Flow Rate Calculation

Calculating Flow Rate

How many gallons drained from this tank?

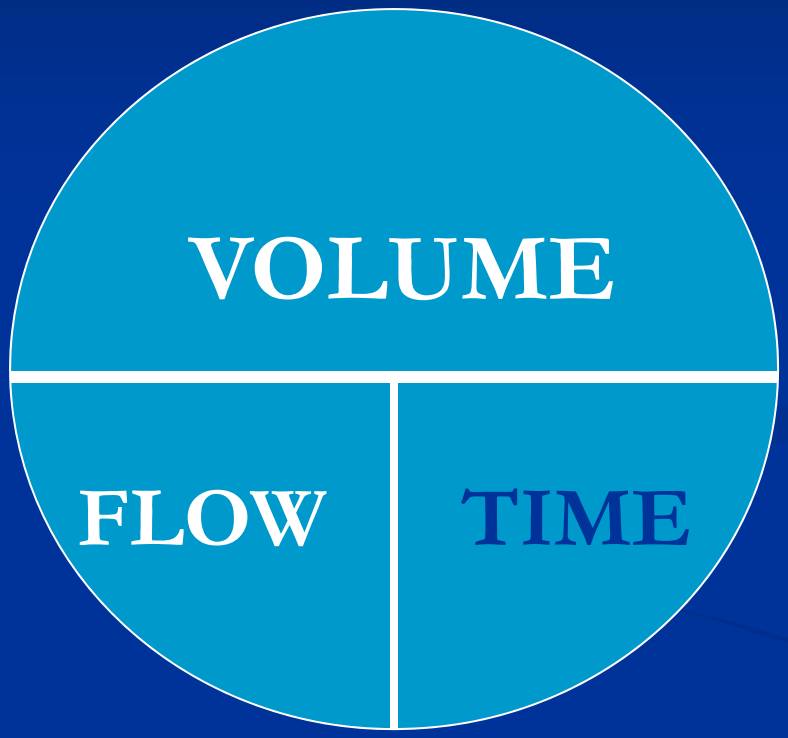
What is the detention time in this basin?

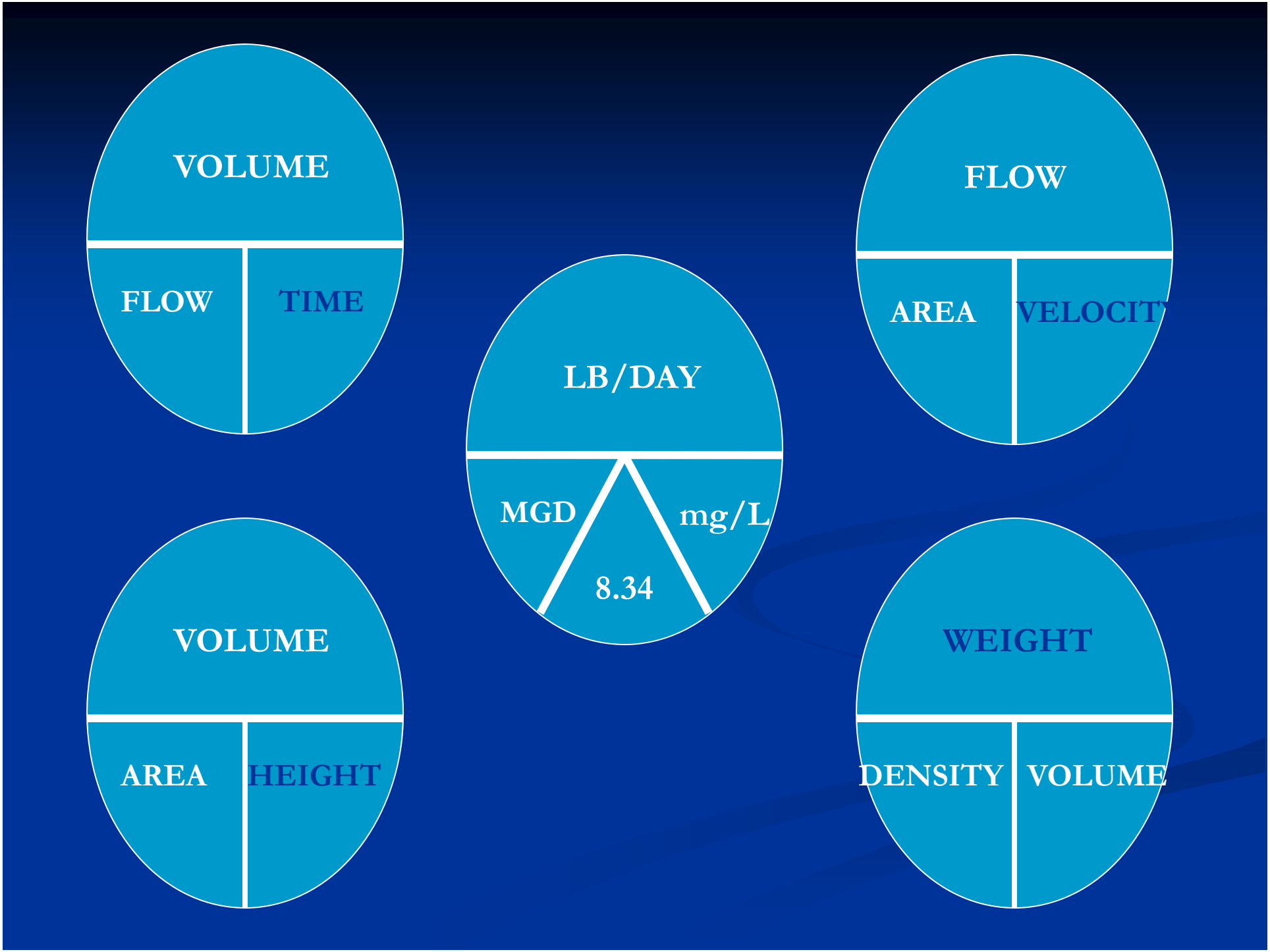
How much water went into storage?

How long will the water last?

Flow Rate Equation

Flow Rate = Volume ÷ Time


VOLUME
FLOW
TIME


VOLUME
FLOW
TIME
FLOW
AREA
VELOCITY
LB/DAY
MGD
mg/L
8.34
VOLUME
AREA
HEIGHT
WEIGHT
DENSITY
VOLUME

Flow Rate Formula

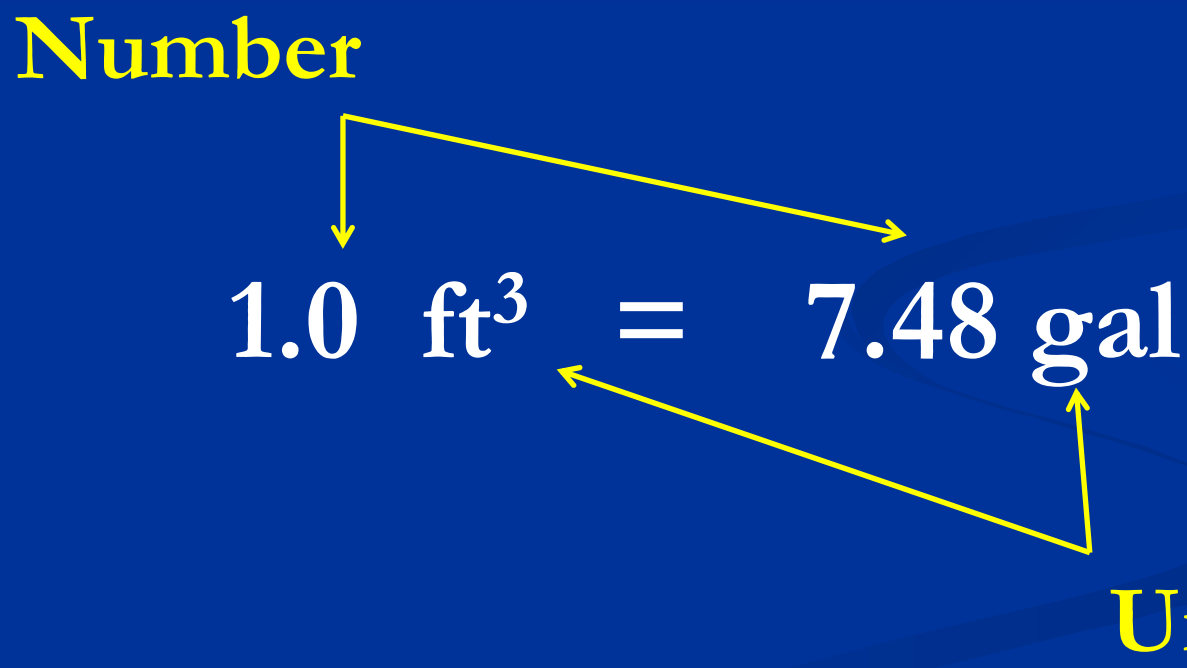
Flow Rate = Volume ÷ Time

Volume = Flow Rate x Time

Time = Volume ÷ Flow Rate

This is the ONLY formula that uses "Time"!

Measurements



Flow Rate Units

- **Volume:** Cubic Feet (ft x ft x ft)
- **Time:** Seconds

When divided,

- **Flow Rate:** Cubic Feet per second (cfs)

Flow Rate Units

- Volume: Gallons
- Time: Minute

When divided,

- Flow Rate: Gallons per minute (gpm)

Flow Rate Units

- Volume: *Million* gallons
- Time: Day

When divided,

- Flow Rate: Million gallons per day (MGD)

Solving Math Problems

Read the Problem – *Twice!*

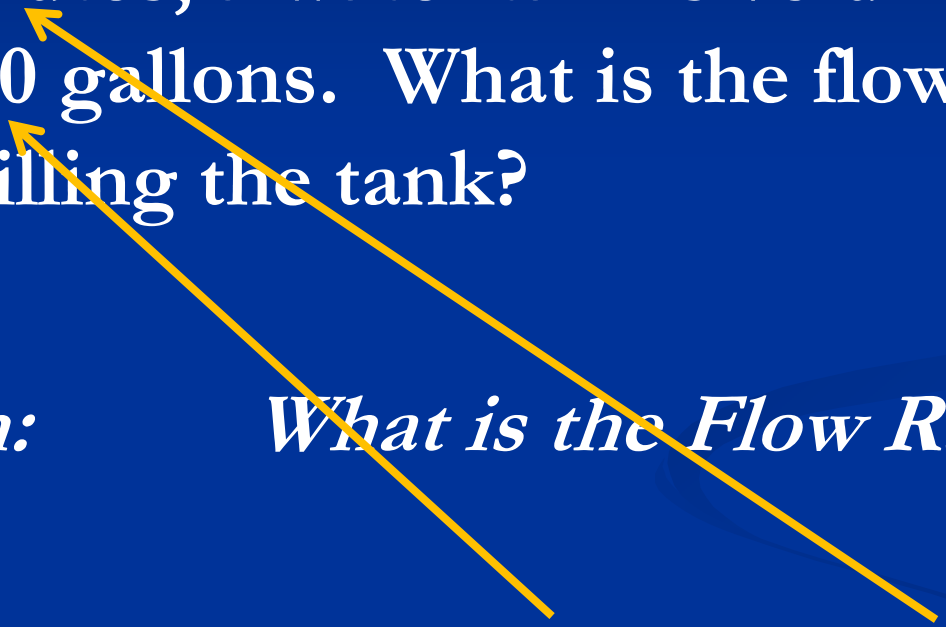
Simplify the Question

Identify the Formula

Find the "Variables"

Flow Rate Problem

In 60 minutes, a water tank's volume increases by 4,200 gallons. What is the flow rate of water filling the tank?



Question: ***What is the Flow Rate?***

Formula: Flow rate = Volume ÷ Time

Flow Rate Problem

In 60 minutes, a water tank's volume increases by 4,200 gallons. What is the flow rate of water filling the tank?

$$\text{Flow Rate} = \frac{\text{Volume}}{\text{Time}}$$

$$\text{Flow Rate} = \frac{4{,}200 \text{ gal}}{60 \text{ min}}$$

$$= \textit{70 gallons per minute}$$

Flow Rate Example – I

In four hours, a water tank's volume increases by 24,000 gallons. What is the flow rate of water filling the tank?

Question: *What is the Flow Rate?*

Formula: Flow rate = Volume ÷ Time

Flow Rate Example – I

In four hours, a water tank's volume increases by 24,000 gallons. What is the flow rate of water filling the tank?

Volume

$$\text{Flow Rate} = \frac{24{,}000 \text{ gal}}{4 \text{ hours}} \times \frac{1 \text{ hour}}{60 \text{ min}}$$

Time

Conversion Factor

$$= \textit{100 gallons per minute}$$

Flow Rate Example – II

How many gallons of water can be pumped into a water tank in six hours, if the pumping rate is 2000 gallons per minute?

Question: *What is the Volume?*

Formula: *Volume = Flow Rate x Time*

Flow Rate Example – II

How many gallons of water can be pumped into a water tank in six hours, if the pumping rate is 2000 gallons per minute?

$$\text{Volume} = \frac{2{,}000 \text{ gal}}{1 \text{ min}} \cdot \frac{6 \text{ hours}}{1} \cdot \left\{ \frac{60 \text{ min}}{1 \text{ hour}} \right\}$$

$$= \textit{720,000 gallons}$$

Flow Rate Example – III

How long will it take to completely drain a full, 200,000 gallon water tank, if the drain rate is 5000 gallons per minute?

Question: ***What is the Time?***

Formula: ***Time = Volume ÷ Flow Rate***

Flow Rate Example – III

How long will it take to completely drain a full, 200,000 gallon water tank, if the drain rate is 5000 gallons per minute?

$$\text{Time} = \frac{200{,}000 \text{ gal}}{\left\{\frac{1 \text{ min}}{5000 \text{ gal}}\right\}}$$

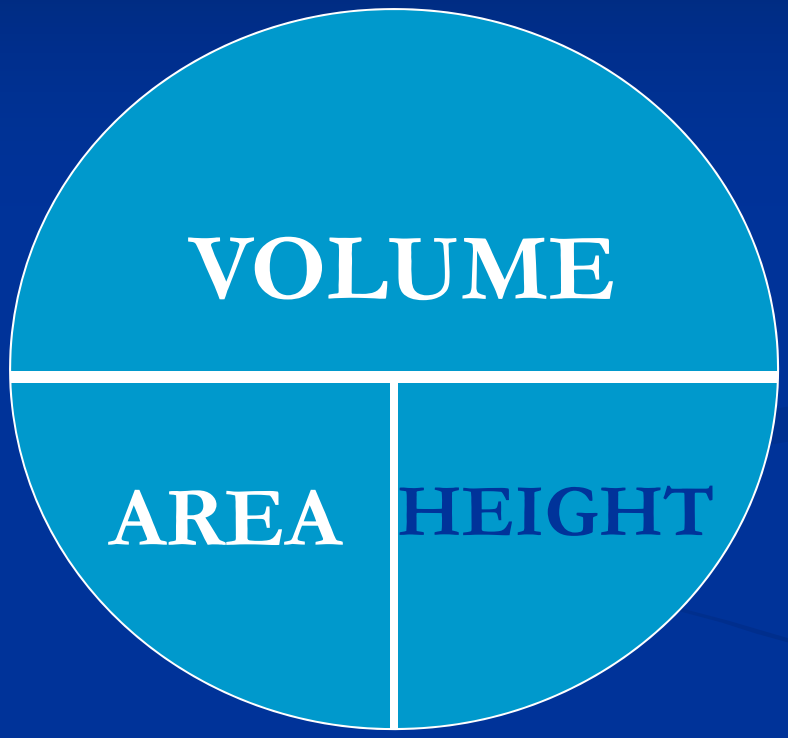
Invert and Multiply

$$= \textit{40 minutes}$$

Flow Rate Example – IV

A storage tank that is 100 feet wide by 150 feet long with a water depth of 25 feet drains completely in 46.75 minutes. What was the flow rate (gpm) during this draining operation?

Flow Rate = *Volume* ÷ Time


VOLUME
AREA
HEIGHT

Flow Rate Example – IV

Find the number of gallons in a storage tank that is 100 feet wide by 150 feet long with a water depth of 25 feet.

Volume = (100 ft x 150 ft) x 25 ft

= 375,000 ft^3

$$= \frac{375{,}000\ ft^3}{1} \times \frac{7.48\ gal}{1\ ft^3}$$

= *2,805,000 gal*

Flow Rate Example – IV

A water tank (volume = 2,805,000 gal) drains in 46.75 minutes. What is the flow rate?

$$\text{Flow Rate} = \frac{2{,}805{,}000 \text{ gal}}{46.75 \text{ min}}$$

$$= \textit{60,000 gallons per minute}$$

Flow Rate Example – V

How long will the supply last in a storage tank that is 100 feet wide by 150 feet long with a water depth of 25 feet, if it is drained at 60,000 gpm?

Time = *Volume* ÷ Flow Rate

Flow Rate Example – V

Find the number of gallons in a storage tank that is 100 feet wide by 150 feet long with a water depth of 25 feet.

$$\text{Volume} = (100\ \text{ft} \times 150\ \text{ft}) \times 25\ \text{ft}$$

$$= 375{,}000\ \text{ft}^3$$

$$= \frac{375{,}000\ \text{ft}^3}{1} \times \frac{7.48\ \text{gal}}{1\ \text{ft}^3}$$

$$= \textit{2,805,000 gal}$$

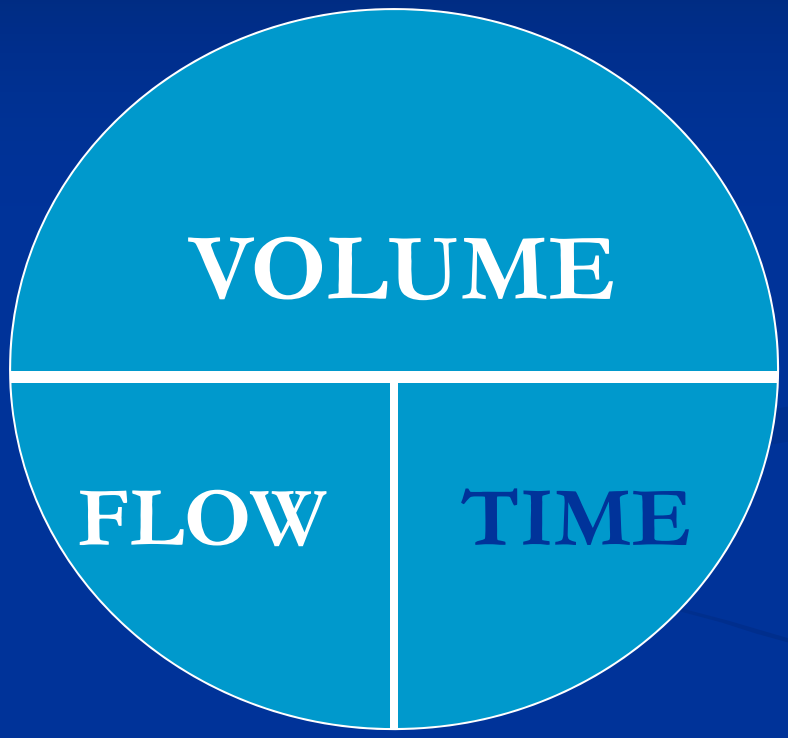
Flow Rate Example – V

How long will it take to drain a water tank (volume = 2,805,000 gal) at 60,000 gpm?

$$\text{Time} = \frac{2{,}805{,}000 \text{ gal}}{60{,}000 \text{ gal}} \times 1 \text{ min}$$

$$= \textit{46.75 minutes}$$

The Flow Rate Formula



Water Math: Flow Rate

Quiz

Question 1

A 2 million gallon reservoir is expected to serve its customers for 24 hours. What is the maximum flow rate (in gpm) this reservoir is expected to deliver in this case?

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A 2 million gallon reservoir is expected to serve its customers for 24 hours. What is the maximum flow rate this reservoir is expected to deliver in this case?

Question: *What is the Flow Rate?*

Formula: *Flow Rate = Volume ÷ Time*

Question 1

A 2 million gallon reservoir is expected to serve its customers for 24 hours. What is the maximum flow rate?

$$\text{Flow Rate} = \frac{2{,}000{,}000 \text{ gal}}{24 \text{ hours}} \cdot \frac{1 \text{ hour}}{60 \text{ min}}$$

$$= \textit{1,389 gallons per minute}$$

Question 2

A 2,000 gpm pump station is filling an empty 2 MG reservoir. How much water will be in storage after 12 hours?

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Question: *What is the Volume?*

Formula: *Volume = Flow Rate x Time*

Question 2

A 2,000 gpm pump station is filling an empty 2 MG reservoir. How much water will be in storage after 12 hours?

$$\text{Volume} = \frac{2{,}000 \text{ gal} \quad 12 \text{ hours} \quad 60 \text{ min}}{1 \text{ min} \quad 1 \quad 1 \text{ hour}}$$

$$= \textit{1,440,000 gallons}$$

Question 3

A system is serving its customers from storage from a 2 million gallon reservoir. If the reservoir held 1.8 MG when this operation began, and the average flow rate to the customers was 3.0 MGD, how many hours will the supply in the reservoir last?

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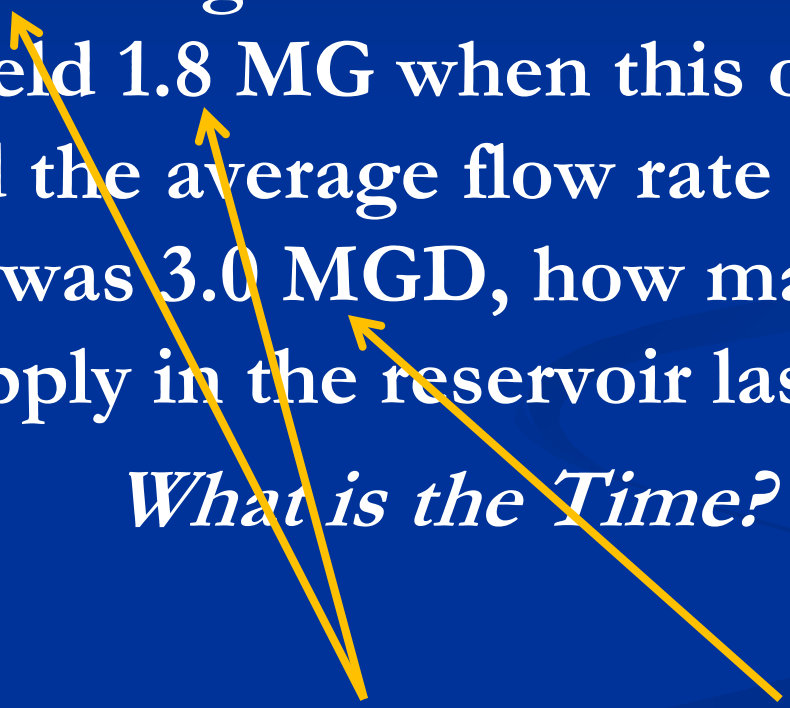
Question: *What is the Time?*



Formula: Time = Volume ÷ Flow Rate

Question 3

$$\text{Time} = \frac{\text{Volume}}{\text{Flow Rate}}$$

$$\text{Time} = \frac{1.8 \text{ Mgallons}}{3.0 \text{ Mgal/day}}$$

$$\text{Time} = 0.6 \text{ days} \quad (\text{x } 24 \text{ hours}/1 \text{ day})$$

$$\text{Time} = \textit{14.4 hours}$$

Question 4

A reservoir is 80 feet in length and 25 feet wide. If the water level drops from 22 feet to 14 feet in 8 hours, what is the flow rate leaving this reservoir, measured in gallons per minute?

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A reservoir is 80 feet in length and 25 feet wide. If the water level drops from 22 feet to 14 feet in 8 hours, what is the flow rate leaving this reservoir, measured in gallons per minute?

Question: ***What is the Flow Rate?***

???

Formula: ***Flow rate = Volume ÷ Time***

Question 4

Flow Rate = Volume ÷ Time

Volume = L x W x H

= 80 ft x 25 ft x (22-14 ft)

= 16,000 ft^3, or 119,680 gallons

$$\text{Flow Rate} = \frac{119{,}680 \text{ gal}}{(8 \text{ hours} \times 60 \text{ min/hr})}$$

Flow Rate = *249 gallons per minute*

Question 5

What will be the depth of water in a 110-foot diameter, 1.5 MG reservoir after 4 hours, if the reservoir starts full and drains at a rate of 5000 gpm?

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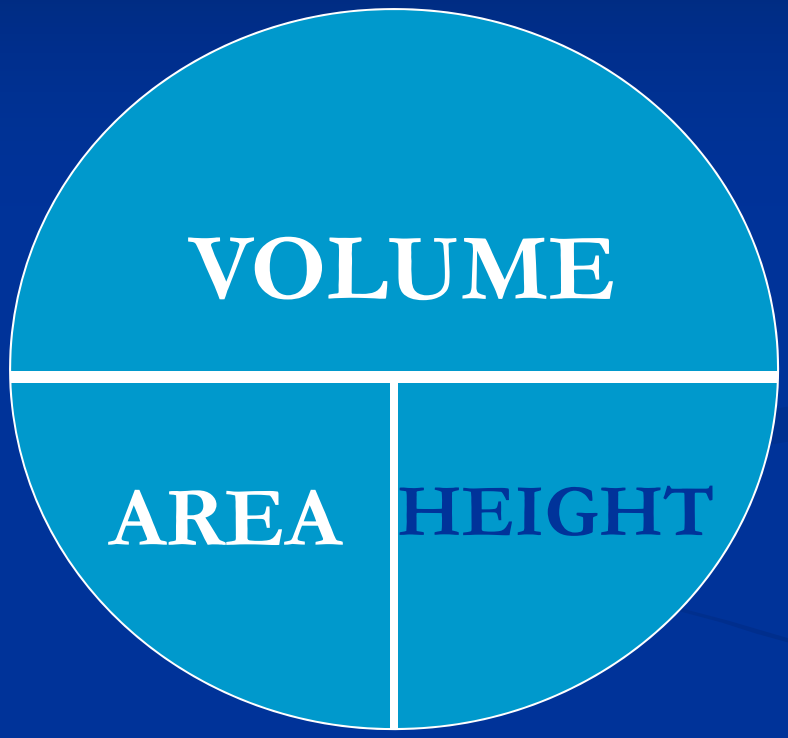
What will be the depth of water in a 110-foot diameter, 1.5 MG reservoir after 4 hours, if the reservoir starts full and drains at a rate of 5000 gpm?

Question: ***What is the Depth?***



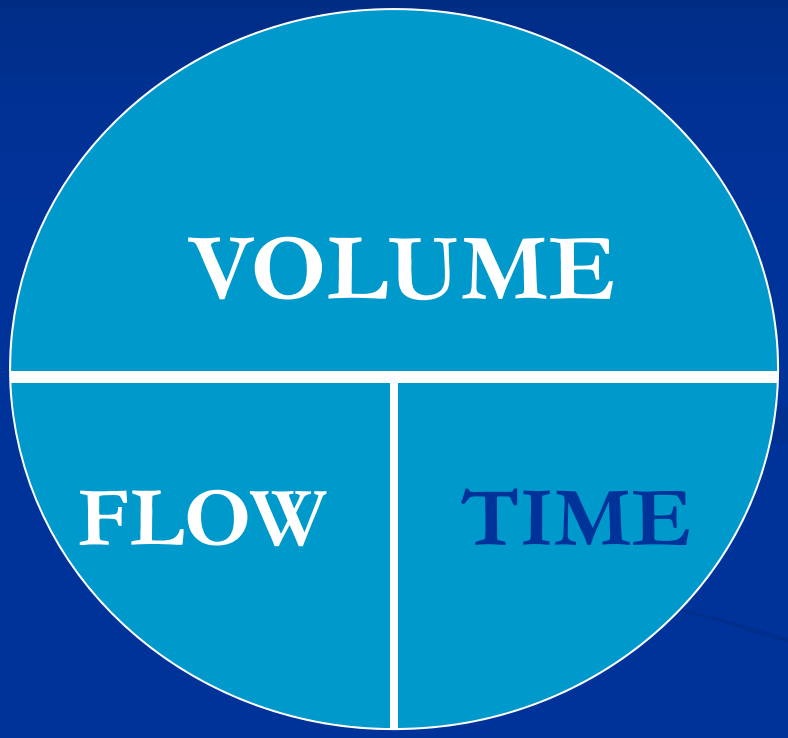
Volume Calculation Formula

Question 5

Question: *What is the Depth?*

Formula: *Depth* = *Volume* ÷ *Area*

Formula: *Volume* = *Flow Rate x Time*


VOLUME
FLOW
TIME

Question 5

$$\text{Volume} = \frac{5{,}000\ \text{gal}}{1\ \text{min}} \times \frac{4\ \text{hours}}{1} \times \frac{60\ \text{min}}{1\ \text{hour}}$$

$$= \textit{1,200,000 gallons – drained}$$

Volume left in tank after 4 hours =

1,500,000 – 1,200,000 = 300,000 gal

$$= \textit{40,107 ft}^3$$

Question 5

Why do we need the volume in cubic feet?

$$\text{Height} = \frac{\text{Volume}}{\text{Area}_{base}}$$

$$= \frac{ft^3}{ft^2}$$

$$= \frac{\cancel{ft} \times \cancel{ft} \times ft}{\cancel{ft} \times \cancel{ft}}$$

$$= \textit{feet}$$

Question 5

How deep is the water in a 110-foot diameter reservoir that holds 40,107 cubic feet?

$$\text{Height} = \frac{\text{Volume}}{\text{Area}_{base}}$$

$$= \frac{40{,}107\ ft^3}{0.785\ d^2}$$

$$= \frac{40{,}107\ ft^3}{9{,}499\ ft^2}$$

$$= \textit{4.22 feet}$$

Question 6

A system is serving its customers from storage from a 2.5 million gallon reservoir that is 80% full. The average flow rate to the customers is 3500 gpm. A pump station is refilling this tank at a rate of 3.5 cfs. How many hours will the supply in the reservoir last?

Question: *What is the Time?*

Formula: *Time = Volume ÷ Flow Rate*

Question 6

What is the volume of water in the tank when the operation begins?

80%

= 2,500,000 gallons x 0.80

= *2,000,000 gallons*

Question 6

What is the *net* flow rate into/out of the reservoir?

$$\text{Flow In} = \frac{3.5\ \text{ft}^3}{1\ \text{sec}} \times \frac{60\ \text{sec}}{1\ \text{min}} \times \frac{7.48\ \text{gal}}{1\ \text{ft}^3}$$

Flow In = 1,571 gpm

Flow Out = − 3,500 gpm

Net Flow = *1,929 gpm – out*

Question 6

$$\text{Time} = \frac{\text{Volume}}{\text{Flow Rate}}$$

$$\text{Time} = \frac{2{,}000{,}000 \text{ gallons}}{1{,}929 \text{ gallons/minute}}$$

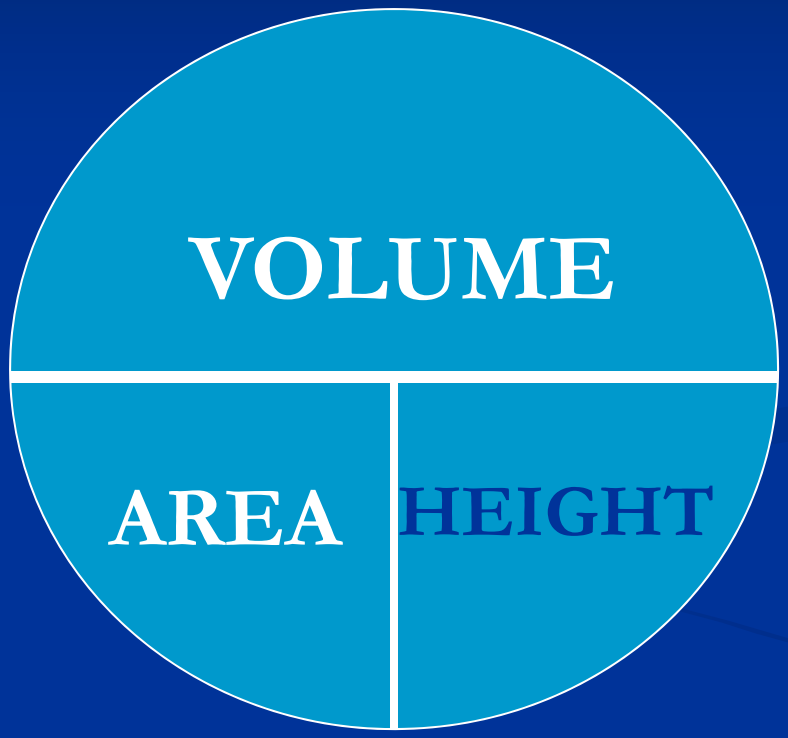
$$\text{Time} = 1{,}037 \text{ minutes} \quad (\div 60 \text{ min}/1 \text{ hr})$$

$$\text{Time} = \textit{17.3 hours}$$

Question 7

A system is serving its customers from a full, 1-million gallon reservoir, with a diameter of 90 feet. The average flow rate to the customers is 6.7 cfs. A pump station is refilling this tank at a rate of 2000 gpm. What will be the water level in this tank after 8 hours?

Question: *What is the Depth?*


VOLUME
AREA
HEIGHT

Question 7

Question: *What is the Depth?*

Formula: *Depth* = *Volume* ÷ *Area*

Formula: *Volume* = *Flow Rate x Time*

Net

Question 7

What is the *net* flow rate into/out of the reservoir?

$$\text{Flow Out} = \frac{6.7\ \text{ft}^3}{1\ \text{sec}} \times \frac{60\ \text{sec}}{1\ \text{min}} \times \frac{7.48\ \text{gal}}{1\ \text{ft}^3}$$

Flow In = 2,000 gpm

Flow Out = − 3,007 gpm

Net Flow = *1,007 gpm – out*

Question 7

$$\text{Volume} = \frac{1{,}007 \text{ gal} \quad 8 \text{ hours} \quad 60 \text{ min}}{1 \text{ min} \quad 1 \quad 1 \text{ hour}}$$

$$= \textit{483,360 gallons – drained}$$

Volume left in tank after 8 hours =

1,000,000 – 483,360 = 516,640 gal

= *69,070 ft^3*

Question 7

How deep is the water in a 90-foot diameter reservoir that holds 69,070 cubic feet?

$$\text{Height} = \frac{\text{Volume}}{\text{Area}_{\text{base}}}$$

$$= \frac{69{,}070\ \text{ft}^3}{0.785\ d^2}$$

$$= \frac{69{,}070\ \text{ft}^3}{6{,}359\ \text{ft}^2}$$

$$= \textit{10.9 feet}$$