Chapter

2

Using CAD Software to Solve Problems

In this chapter, you will learn the following to World Class standards:

- **Solving Design Problems with a Calculator or a Spreadsheet**
- **Measuring Distances between Two Points**
- **Calculate the Surface Area**
- **Calculate the Subcomponents of a Line**

Solving Design Problems with a Calculator or a Spreadsheet

Over the last two decades, Computer Aided Design (CAD) tools have been replacing math that was done on paper and with a calculator. Whether the program is AutoCAD, Pro Engineer, Microstation or Math CAD, the files made with these software applications are typically more presentable, have fewer errors than calculated and hand written computations, and are easily archived for future reference.

A modern CAD application is a three dimensional database that has the capability of modeling either surface meshes or solids. Many CAD packages have the potential to produce two-dimensional orthographic layouts of the solids. When the evaluation task involve assessing the physical assembly or part, the virtual model provides clear and concise data that any designer or engineer can use. If a computational tool is not available or written, we can utilize the Visual Basic Application (VBA) development software to make a simple application to analyze the virtual assembly.

Some of the tasks that a CAD software package can perform include the following:

Distance between Two Points
Surface Area
Volume (Weight)
Arc Length
Free Body Diagrams
Shear Force Diagram
Bending Moment Diagram
2D and 3D Vector Analysis
Moment of Inertia
Center of Gravity
Interference Fits

For many engineering specialist, they use paper and pencil to interpret their design. More popular than ever are spreadsheets that contain data and do the repetitive calculations. Whenever a professional in an architectural or engineering department repeats a task, that common undertaking should be streamlined for efficiency and accuracy. Some department managers teach that the first time a design is done, document the work in the project folder. The second time the same engineering task is done, take the time to record the process and save the project work in the project folder and distribute the new process for review by personnel in the office. When the process is completely reviewed and approved, the department manager can have a person make templates and custom applications in any software program to perform the procedure efficiently and accurately.

The learning point in this chapter is to begin to develop procedures for ourselves that keeps us working efficiently or accurately. Computer tools are available to assist us in our endeavors and we can choose to do work manually and slowly or choose good organization using computer tools. Some engineers and designers say that companies like Autodesk (AutoCAD) or Bentley (Microstation) will have a software tool for us, so we do not need to develop customized systems for ourselves. The top companies in the engineering world have CAD systems and

teams that make them unique and irreplaceable. If a customer can go to any company down the street and buy their abilities and expertise, then the architectural and engineering company we are working for is not distinctive. Building experience by doing excellent work and pushing ourselves to learn more techniques enables us to develop better solutions for our customers.

Measuring Distances between Two Points

In this problem, we need to measure the distance between two points, since we need to order communication cable that will hang between these four buildings. We need to plan on the cable having in an arc with 24 inches from the bottom of the cable to the top of the pole. When the cable gets to the back of the buildings, we need 40 ft to go down the pole and to the connection box at the bottom. The cable works in daisy chain so in the first building; the cable goes up the pole. In the second, the cable goes down to the connection box and a new cable goes to building three. The third pole is just suspending the cable and does not go down the conduit. The daisy chain ends at building four.

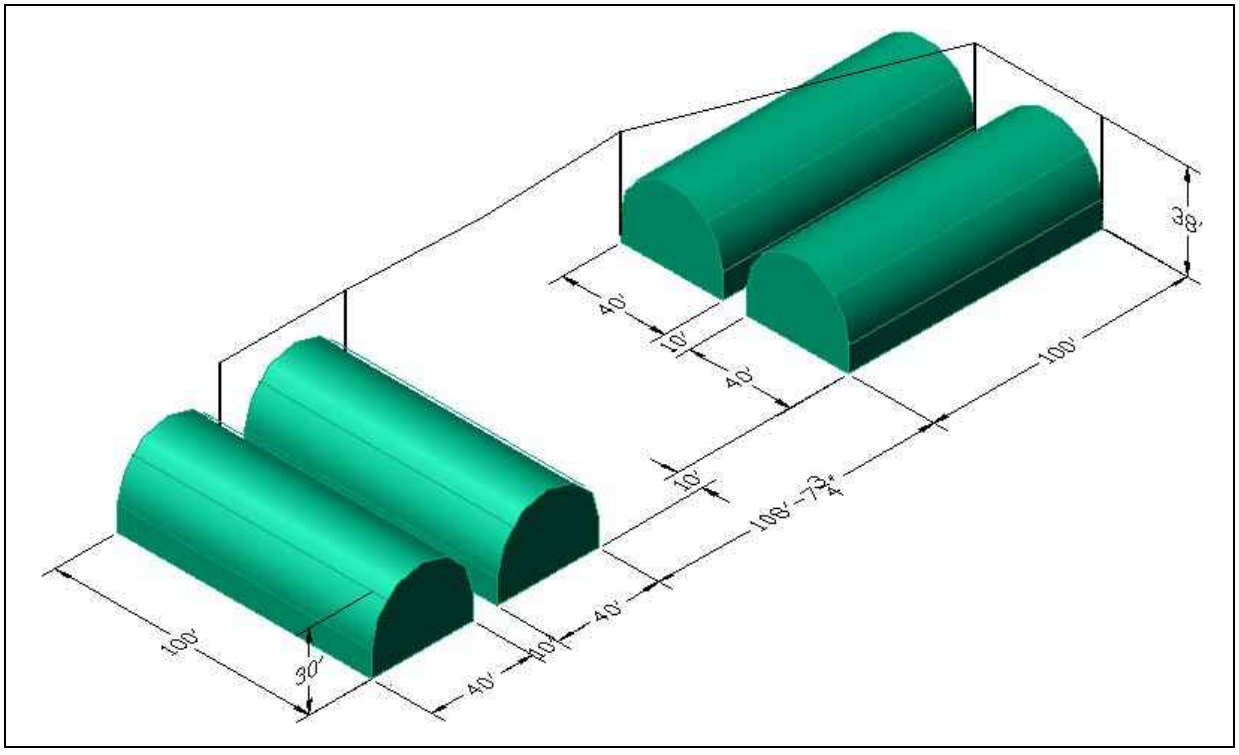

Figure 2.1 – Building and Communication Cable Layout

The challenge is to figure out the distance from one pole to another and then draw a 3-point arc to account for the 24-inch slack in the cable. Place the straight-line distances in the table and add the true length curved distances. Add the different legs of the cable together to obtain the total distance for each cable. Add the cables together to get the total amount required. Since Category 5e cable comes in boxes containing 1000 foot of cable and plenum cable is rated for

outside usage, one box is capable of doing the job. We could have done this problem with a calculator or a spreadsheet.

Cable	Leg 1	Leg 2	Leg 3	Leg 4	Total
1	40 ft straight	50'-2 9/16" arc	40 ft straight	---	130'-2 9/16"
2	40 ft straight	108'-8 5/8" arc	107'-9 5/8" arc	40 ft straight	296'-6 1/4"
3	40 ft straight	50'-2 9/16" arc	40 ft straight	---	130'-2 9/16"
					556'-11 3/8"

After drawing the building problem in CAD, did you et a similar answer? Did you find that drawing a three-point arc out of the regular XY, YZ or ZX plane difficult? After getting an answer to the distances for the primary cable, try the World Class Challenge to get the length of the secondary cable.

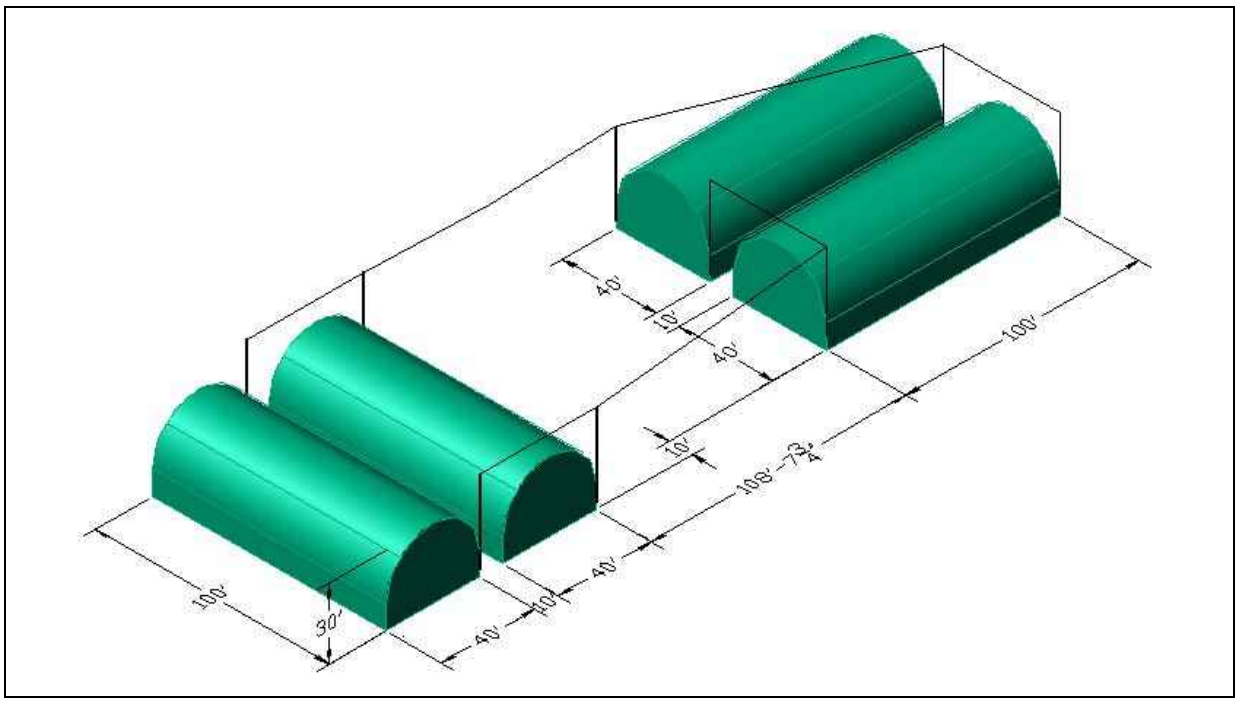

Figure 2.2 – Point to Point Distances with a Modification of the Building Project

Cable	Leg 1	Leg 2	Leg 3	Total
1				
2				
3				

Figure 2.3 – Table of Cable Lengths for Building and Communication Cable

*** World Class CAD Challenge 10-4 * - In this problem, the Project Engineer wants to add a secondary cable that does not run the same route as the primary cable. There is maximum 24-inch arc in the cable when strung between the poles that will add length to**

the cable. When the cable gets to the front of the buildings, we need 40 ft to go down the pole and to the connection box at the bottom. The cable works in daisy chain so in the first building; the cable goes up the pole. In the second, the cable goes down to the connection box and a new cable goes to building three. The daisy chain ends at building four. Complete the task in 30 minutes to maintain your World Class ranking.

Calculate Surface Area of the Stairs

In our second problem, we will draw the stairs for a building we will be remodeling. The stairway is made of 48 inch wide concrete steps and they need several patches. When we are done, we will seal the concrete that makes up the stairway and not the walls. High traffic areas where we walk call for two coats of special sealer. How much paint do we need if a regular gallon covers 400 square feet of concrete and the special non-skid covers 60 square feet?

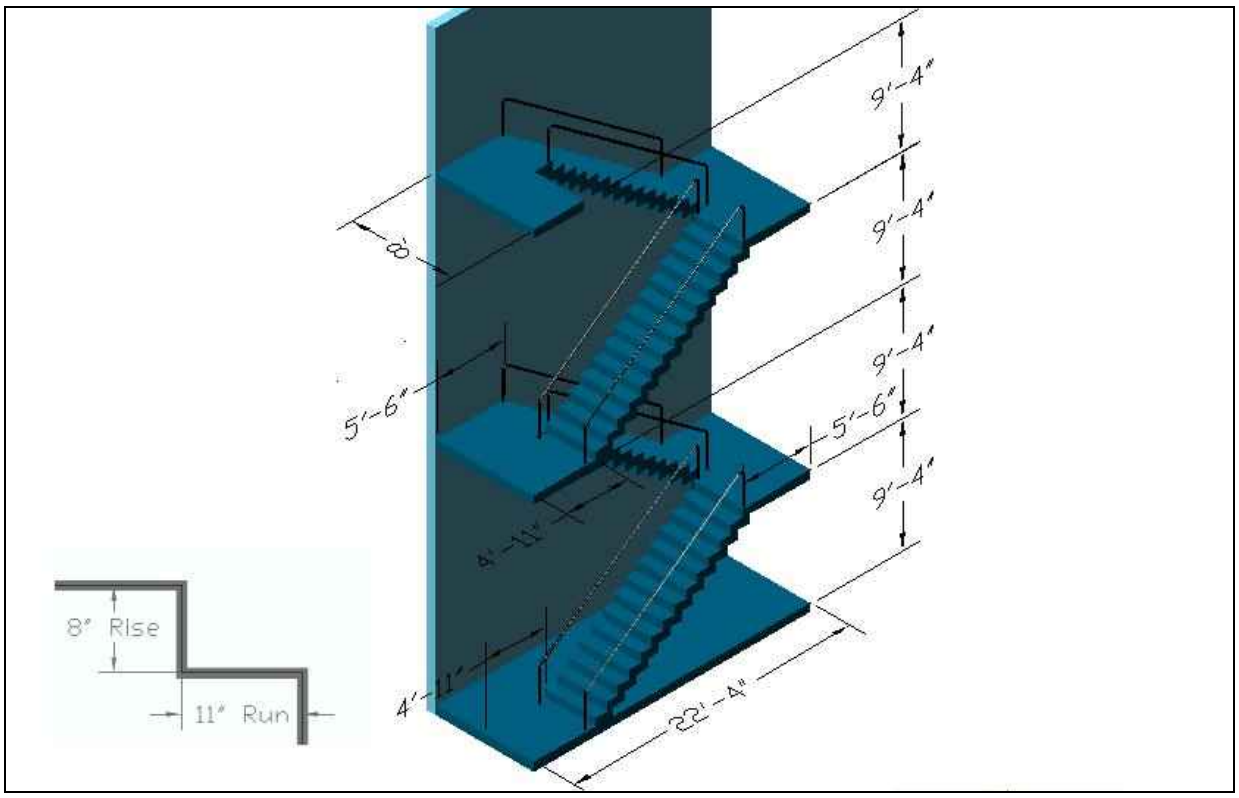

Figure 2.4 – Surface Area of a Stairway

There is a total of 1444.6 square feet of concrete stairway to cover with two coats of concrete paint and we need to subtract 357.4 square feet where we can walk on the concrete. In this area, we will use the non-skid concrete paint. We were able to compute the data from using the Area tool in the program

After getting the total area of the stairway, we create a table to total the area for non-skid concrete paint. The runners and the landings need the non-skid coating.

Description	Qty	Area	Total
Runners	52	3.6667 sq. ft.	190.6684 sq. ft.
Landings	4	41.6667 sq. ft.	166.6668 sq. ft.
			357.3352 sq. ft.

Subtract 357.4 square feet from 1444.6 sq. ft. to get 1087.2 square feet. The regular concrete coating covers 400 square feet, so we need 3 gallons. The special non-skid paint covers 60 square feet per gallon, so we take 2 coatings times 357.4 sq. ft. divided by 60 square feet per gallon equals 12 gallons.

*** World Class CAD Challenge 10-5 * - In this problem, the Project Engineer wants to know how much paint we will need to do a similar job to a stairway on the other side of the building that is the same except they built the stairs to 40 inches wide for a stairway of 80 inches. Compute how much paint we need in 30 minutes to maintain your World Class ranking.**

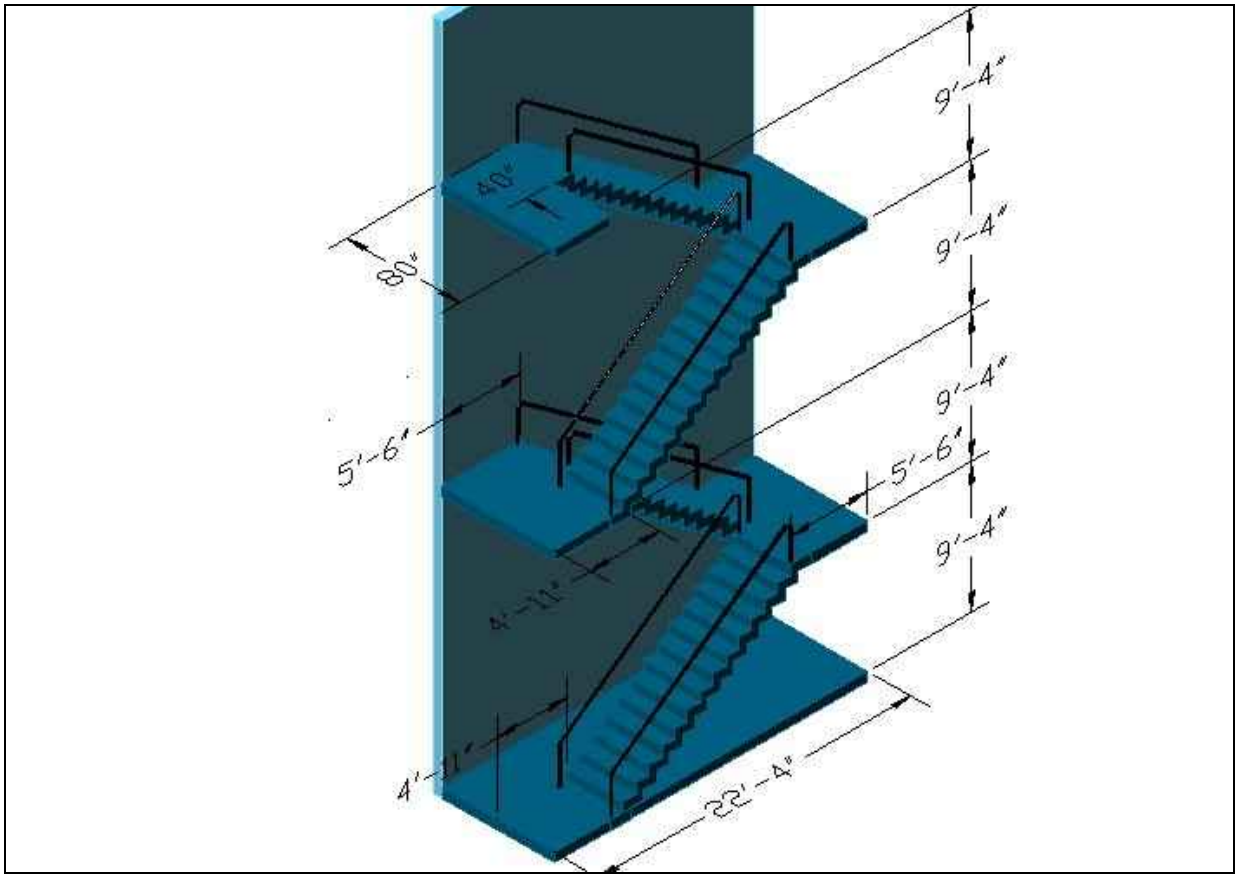

Figure 2.5 – Surface Area of a Second Stairway

Calculate the Subcomponents of a Line

In mechanics, we use a vector to show a force and they are given two values, magnitude and direction. A one-pound force vector is shown in figure 2.6 at 38 degrees.

When doing math with a calculator and paper, we need to know the relationships that were developed for the radius of 1 in a Sine and Cosine table. The length of Sine 38° is the distance in the Y –direction. The length of Cosine 38° is the distance in the X –direction.

When we utilize a scientific calculator, we compute the Sine of 38° as 0.61566.

When we work out the Cosine of 38° on the calculator, the answer is 0.7880.

The Sine and Cosine functions are available to give us the size of the X and Y leg of the 1 unit radius around the 360° circle.

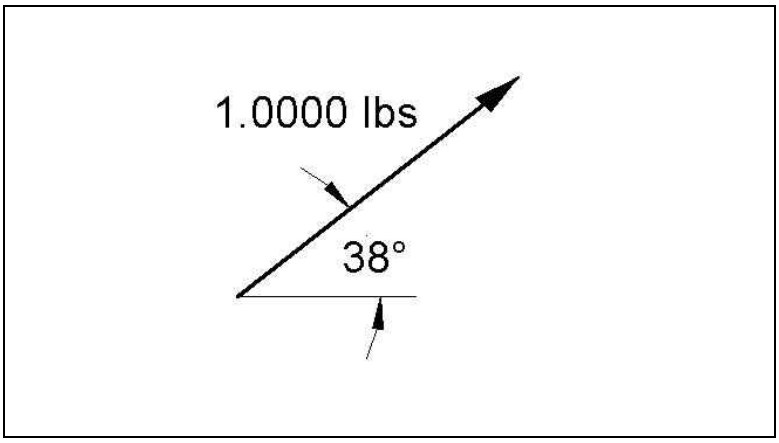

Figure 2.6 – A Vector with Magnitude and Direction

In our CAD program, we are able to achieve the same values by drawing the two legs of the 1.0-pound hypotenuse. When we dimension the X and Y legs of the sloping line, the numeric value is the same as above. Many individuals who are content with their previous math abilities will stay with using the Sine and Cosine tables and calculators, but when we have to calculate a vector in three dimensions, CAD method will be quicker.

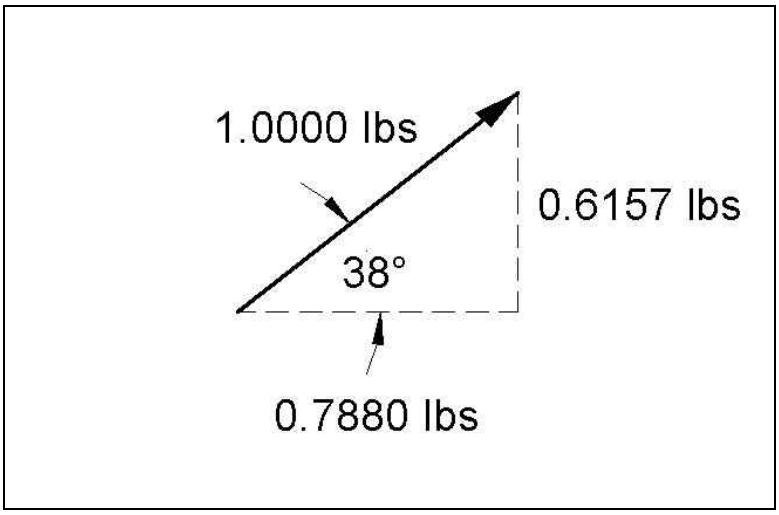

Figure 2.7 – Subcomponents of a Vector

When the force vector is not one unit, we can compute the value of the Y-leg of the triangle by multiplying the radius 4.0 times the Sine of 38° to get 2.4626 lbs. We can find the length of X-leg of the triangle by multiplying the radius 4.0 times the Cosine of 38° to get 3.1520 lbs. We did not use a calculator where the number is cleared after use, we made the drawing and saved the file in our project folder.

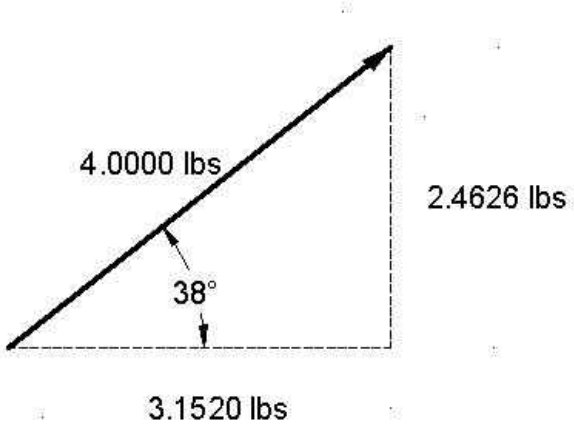

Figure 2.8 – Computing a Vector

*** World Class CAD Challenge 10-6 * - In this problem, the Project Engineer wants to know what is the subcomponent values of several vectors. Compute the values by calculator or CAD in 30 minutes to maintain your World Class ranking.**

Vector	Magnitude	Direction	X – Leg	Y – Leg
1	1500 lbs	88°		
2	56 lbs	43°		
3	24.5 lbs	17°		
4	38.9 lbs	15.6°		
5	75.125 lbs	30° 30'		
6	25 N	30° 5'		
7	35 N	15°		
8	100 N	20.15°		
9	57.2 N	10.25°		
10	151.03 N	17.5°		