1128-003 TEAMS, Middle School Math

"Fresh Water in Urban Areas" - Solutions

Agua Fria is a fictitious municipal water district servicing the town of Llano, Texas.

Assumptions and Givens

The formula for percentage change is $\frac{\text{new value - old value}}{\text{old value}} \times 100$.

31. The town of Llano, TX has been experiencing a drought. The nearby Llano River usually flows at a rate of 123 cubic feet per second $\left(\frac{ft^3}{s}\right)$, but during the drought its flow has been averaging 2.8 $\frac{ft^3}{s}$. What is the percentage change in the flow rate of the river during the drought?

    a. −42.9%
    b. 87.2%
    c. 42.9%
    d. −97.7%
    e. −95.1%

    Answer: d

    The new value = 2.8 $\frac{ft^3}{s}$, and the old value = 123 $\frac{ft^3}{s}$.

    Using the formula provided, $\frac{2.8 - 123}{123} \times 100 = \frac{-120.2}{123} \times 100 = -97.7\%$. The correct answer is d.

Assumptions and Givens

Cubic feet x 7.48 = 1 gallon

32. Despite the drought, the Llano River still delivers water to the town's water treatment plant. If the river is flowing at a rate of 2.8 cubic feet per second $\left(\frac{ft^3}{s}\right)$, how many gallons of water does it deliver in 1 hour?

a. 67,320.5 gallons
b. 75,398.4 gallons
c. 80,784.0 gallons
d. 86,169.6 gallons
e. 94,248.3 gallons

Answer: b
The flow rate is given in cubic feet per second, so to find the flow rate per hour we use $2.8\frac{\text{ft}^3}{\text{s}} \times \frac{60\text{ s}}{\text{min}} \times \frac{60\text{min}}{\text{h}} = 10{,}080\frac{\text{ft}^3}{\text{h}}$. Then, to find the volume of water delivered in gallons in one hour, multiply this answer by the conversion rate,
$10{,}080\frac{\text{ft}^3}{\text{h}} \times 7.48\frac{\text{gal}}{\text{ft}^3} \times 1\text{ h} = 75{,}398.4$ gallons.

33. During times of drought, an electric pump is used 24 hours a day to draw water from various wells servicing Agua Fria to provide the town of Llano with enough water for its daily needs. The pump requires 18 kW of power to run, and the electric rate in Llano is $0.14/kWh. How much does it cost Agua Fria to use the pump if the drought lasts for 30 days?

a. $1,432.60
b. $1,519.30
c. $1,592.90
d. $1,655.40
e. $1,814.40

Answer: e
First, find the number of kWh used per day: 18 kW x 24 hours = 432 kWh/day.
Then, we find the cost per day to run the pump: 432 kWh/day x $0.14/kWh = $60.48/day.
Finally, find the cost to run the pump for the entire month: $60.48/day x 30 days = $1,814.40. The correct answer is e.

34. When Agua Fria uses the electric water pump during droughts it incurs an additional cost of $36,000/year. In order for the company to break even (revenues equal costs), it must charge households extra for the use of this well water. If there are 450 households in the town of Llano, what should Agua Fria charge each household per month?

a. $6.67
b. $15.01
c. $40.02

d. $53.36
e. $80.00

Answer: a
First, find what each household should be charged for the year for Agua Fria to break even: $36,000/year ÷ 450 households = $80/household each year.
Then, we can find how much each household will be charged per month: $80/year ÷ 12 months/year = $6.67/month.

Assumptions and Givens

Volume of a cylinder = $\pi \times r^2 \times h$, *h* is the height and *r* is the radius.

35. The water that Agua Fria pumps from its wells is stored in a large concrete container in the shape of a cylinder. The radius of the container is 8 meters and it is 14 meters tall. What is the maximum volume of water that this container can hold?

a. 351.86 m^3
b. 1,105.40 m^3
c. 1,452.67 m^3
d. 2,814.87 m^3
e. 4,926.02 m^3

Answer: d
Using the given equation, with *r* = 8 m and *h* = 14 m, we find that the volume of the container is $V = \pi \times 8^2 \times 14 = \pi \times 64 \times 14 = 2{,}814.87\ m^3$. This is the maximum amount of water that the container can hold.

Assumptions and Givens

1 gallon = 3.79 liters

36. Because the water that Agua Fria draws from its wells is rather brackish (salty), a desalination system is used to remove the salt and produce fresh water. In the town of Llano, the well water has a salt concentration of 17 g/L. If the desalination system can process 5,000 gallons of water/day, how many kilograms (kg) of salt will be removed each day?

a. 85.00 kg
b. 322.15 kg
c. 850.00 kg
d. 3221.50 kg
e. 8500.50 kg

Answer: b
First, calculate the number of liters of water the desalination system processes every day: 5,000 gal/day x 3.79 L/gal = 18,950 L/day.
Then, calculate the mass of salt that will be produced each day: 18,950 L/day x 17 g/L = 322,150 g/day.
Finally, divide by 1,000 to find the number of kilograms of salt produced every day: 322,150 g/day x 1 kg/1,000 g = 322.15 kg/day.

Assumptions and Givens

1 acre = 43,560 square feet

37. During times of drought, limits are set on the amount of water that should be used for lawn and garden care every week. Residents are asked to use only 0.25 ft^3 of water for every square foot of lawn. If the average house has a lawn size of 0.55 acres, how many cubic feet of water can be used for lawn and garden care every week?

    a. 4,526.3 ft^3
    b. 5,256.6 ft^3
    c. 5,989.5 ft^3
    d. 6,289.1 ft^3
    e. 6,812.8 ft^3

    Answer: c
    First, find the size of an average lawn in square feet: 0.55 acres x 43,560 ft^2/acre = 23,958 ft^2.
    Then, find out how much water can be used on a lawn of this size: 23,958 ft^2 x 0.25 ft^3 water/ft^2 lawn = 5,989.5 ft^3 water.

Assumptions and Givens

The velocity of water moving through a pipe is $v_{water} = \text{flow rate} / \text{area}$,

v_{water} is the velocity of the water (in ft/s), flow rate is in ft^3/s, and the area of the pipe is in ft^2.

38. To avoid problems with future local droughts, Agua Fria may become part of a regional water-sharing system. This system would—when needed—bring water from neighboring areas through a pipe with a diameter of 60 in. at a flow rate of 36 ft^3/s. At what velocity will this water be delivered through the pipe?

    a. 0.46 ft/s
    b. 0.55 ft/s
    c. 1.83 ft/s

d. 2.29 ft/s
e. 2.71 ft/s

Answer: c
First, find the area of the pipe in ft.^{2}. The diameter is 60 in.and the radius of the pipe is 30 in., or 2.5 ft. The area of the pipe is (2.5 ft)^2 x π = 19.64 ft^2. Then, calculate the velocity of the water by dividing the flow rate by this area: v = 36 ft^3/s. ÷ 19.64 ft^2 = 1.83 ft./s.

39. During droughts, Agua Fria can either receive water through the regional water sharing system at a cost of $240/4,800 gallons, or pump and desalinate water from its own wells at a cost of $100/2,500 gallons. What is the difference in cost per gallon between these two methods?

a. $0.01
b. $0.02
c. $0.03
d. $0.04
e. $0.05

Answer: a
First, calculate the cost per gallon of each method:
- Water-sharing: $240/4,800 gallons = $0.05/gallon.
- Well: $100/2,500 gallons = $0.04/gallon.
Then we can see that the difference between the costs of these two methods is $0.05/gallon − $0.04/gallon = $0.01/gallon.

40. Although Agua Fria can currently choose between the regional water-sharing system and its own wells, the aquifer that supplies its wells is disappearing. The aquifer currently has a volume of 1,550,000 gallons, and Agua Fria pumps 123,000 gallons/year from its wells. At this rate, and assuming that the aquifer is not replenished, how long will it be until Agua Fria is completely dependent on the regional water-sharing system for emergencies?

a. 8.3 years
b. 9.1 years
c. 10.8 years
d. 11.6 years
e. 12.6 years

Answer: e
Calculate the number of years that the aquifer can still provide its own water: 1,550,000 gallons ÷ 123,000 gallons/year = 12.6 years.