



## Operator Certification Webinar Series

Date: March 21, 2023

Topic: Areas and Volumes Math



www.efcnetwork.org

This program is made possible under a cooperative agreement with US EPA.

## Logistics

### Opening the control panel

- Show your control panel
- All phones/microphones are muted for the duration of the webinar
- Toggle between full screen/window screen view

### Using the control panel

Audio: please choose between computer audio or phone call if you do not hear audio right now, please check your speaker volume or enter #your Audio PIN# if using phone

Click [X] to open in Control Panel

Click [Y] to open in separate box and resize

Submit questions in the Questions box at any time, and press [Send]

For questions, please take note of the slide number at the bottom right of the screen

## Certificate of Completion

This session has NOT been submitted for pre-approval of Continuing Education Credits, but eligible attendees will receive a certificate of attendance for their personal record.

### To receive a certificate:

- You must attend the entire session
- You must register and attend using your real name and unique email address - group viewing credit will not be acceptable
- You must participate in practice polls
- Certificates will be sent via email within 30 days

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## About Us

The Environmental Finance Center Network (EFCN) is a university- and non-profit-based organization creating innovative solutions to the difficult how-to-pay issues of environmental protection and environmental infrastructure.

The EFCN works collectively and as individual centers to address these issues across the entire U.S., including the 5 territories and the Navajo Nation. The EFCN aims to assist public and private sectors through training, direct professional assistance, production of durable resources, and innovative policy ideas.



## Perimeters, Areas and Volumes

Please gather a calculator, scrap paper, pen/pencil



## Units Compatibility

### Formula Sheets

- You may be given different units within the same question
- Conversions must be made before calculations are done
- Most formula sheets have conversion factors given

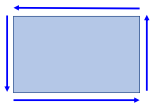
1 inch = 2.54 cm	1 foot = 12 inches	1 mile = 5,280 feet	1 mile = 1,760 yards
1 yard = 3 feet	1 meter = 1.0936 yards	1 kilometer = 0.6214 miles	1 mile = 1.6093 kilometers
1 gallon = 128 fluid ounces	1 quart = 32 fluid ounces	1 liter = 1.0567 quarts	1 quart = 0.9463 liters
1 cubic foot = 7.4805 gallons	1 cubic yard = 27 cubic feet	1 cubic meter = 1.3565 cubic yards	1 cubic yard = 1.3565 cubic meters
1 acre = 43,560 square feet	1 square mile = 277.44 acres	1 hectare = 2.4710 acres	1 acre = 0.4047 hectares
1 square foot = 144 square inches	1 square yard = 9 square feet	1 square meter = 1.1960 square yards	1 square yard = 1.1960 square meters
1 cubic inch = 1.6387 cubic centimeters	1 cubic foot = 28.3168 cubic liters	1 cubic meter = 35.2335 cubic feet	1 cubic yard = 764.5549 cubic feet
1 cubic yard = 27 cubic feet	1 cubic meter = 1.3565 cubic yards	1 cubic centimeter = 0.000001 cubic meters	1 cubic meter = 1,000,000 cubic centimeters

It helps to familiarize yourself with the formula sheet ahead of exam time

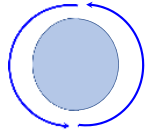


## PERIMETERS & CIRCUMFERENCES

❖ Distance around 2D objects/surfaces



**Perimeter:** Distance around a rectangle/square/triangle

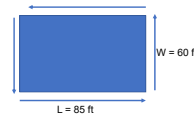


**Circumference:** Distance around a circle

## PERIMETERS... let's practice together

Q: What is the perimeter of a rectangular enclosure measuring 85ft in length and 60ft in width?

- Steps:
- Draw a sketch
  - Add given units
  - What is the question asking for?
  - Write down formula
  - Are the units compatible?



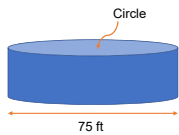
$$\text{Perimeter} = L + W + L + W$$

$$\text{Perimeter} = 85\text{ft} + 60\text{ft} + 85\text{ft} + 60\text{ft}$$

$$\text{Perimeter} = 290\text{ft}$$

## CIRCUMFERENCES... let's practice together

Q: What is the circumference of a circular clarifier that is 75 ft in diameter?



Diameter (D) = Distance across the middle of a circle

$$\text{Circumference} = \pi D$$

$$\text{Circumference} = 3.14 \times 75 \text{ ft}$$

$$\text{Circumference} = 235.5\text{ft}$$

Rounding up.....

$$\text{Circumference} = 236\text{ft}$$

## Areas



- Measure of a region's size on a surface
- Two dimensional space occupied by an object

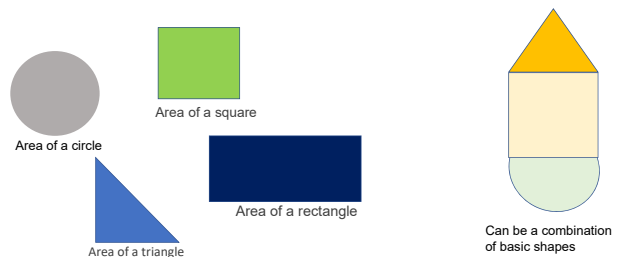
## AREA: Applications

- How much space do I need to install my new tank?
- How much paint do I need to paint my tank or clarifier? (interior or exterior surface area)
- Cross sectional area is important in the calculation of volumes (e.g. pipes)



Source: <https://www.winenv.com/solids-contact-clarifiers.html>

## Area: Space occupied by 2-dimensional shapes



Area of a circle

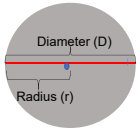
Area of a square

Area of a triangle

Area of a rectangle

Can be a combination of basic shapes

## Area of Circles: Applications



- Given Formula:  $\text{Area (circle)} = \pi r^2$  or  $\text{Area (circle)} = 0.785 \times D^2$

### Quick Tips:

- Pipe sizes are measured in terms of their diameters
- Don't confuse area with volume!



Cross Sectional area

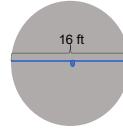
- Conveyance Pipes
- Clarifiers
- Water storage tanks



13

## Area of Circles...let's practice together

Q: How much area do we need for installing 3 circular clarifiers measuring 16 ft in diameter?



Diameter (D) = 16 ft  
Radius (r) = 8 ft

- Given Formulas:  $\text{Area (circle)} = \pi r^2$  or  $\text{Area (circle)} = 0.785D^2$

Cross Sectional Area

$$\text{Area (circle)} = \pi \times r \times r$$

$$\text{Area (circle)} = 3.14 \times 8 \text{ ft} \times 8 \text{ ft}$$

$$\text{Area (circle)} = 200.96 \text{ ft}^2 \text{ (1 clarifier)}$$

3 clarifiers

$$200.96 \text{ ft}^2 \times 3$$

$$\text{Area needed for 3 clarifiers} = 603 \text{ ft}^2$$

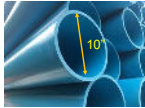


14

## Cross Sectional Area of a Pipe...Give it a try

Q: What is the cross-sectional area in square feet (ft<sup>2</sup>) of a pipe that is 10" in diameter?

- Given Formulas:  $\text{Area (circle)} = \pi r^2$  or  $\text{Area (circle)} = 0.785 \times D^2$
- Conversion Factor: 1 ft = 12 inches



### Answers

- 78.5 ft<sup>2</sup>
- 4.5 ft<sup>2</sup>
- 0.55 ft<sup>2</sup>
- 2.09 ft<sup>2</sup>

15

## Cross Sectional Area of a Pipe...Solving

Q: What is the cross-sectional area in square feet (ft<sup>2</sup>) of a pipe that is 10" in diameter?

- Given Formulas:  $\text{Area (circle)} = \pi r^2$  or  $\text{Area (circle)} = 0.785 \times D^2$       1 ft = 12 inches

$$\text{Area (circle)} = \pi r^2$$

$$\text{Diameter (D)} = 10 \text{ inches}$$

$$\text{Radius (r)} = 5 \text{ inches}$$

$$\text{Radius (ft)} = \frac{5 \text{ inches}}{12 \text{ inches}}$$

$$\text{Radius} = 0.42 \text{ ft}$$

$$\text{Area (circle)} = \pi \times r \times r$$

$$\text{Area (circle)} = 3.14 \times 0.42 \text{ ft} \times 0.42 \text{ ft}$$

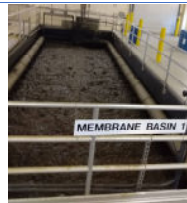
$$\text{Cross Sectional Area} = 0.55 \text{ ft}^2$$

16

## Area of Rectangles and Squares: Applications



- Given Formula:  $\text{Area} = \text{Length} \times \text{Width}$



Source: IHS.gov

- Rectangular aeration basins
- Dirt excavations

17

## Area of rectangles & squares... let's practice together

Q: What is the area of a rectangular aeration basin measuring 100 ft in length by 80 ft in width?

- Draw a sketch!
- Add in given units

- Given Formula:  $\text{Area} = \text{Length} \times \text{Width}$

Width = 80 ft

Wastewater aeration basin

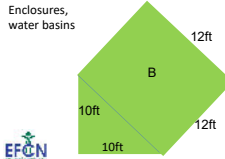
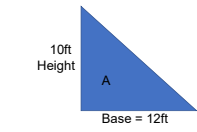
Length = 100 ft

$$\text{Area of basin} = 100 \text{ ft} \times 80 \text{ ft}$$

$$\text{Area of basin} = 8,000 \text{ ft}^2$$

18

## Area of Triangles



- Given Formulas: Area of Triangle =  $\frac{1}{2} \times \text{base} \times \text{height}$   
Area of a Rectangle/Square =  $L \times W$

### Shape A (Triangle)

$$\text{Area}_{(\text{Shape A})} = \frac{1}{2} \times \text{Base} \times \text{Height}$$

$$\text{Area}_{(\text{Shape A})} = \frac{1}{2} \times 12 \text{ ft} \times 10 \text{ ft}$$

$$\text{Area}_{(\text{Shape A})} = 60 \text{ ft}^2$$

### Shape B (mixed shapes)

$$\text{Area}_{(\text{Shape B})} = (\text{area of square}) + (\text{area of triangle})$$

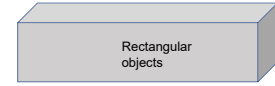
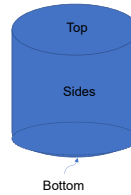
$$\text{Area}_{(\text{Shape B})} = (12 \text{ ft} \times 12 \text{ ft}) + (\frac{1}{2} \times 10 \text{ ft} \times 10 \text{ ft})$$

$$\text{Area}_{(\text{Shape B})} = (144 \text{ ft}^2) + (50 \text{ ft}^2)$$

$$\text{Area}_{(\text{Shape B})} = 194 \text{ ft}^2$$

## Surface Area (3-D Objects)

### Cylindrical objects



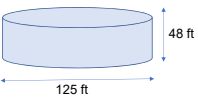
Rectangular/Square objects:  
6 Sides



Square objects  
(cube)

## a) Surface Area.. let's practice together

What is the surface area (S.A) of a cylindrical tank (top, bottom, and walls), with a diameter of 125ft and a height of 48 ft?



Given formula:

$$S.A = (2\pi rh) + (2\pi r^2)$$

Sides    Top and bottom

$$S.A = (2 \times 3.14 \times 62.5 \text{ ft} \times 48 \text{ ft}) + (2 \times 3.14 \times 62.5 \text{ ft} \times 62.5 \text{ ft})$$

$$S.A = 18,840 \text{ ft}^2 + 24,531.25 \text{ ft}^2$$

$$S.A = 43,371 \text{ ft}^2$$

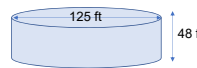
Note: If painting the tank, exclude the area of the base/top of cylinder

( ~~$\pi r^2$~~ )

Diameter (D) = 125ft  
Radius (r) = 62.5ft

## b) Surface Area.. No formula?

What is the surface area of a cylindrical tank (bottom, top, and walls), with a diameter of 125ft and a height of 48 ft?

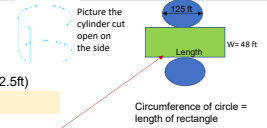


Given formulas:

Area of a rectangle =  $L \times W$

Area of a circle =  $\pi r^2$

Circumference circle =  $\pi D$



$$A_{(\text{top \& bottom circles})} = 2 (3.14 \times 62.5 \text{ ft} \times 62.5 \text{ ft})$$

$$A_{(\text{top \& bottom circles})} = 24,531 \text{ ft}^2$$

$$C_{\text{circle}} = \pi D$$

$$C_{\text{circle}} = 3.14 \times 125 \text{ ft}$$

$$C_{\text{circle}} = 393 \text{ ft} = (\text{also equal to the length of the rectangle})$$

$$A_{\text{rectangle}} = L \times W = 393 \text{ ft} \times 48 \text{ ft}$$

$$A_{\text{rectangle}} = 18,864 \text{ ft}^2$$

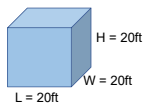
$$\text{Adding up area of top + bottom + sides... } 24,531 \text{ ft}^2 + 18,864 \text{ ft}^2 = A = 43,395 \text{ ft}^2$$

## Surface area – Cubes..Give it a try



Q: Find the surface area of a cube if the sides measure 20 ft?

$$\text{Surface Area}_{\text{sides}} = (L \times W) \times 6$$



Answers:

- 1,600 ft<sup>2</sup>
- 2,400 ft<sup>2</sup>
- 400 ft<sup>2</sup>
- 800 ft<sup>2</sup>

## Surface area – Cubes..Solving

Q: Find the surface area of a cube if the sides measure 20 ft?

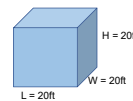
S.A Cubes

$$\text{Surface Area}_{\text{sides}} = (L \times W) \times 6$$

$$\text{Surface Area}_{\text{sides}} = (L \times W) \times 6$$

$$\text{Surface Area}_{\text{sides}} = (20 \text{ ft} \times 20 \text{ ft}) \times 6$$

$$\text{Surface Area}_{\text{all sides}} = 2,400 \text{ ft}^2$$



Note: Exclude top or bottom in different situations e.g. painting

## Surface area – Rectangles

Q: Find the surface area of a rectangular box below?



Not all sides are equal!

$$\text{Surface Area}_{\text{all sides}} = 4(L \times W) + 2(L \times H)$$

$$\text{Surface Area}_{\text{all sides}} = 4(50\text{ft} \times 10\text{ft}) + 2(10\text{ft} \times 10\text{ft})$$

$$\text{Surface Area}_{\text{all sides}} = 2000 \text{ ft}^2 + 200 \text{ ft}^2$$

$$\text{Surface Area} = 2,200 \text{ ft}^2$$

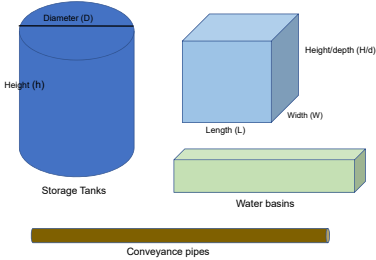
Note: Exclude top or bottom in different real life situations e.g. painting

## Volumes



## Volumes: Applications

- Water takes on the shape of the object it is contained in



Clarifiers



Excavations

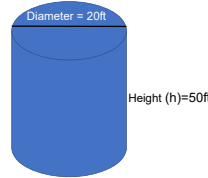
## Volumes of Cylinders

Picture a cylinder as a stack of circles



$$\text{Area}_{\text{circle}} = \pi r^2$$

$$\text{Vol}_{\text{cylinder}} = \pi r^2 \times h \times \# \text{ of circles}$$



Q: Find the volume in ft<sup>3</sup> and in gals of a tank measuring 20 ft diameter and 50 ft height

$$\text{Vol}_{\text{cylinder}} = \pi r^2 \times h$$

$$\text{Vol}_{\text{cylinder}} = 3.14 \times 10\text{ft} \times 10\text{ft} \times 50\text{ft}$$

$$\text{a) Vol}_{\text{cylinder}} = 15,700 \text{ ft}^3$$

Conversion Factor  
7.48 gals = 1 ft<sup>3</sup>

$$\text{Vol}_{\text{cylinder}} = 15,700 \text{ ft}^3 \times 7.48 \text{ gal/ft}^3$$

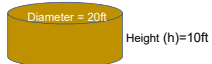
$$\text{b) Volume} = 117,436 \text{ gallons}$$

## Volumes of Cylinders . . Give it a try...



$$\text{Vol}_{\text{cylinder}} = \pi r^2 \times h$$

Q: Find the volume of a cylindrical clarifier in gallons. The tank has a height of 10ft and a diameter of 20ft



Answers:

- 3,140 gallons
- 10,500 gallons
- 15,000 gallons
- 23,500 gallons

## Volumes of Cylinders . . Solving

$$\text{Vol}_{\text{cylinder}} = \pi r^2 \times h$$

Q: Find the volume of a cylindrical clarifier in gallons. The tank has a height of 10ft and a diameter of 20 ft

$$\text{Vol}_{\text{cylinder}} = \pi r^2 \times h$$

$$\text{Vol}_{\text{cylinder}} = 3.14 \times 10\text{ft} \times 10\text{ft} \times 10\text{ft}$$

$$\text{Vol}_{\text{cylinder}} = 3,140 \text{ ft}^3$$

Converting to gallons....

$$1 \text{ ft}^3 = 7.48 \text{ gals}$$

$$3,140 \text{ ft}^3 = ?$$

$$= \frac{7.48 \text{ gal} \times 3,140 \text{ ft}^3}{1 \text{ ft}^3}$$

$$= 23,487.2 \text{ gals}$$

$$23,500 \text{ gals}$$



## Volumes of pipes . . Let's practice together

Q: Your main 2ft sewer line collection system runs for 5 miles to the wastewater treatment plant. How many gallons of wastewater are in the pipe during peak usage periods?

Given Formula:  $Vol_{cylinder} = \pi r^2 \times h$   
 Conversion Factor: 1 mile = 5,280 ft

2ft = diameter  
 1ft = radius (r)      5 miles = 26,400 ft

$$Vol_{pipe} = \pi r^2 \times h$$

$$Vol_{pipe} = 3.14 \times 1ft \times 1ft \times 26,400ft$$

$$Vol_{pipe} = 82,896ft^3$$

(Full vol. in the pipe)



$$Peak Vol_{pipe} = 82,896ft^3 / 2 = 41,448 ft^3$$

Converting to gallons...

$$7.48 gal \times 41,448 ft^3$$

$$1 ft^3$$

310,031gals

310,000gals

31

## Volumes of Excavations: collection systems, buried septic tanks etc.

Q: You need to dig a 4 ft deep by 3 ft wide trench for a collection piping system. The pipe will run for 2 miles to the lagoon system. How much fill dirt in yd<sup>3</sup> (cubic yards) should you order to replace the native excavated dirt?

Vol. Rectangular Shapes:

Length (L) x Width (W) x Height (H)/Depth (D)

1 mile = 5,280 ft

2 miles = 10,560 ft



$$Vol = L \times W \times D$$

$$Vol = 10,560ft \times 3ft \times 4ft$$

$$Vol = 126,720 ft^3$$

Converting to cubic yards.....

$$27 ft^3 = 1 yd^3$$

$$126,720 ft^3 = ?$$

$$= \frac{126,720 ft^3 \times 1 yd^3}{27 ft^3}$$

$$= 4,693 yd^3$$

4,693 yd<sup>3</sup>

4,700 yd<sup>3</sup>

32



## CONTACT INFORMATION



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