Sanitation Systems

CONTEXT

The need for sanitation systems was recognized by the first civilizations of India, Babylon, Egypt, Crete, and Greece—going back as far as 1500 to 2500 BC. The cities of the ancient Greeks and Romans suffered from refuse and sewage problems worse than many large cities. Even with new sanitation and waste disposal technologies at hand, lasting solutions are difficult to achieve due to population growth.

The modern era of waste management in the United States is only a little more than a hundred years old. It is within this relatively short period that modern waste treatment systems have been developed and widely implemented. These developments have made possible the control of many diseases and the improvement of health for the great majority of the population.

The wastewater treatment systems in every city are major engineering accomplishments. Although most people never give it much thought, the sewer systems under their streets required careful design, layout, and construction. This system of piping allows for an efficient and safe means of transporting waste and dirty water from anywhere in a city, to a centralized treatment plant where it can be broken down and disposed of properly. A close look at your local sewer system will provide an excellent example of the contribution of Civil Engineering to the health and well being of a society.

CHALLENGE

EXPLORATORY

Arrange an interview with a Civil Engineer or City Manager to discuss some of the waste treatment problems in your region. If your teacher arranges a classroom visit by one of the above people, attend their presentation and participate in the discussion that follows. Ask questions about the history of your local sewage system and plans for future advancements.

INTERMEDIATE

Ask your teacher for the page that provides the "Sewer Layout Diagram." Pretend you are working for a construction company and you are looking at the engineering drawings for a proposed new sewage line. Your job is to make a drawing of each manhole so that construction of the sewer lines can begin. You must determine the angle at which each pipe enters the manhole, and the height of each manhole. This will require accurate measurements, to determine what is needed for each manhole, and the preparation of a "Take Off Sheet" for each of the manholes. If you follow the simple directions, provided in the "To Do" section, you will successfully complete this project and be rewarded with a promotion. Good Luck!

ADVANCED

Now that you have completed the Intermediate section of this project you can begin constructing this sewer system. Using your calculations and the material provided (clay. straws, tape, and paper towel rolls) begin the construction of each manhole. Inlet and outlet angles are very important in constructing the base. Follow your calculations carefully so the sewer system will make sewage coming into the system flow effectively to the treatment plant.

After completing this part of your model, use brown cardboard or stiff paper to show what the shape of the ground might be from one manhole cover to the next. You should make the slope of the ground between the manhole covers as gradual as possible. What additional information do you need to make this model more realistic?

MATERIALS

Exploratory (none)

Intermediate (none)

Advanced

- Modeling Clay
- Straws
- Masking Tape
- Paper Towel Rolls
- Scissors
- X-acto Knife

CRITERIA

Your success on this Challenge will be based on your completion of the activities below. Three general criteria for your performance will be: **participation** in the activity; the **accuracy** of your measurement and model construction; and the **performance** of your design. Your teacher will advise you on the grading of your performance.

EXPLORATORY

Conduct an interview with an engineer or city manager, and/or participate in Speakers presentation. Develop questions for the speaker. Participate in the field trip, if provided by your teacher.

INTERMEDIATE

Analyze the forms and drawings provided by your teacher and complete all worksheets. Determine all the distances and dimensions from the Sewer Layout Diagram and record them as directed. Calculate the dimensions and depth of each manhole based on the established slope of the sewer line. Determine the angles of the pipes entering and leaving the manholes and record them on a Take Off Sheet for each manhole.

ADVANCED

Follow the design and build a model sewer line. It should be sloped in accordance with the sewer diagram so sewage consistently flows in the proper direction. Under the supervision of your teacher, test your sewer line system by running a small amount of water through the lines. Make a presentation on your work and your sewer line.

INTEGRATED SCIENCE MATH AND TECHNOLOGY ACTIVITIES

There are numerous math competencies incorporated into these activities. The activities provide a number of opportunities to cover basic measurements, scale, and angles and the use of rulers and protractors, Model construction normally requires a great deal of measuring and attention to ratios and proportion. The use of standard measurements, as opposed to the metric system, provides a practical opportunity to calculate and use fractions. You may decide to also use metric measurements to provide opportunities to calculate and apply decimals.

You will find it easier to assess the work of your students if you have them develop a design portfolio. Students can use a portfolio to capture the design and problem solving process that they used and to record the completion of the required criteria. This documentation can provide a clearer view of the competencies acquired by the students.

PROBLEM SOLVING PROCESS

These steps may be helpful to students in approaching their activity.

- Form cooperative groups - three to four students per group
- Select a team leader
- Assemble necessary materials
- Construct the sewer line
- Present the work

Intermediate Challenge/Activities

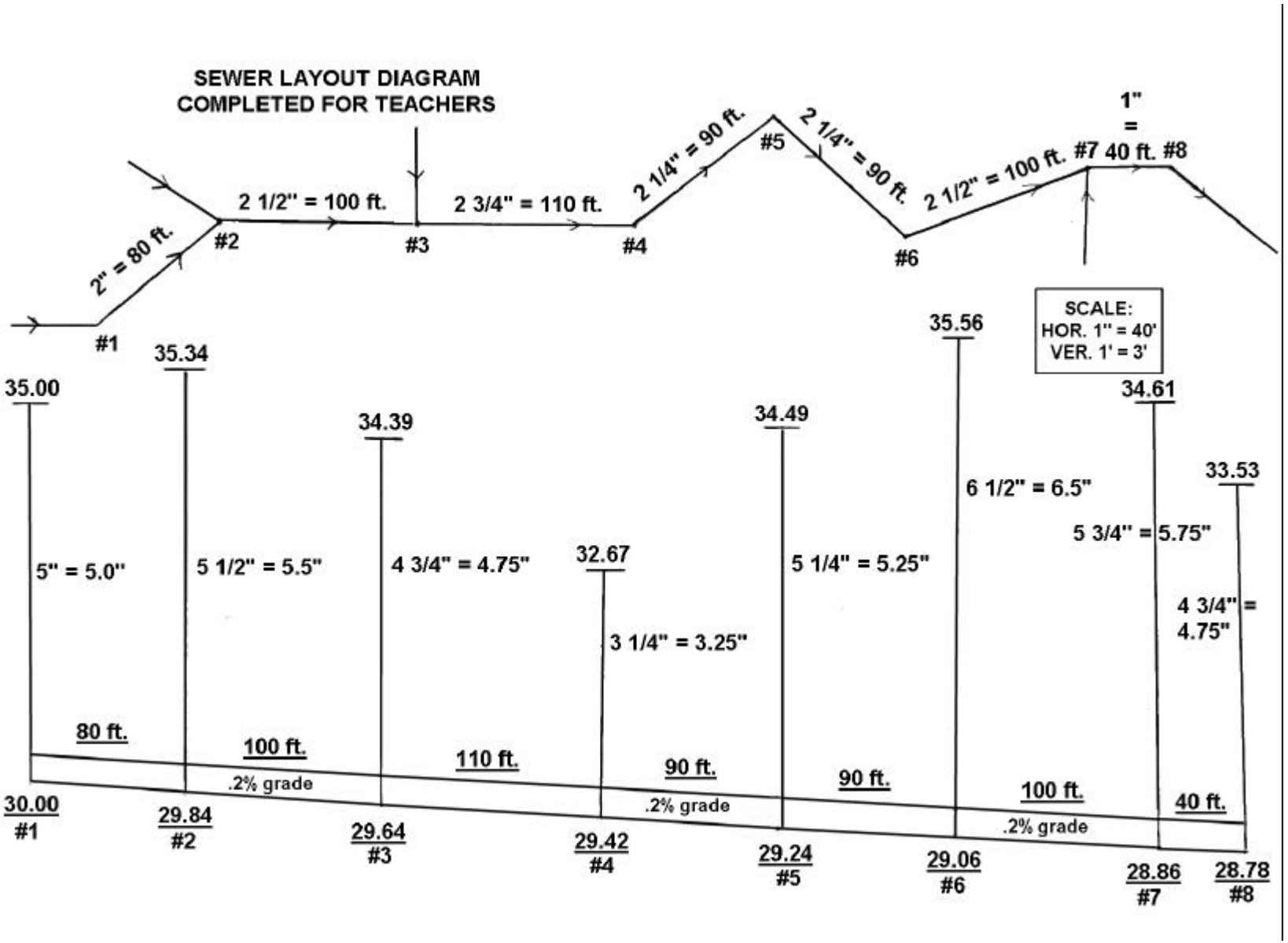
1. Secure from your teacher the Sewer Layout Diagram for the problem. Note that there are no dimensions provided. With your ruler determine the distance between each manhole. Measurements should be rounded to the nearest quarter inch (1/4, 1/2, 3/4, or whole inch) Using the Horizontal scale of 1" = 40', convert each measurement to feet and mark the distance on the drawing. (For example, refer to the distance between manholes #1 and #2. This distance is 2" which is equal to 80'.)
2 Determine how far below the ground the sewer line is at each manhole. To start you need to know the depth of the sewer line at manhole #1. That information is provided as 30 feet (30'). You can now determine the depth of each manhole and the bottom measurement for each. To do this, you will need to allow for the downhill slope of the sewer line. (In this case you will use a slope of 2%.) You can then use the formula that indicates the slope will equal the amount of rise (or fall) divided by the horizontal distance. Written in symbols the formula is: S = R/HD, where slope equals S, rise equals R, and the horizontal distance equals HD) As indicated, in this case, we will use a slope of 2% or .02. (For example refer to the distance between manhole #1 and #2, which is 80'. A 2% slope for 80' equals .16'.) Substitute the numbers you have for the symbols in the formula (S = 2% or .02, and HD = 80') and calculate the rise/fall. Do you agree that the rise/fall is .16 of a foot?
3. With your ruler, measure the height of each manhole to the nearest quarter inch and mark this on the drawing. Convert this measurement to a decimal. Now add this number to the bottom measurement. This new number represents your top measurement. Place the top measurement on top of each manhole.
4. Refer to the information sheets provided in the Appendix, and secure a copy of the "take off" sheet. If this sheet is not available, see your teacher for a copy. Use your protractor and measure where the inlet and outlet holes should be. Mark the degree measurement between all holes and indicate which holes are inlets and outlets. (Pay particular attention to the arrows on the lines of the planning drawings.)
5. Transfer the information that you know about each manhole (manhole #, top, bottom and height) to the take off sheets. This completes step 1. Follow the next few steps on the take off sheet and the manholes are now ready for the construction of the sewer line model.

PROPOSED CURRICULUM / STANDARDS CONNECTIONS

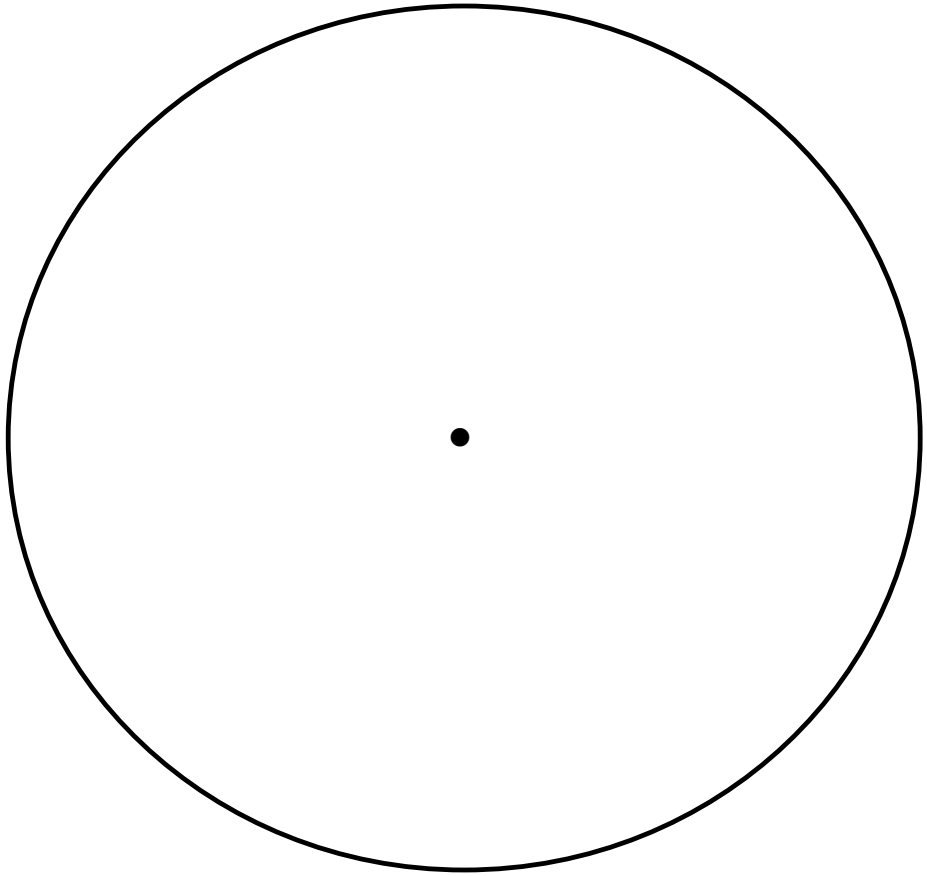
The following Curriculum/Standards Connections for grades 5-8 have been included to aid in the use and assessment of the design challenge projects. NOTE: These connections have been extracted from the National Standards. You will need to check their correlation with your own State Curriculum Standards to ensure consistency with your curriculum goals.

Note on Assessment: We strongly recommend using the Student Reflection Sheet and the Rubric provided in the Appendix to enhance the learning process, by encouraging student awareness and participation in the assessment of their work. These tools can help students to understand the context, meaning, and value of undertaking these challenges.

Science Content Standards	Standards for School Mathematics	Standards for Design and Technology
Science as Inquiry • inquiry into the diseases related to poor treatment and handling of sewage **Physical Science** Properties and changes of properties in matter Motion and Forces **Life Science** Populations and ecosystems • problems related to healthy living for large cities **Earth and Space Science** (no connections made) **Science and Technology** • design of a sewer system **Science in Personal and Social Perspectives** Personal health Populations, resources, and environments **History and Nature of Science** Science as human endeavor • history of diseases related to poor waste and sewage treatment and the work in science to combat them	**Mathematics as problem solving** **Mathematics as communication** **Mathematics as reasoning** **Mathematical connections** • applying math to real problems in science and technology **Number and number relationships** **Number systems and number theory** **Computation and estimation** **Patterns and functions** **Algebra** • solving for problems related to slope and manhole depths **Statistics** **Probability** **Geometry** • determining angles and representing them on drawings **Measurement** • determining distances and directions of sewer lines and dimensions of manholes	**Design** • improvement of sewer system designs **Develop and produce products and systems** • develop working models of sewer line systems (water, gravity, flow, slope) **Use and manage technology** • research and inquiry via the internet and other sources • use of tools and machines in the building of model sewer line systems **Assess the impacts and consequences of technology** • assess the results of improved waste and sewage treatment on society and culture **Nature and history of technology** • history of the technology of waste treatment systems • evolution of materials and processes of waste treatment **Connections** • integration of science, math and technology in the design and development of waste treatment systems


SEWER LAYOUT DIAGRAM
COMPLETED FOR TEACHERS
2" = 80 ft.
2 1/2" = 100 ft.
2 3/4" = 110 ft.
2 1/4" = 90 ft.
2 1/4" = 90 ft.
2 1/2" = 100 ft.
1" = 40 ft.
#1
#2
#3
#4
#5
#6
#7
#8
SCALE:
HOR. 1" = 40'
VER. 1' = 3'
35.00
35.34
34.39
32.67
34.49
35.56
34.61
33.53
5" = 5.0"
5 1/2" = 5.5"
4 3/4" = 4.75"
3 1/4" = 3.25"
5 1/4" = 5.25"
6 1/2" = 6.5"
5 3/4" = 5.75"
4 3/4" = 4.75"
80 ft.
100 ft.
110 ft.
90 ft.
90 ft.
100 ft.
40 ft.
.2% grade
.2% grade
.2% grade
30.00
#1
29.84
#2
29.64
#3
29.42
#4
29.24
#5
29.06
#6
28.86
#7
28.78
#8

TAKE OFF SHEET



Manhole #_____

Step 1: Top
Bottom _____
Height inches

Step 2: Convert the inches to feet using the vertical scale on the drawing. Show all work!!

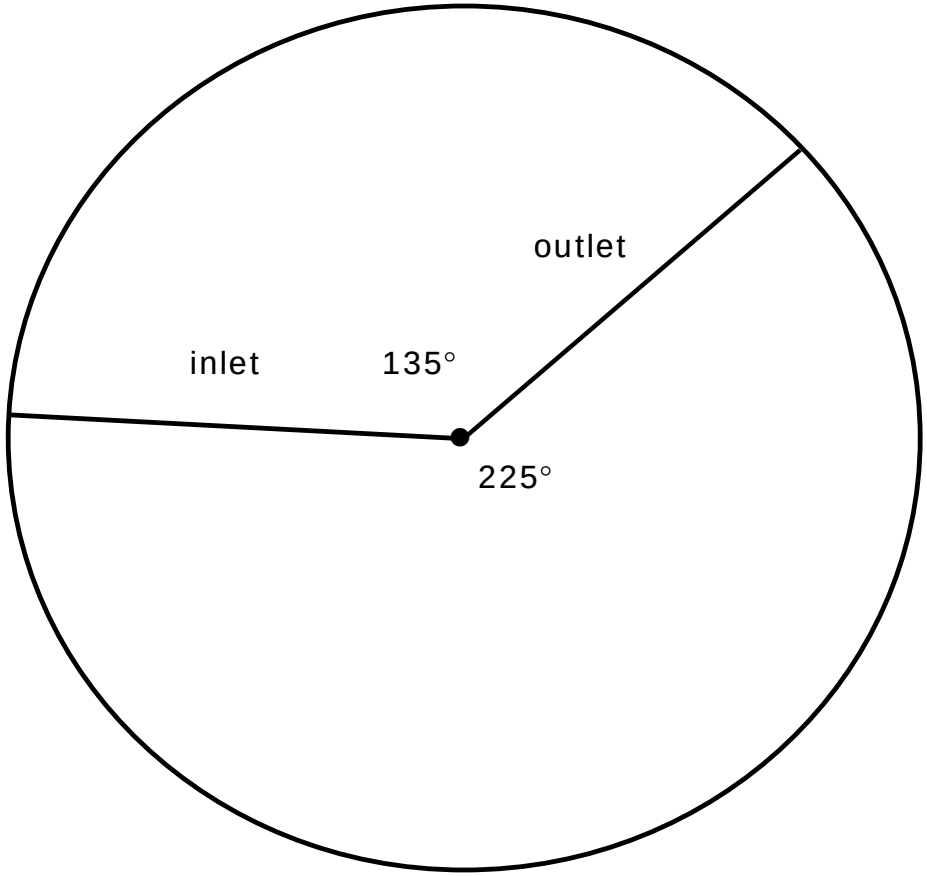
Step 3: Convert this number to feet and inches:
_____ ft, _____ in.

Step 4: Using a 32" cone, choose one base section and as many risers as needed to get within 8 inches of the top without going over.

32" cone	✓
16" riser	
36" riser	
48" riser	
36" base	
48" base	

Production Height:

TAKE OFF SHEET



Manhole #__1_____

Step 1:
Top 35.00
Bottom ___30.00__
Height 5.99 inches

Step 2: Convert the inches to feet using the vertical scale on the drawing. Show all work!!

1" = 3' 3x5 = 15

5" = x x = 15'

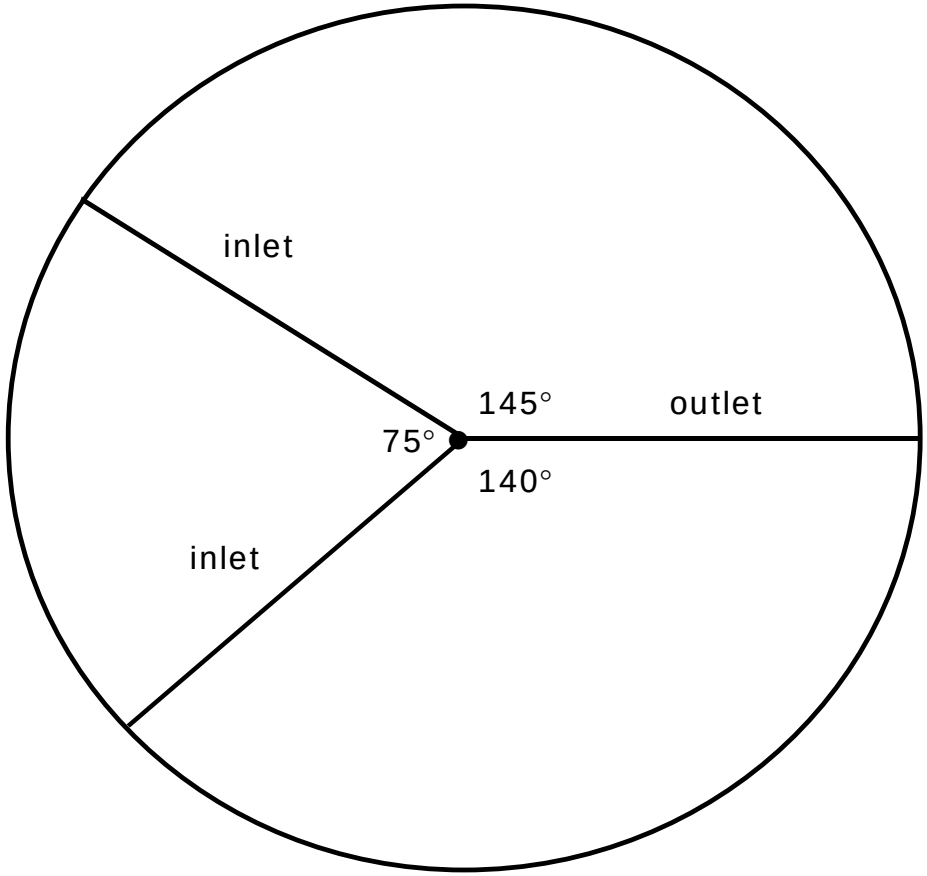
Step 3: Convert this number to feet and inches:
__15_____ ft, ___0____ in.

Step 4: Using a 32" cone, choose one base section and as many risers as needed to get within 8 inches of the top without going over.

32" cone	✓
16" riser	
36" riser	
48" riser	✓✓
36" base	
48" base	✓

Production Height: 14' 8"

TAKE OFF SHEET



Manhole #__2_____

Step 1:
Top 35.34
Bottom ___29.84__
Height 5.50 inches

Step 2: Convert the inches to feet using the vertical scale on the drawing. Show all work!!

1" = 3' 5.5 x 3 = 16.5

5.5" = x

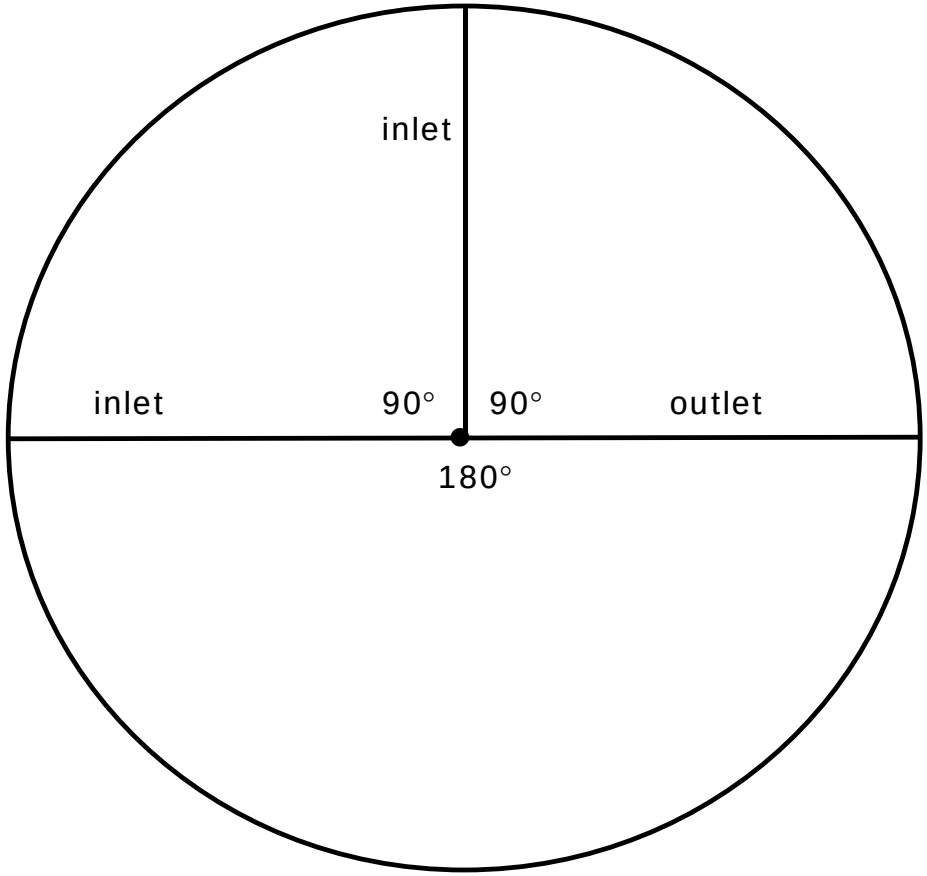
Step 3: Convert this number to feet and inches:
__16_____ ft, ___6____ in.

Step 4: Using a 32" cone, choose one base section and as many risers as needed to get within 8 inches of the top without going over.

32" cone	✓
16" riser	✓
36" riser	
48" riser	✓✓
36" base	
48" base	✓

Production Height: 16' 0"

TAKE OFF SHEET



Manhole #__3_____

Step 1:
Top 34.39
Bottom ___29.64__
Height 4.75 inches

Step 2: Convert the inches to feet using the vertical scale on the drawing. Show all work!!

1" = 3' 4.75 x 3 = 14.25

4.75" = x

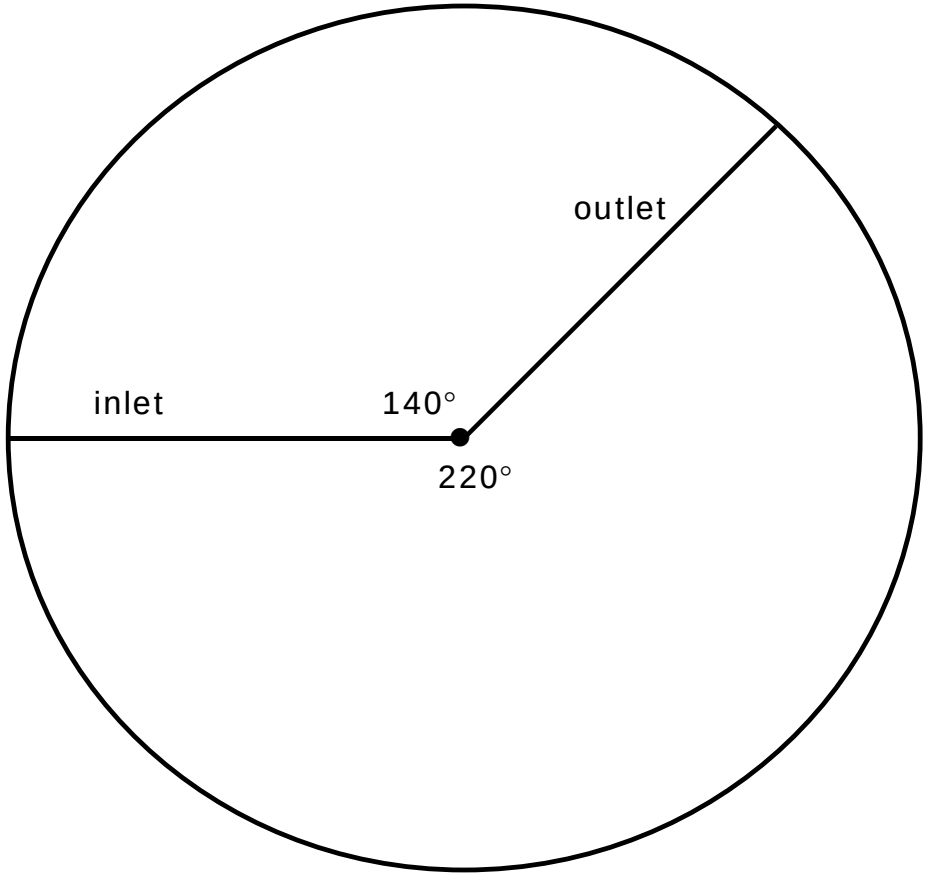
Step 3: Convert this number to feet and inches:
__14_____ ft, ___3____ in.

Step 4: Using a 32" cone, choose one base section and as many risers as needed to get within 8 inches of the top without going over.

32" cone	✓
16" riser	
36" riser	
48" riser	✓✓
36" base	
48" base	✓

Production Height: 13' 8"

TAKE OFF SHEET



Manhole #__4_____

Step 1: Top 32.67
Bottom ___29.42__
Height 3.25 inches

Step 2: Convert the inches to feet using the vertical scale on the drawing. Show all work!!

1" = 3' 3.25 x 3 = 9.75

3.25" = x

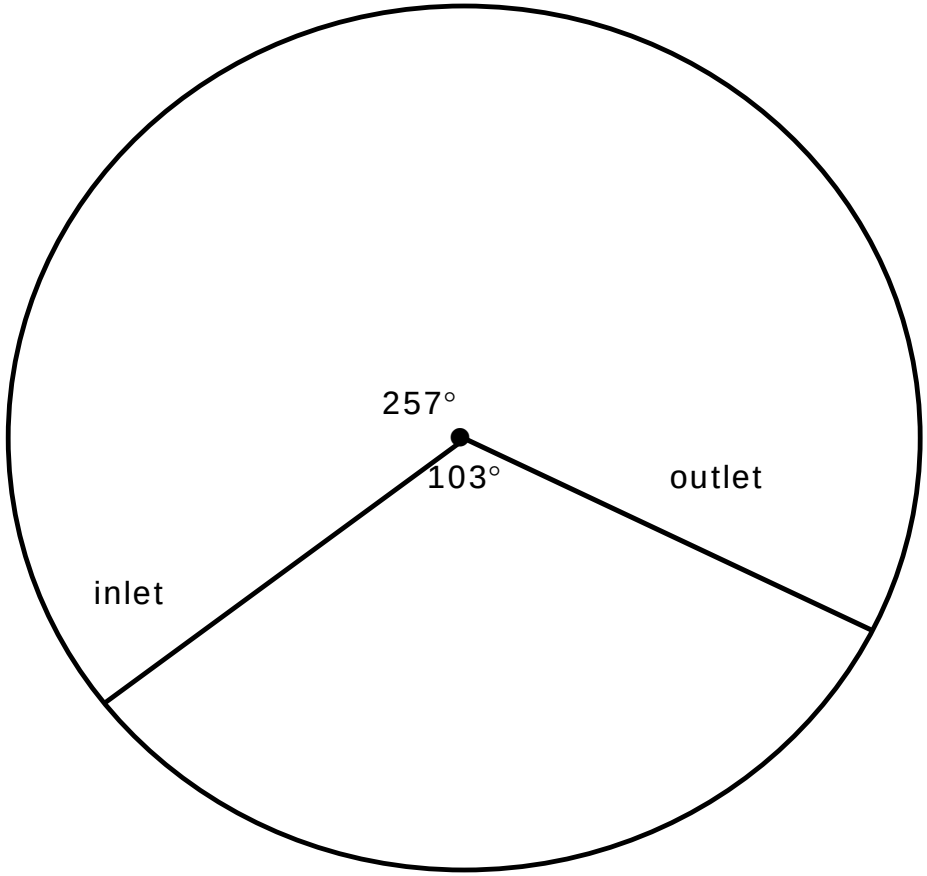
Step 3: Convert this number to feet and inches:
__9_____ ft, ___9____ in.

Step 4: Using a 32" cone, choose one base section and as many risers as needed to get within 8 inches of the top without going over.

32" cone	✓
16" riser	
36" riser	
48" riser	✓
36" base	✓
48" base	

Production Height: 9' 8"

TAKE OFF SHEET



Manhole #__5_____

Step 1:
Top 34.49
Bottom ___29.24__
Height 5.25 inches

Step 2: Convert the inches to feet using the vertical scale on the drawing. Show all work!!

1" = 3' 5.25 x 3 = 15.75

5.25" = x

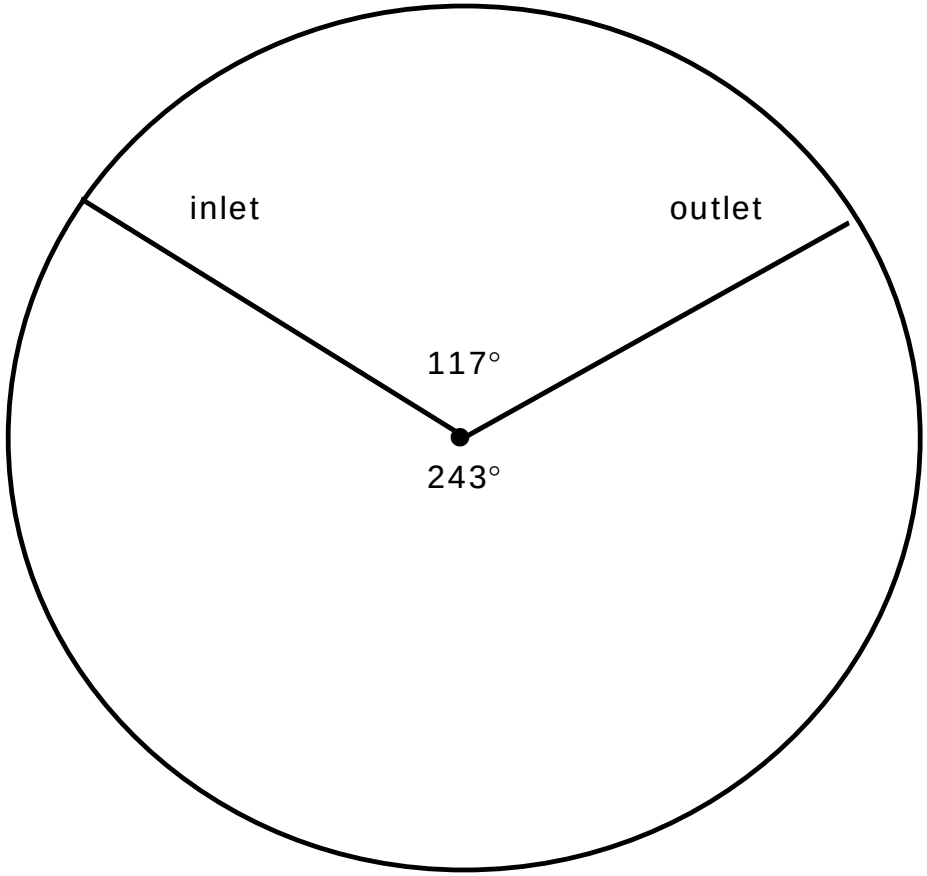
Step 3: Convert this number to feet and inches:
__15_____ ft, ___9____ in.

Step 4: Using a 32" cone, choose one base section and as many risers as needed to get within 8 inches of the top without going over.

32" cone	✓
16" riser	✓✓
36" riser	✓✓
48" riser	
36" base	
48" base	✓

Production Height: 15' 4"

TAKE OFF SHEET



Manhole #__6_____

Step 1: Top 35.56
Bottom ___29.06__
Height 6.50 inches

Step 2: Convert the inches to feet using the vertical scale on the drawing. Show all work!!

1" = 3' 6.5 x 3 = 19.5

6.5" = x

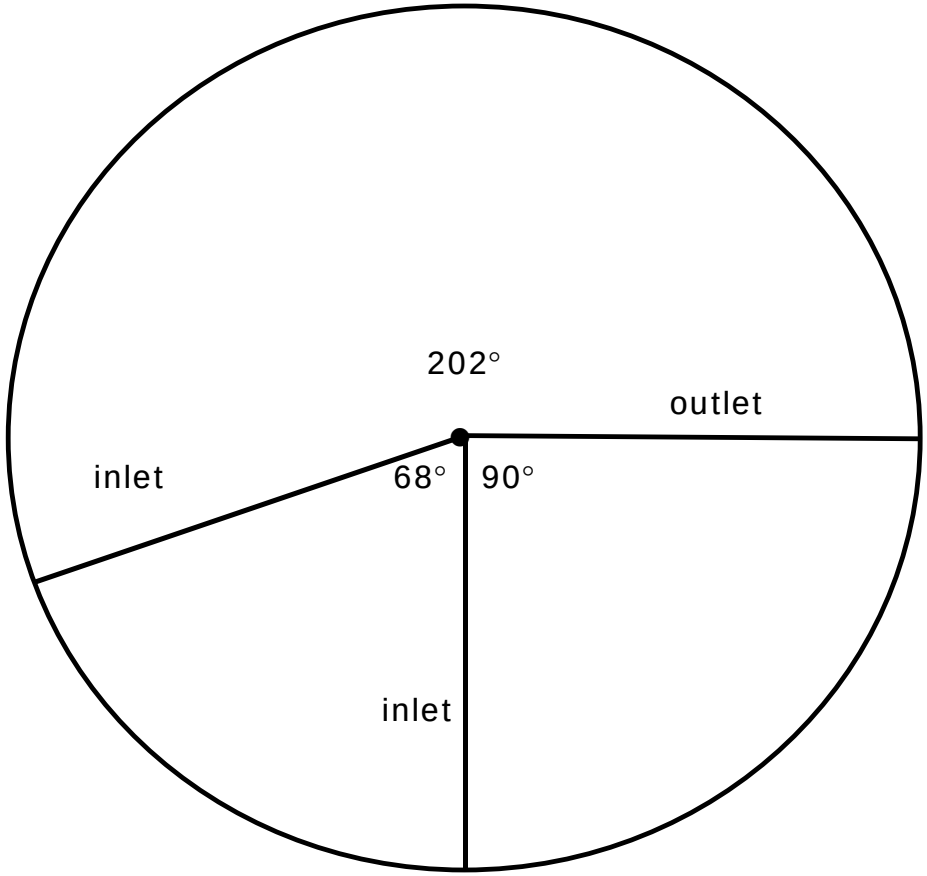
Step 3: Convert this number to feet and inches:
__19_____ ft, ___6____ in.

Step 4: Using a 32" cone, choose one base section and as many risers as needed to get within 8 inches of the top without going over.

32" cone	✓
16" riser	✓
36" riser	
48" riser	✓✓✓
36" base	✓
48" base	

Production Height: 19' 0"

TAKE OFF SHEET



Manhole #__7_____

Step 1: Top 34.61
Bottom ___28.86__
Height 5.75 inches

Step 2: Convert the inches to feet using the vertical scale on the drawing. Show all work!!

1" = 3' 5.75 x 3 = 17.25

5.75" = x

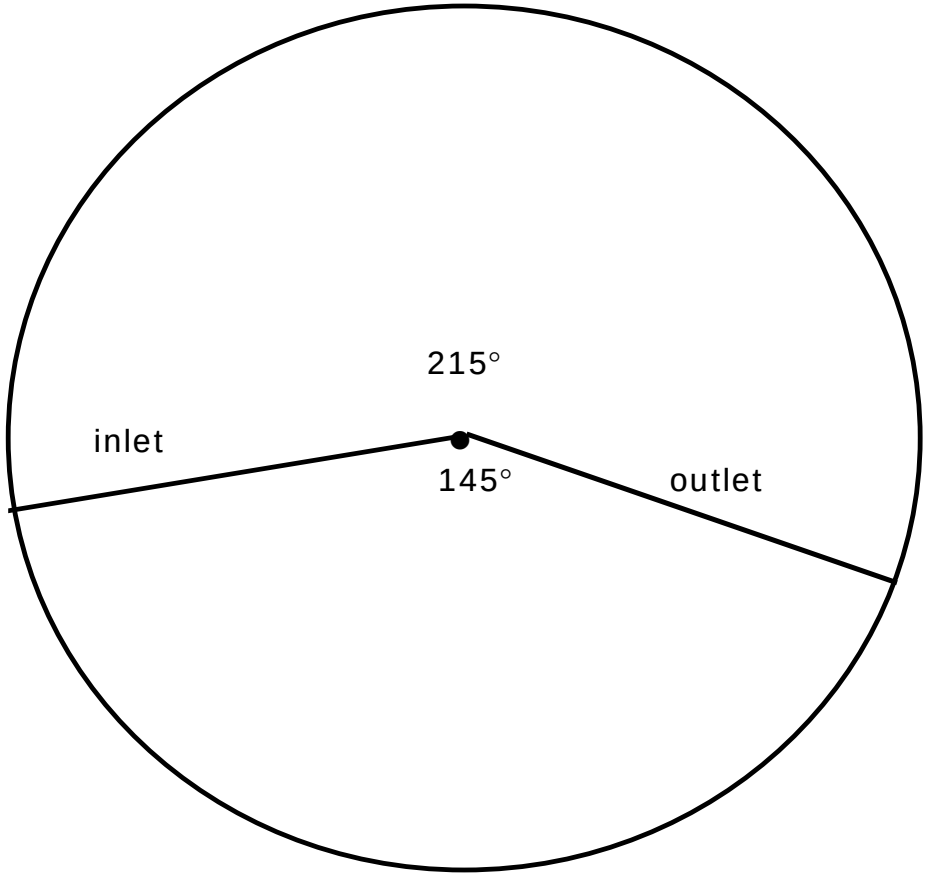
Step 3: Convert this number to feet and inches:
__17_____ ft, ___3____ in.

Step 4: Using a 32" cone, choose one base section and as many risers as needed to get within 8 inches of the top without going over.

32" cone	✓
16" riser	
36" riser	✓
48" riser	✓✓
36" base	✓
48" base	

Production Height: 16' 8"

TAKE OFF SHEET



Manhole #__8_____

Step 1: Top 33.47
Bottom ___28.72__
Height 4.75 inches

Step 2: Convert the inches to feet using the vertical scale on the drawing. Show all work!!

1" = 3' 4.75 x 3 = 14.25

4.75" = x

Step 3: Convert this number to feet and inches:
__14_____ ft, ___3____ in.

Step 4: Using a 32" cone, choose one base section and as many risers as needed to get within 8 inches of the top without going over.

32" cone	✓
16" riser	
36" riser	✓
48" riser	✓
36" base	
48" base	✓

Production Height: 13' 8"