336 \text{ ft}^3$$

$$\text{Step 3: } 1,986,336 \text{ ft}^3 \times \frac{7.48 \text{ gal}}{1 \text{ ft}^3} = 14,857,793 \text{ gal}$$

$$\text{Step 4: } 1,464 \text{ people} \times \frac{75 \text{ gal}}{1 \text{ day}} = 109,800 \text{ gal/day}$$

$$\text{Step 5: } 14,857,793 \text{ gal} \times \frac{1 \text{ day}}{109,800 \text{ gal}} = 135 \text{ days}$$

18. A three-cell lagoon system has a primary cell area of 18 acres and two secondary cells of 4.4 acres each. If the maximum allowable BOD<sub>5</sub> loading is 30 lbs./acre/day on the primary cell and 20 lbs./acre/day over the entire system, what size community is this system adequate for, based on BOD<sub>5</sub> loading? Assume a per capita BOD<sub>5</sub> contribution of 0.17 lbs./day.

$$\text{Step 1 (total area of ponds): } 18 \text{ acres} + 4.4 \text{ acres} + 4.4 \text{ acres} = 26.8 \text{ acres}$$

$$\text{Step 2 (total BOD}_5 \text{ loading per day): } 26.8 \text{ acres} \times \frac{20 \text{ lbs}}{\text{acre day}} = 536 \text{ lbs/day}$$

$$\text{Step 3 (\# of people): } 536 \frac{\text{lbs}}{\text{day}} \div \frac{0.17 \text{ lbs}}{\text{day person}} = 3,153 \text{ people}$$

19. An elevated storage tank is sphere shaped with a diameter of 60 feet. How many gallons of water can this tank hold?

$$V = \frac{4}{3}\pi R^3 \quad \text{Diameter} = 60 \text{ ft}$$

$$\text{Step 1: } \frac{4}{3} \times (3.14) \times (30 \text{ ft})^3 = 112,757.4 \text{ ft}^3$$

$$\text{Step 2: } 112,757.4 \text{ ft}^3 \times \frac{7.48 \text{ gal}}{1 \text{ ft}^3} = 843,425.35 \text{ gal}$$

20. A basin is 50 feet by 25 feet by 20 feet, with a flow of 2 million gallons per day through the basin. What will the detention time be?

$$\text{Step 1: } 50 \text{ ft} \times 25 \text{ ft} \times 20 \text{ ft} = 25,000 \text{ ft}^3 \times \frac{7.48 \text{ gal}}{1 \text{ ft}^3} = 187,000 \text{ gal}$$

$$\text{Step 2: } 187,000 \text{ gal} \times \frac{1 \text{ day}}{2,000,000 \text{ gal}} = 0.0935 \text{ day} \times \frac{24 \text{ hrs}}{1 \text{ day}} = 2.24 \text{ hrs}$$

21. Your plant has a 30-foot square rapid sand filter. What capacity pump may be used to produce a filter loading of 0.5 gallons per square foot per minute?

$$\frac{0.5 \text{ gal/ft}^2}{\text{min}} \times 30 \text{ ft} \times 30 \text{ ft} = 450 \text{ gal/min}$$

## Answers

1. 1.1 hours
2. 46.76 psi
3. 40.6 seconds
4. A) 1,127,385.6 gallons  
B) 3.86 hours  
C) 175.14 lbs.
5. 1.45 MGD
6. 11.8 ft<sup>3</sup>/sec
7. 469.7 gal/min
8. 15,639,782 gal  
145.2 hours
9. A) 12.53 minutes  
B) 16.7 minutes
10. 1.4 ft/sec
11. 7 lbs. HTH
12. 422 lbs. HTH
13. 82.5 lbs./day
14. 10.83 gal/min/ft<sup>2</sup>
15. 6,000 mg/L
16. 3,253 lbs.
17. 135 days
18. 3,153 people
19. 843,425.4 gallons
20. 2.24 hours
21. 450 gal/min