# *Skyscraper*

**Goals: Estimate values in a problem to predict a result. Work with a group to follow a procedure. Communicate results orally. Record data in table format and make it part of a report.**

## PROBLEM

The Willis (formerly Sears) Tower in Chicago is the tallest building in North America. As a scientist riding with a tour group you are asked if you know how many people work and visit there each day. Another tourist asks about how many liters of water are used each minute by the Tower during the day.

You don't have a web site handy, but you know a couple of facts. The tour guide tells you that the building is 110 stories high and sits on one city block (1/16 mile square). From the bus you see this view of the Tower: (picture from Trizec Properties).

**PROBLEM SKILLS**

There are two questions directly posed by the problem. The first is estimating the number of workers in the building. The second is estimating the amount of water used by those workers.

In general a step represents a simple mathematical expression. This can be a simple addition, subtraction, multiplication or division. Sometimes a step will correspond to a single formula. In estimation problems a step probably includes rounding or order of magnitude approximations.

How do we break down steps? Usually there is a formula that we think applies to the problem. That formula will have some number of variables. If you look at the formula you should identify which variables are already known and which are unknown. If there is more than one unknown variable in the formula, you will need to add a preceding step to find a value for one unknown variable.

When all but one of the variables in a step are known, the step can be completed. You may have to rearrange the formula to solve for the remaining unknown variable. After finding the unknown value, you should check the precision of the result. You should use the same number of significant figures as for the least accurate value that goes into the formula.

Communicating our results is as important as solving a problem. There are two ways to communicate results, by speaking and by writing. Oral presentations can be as simple as stating results, but usually the listener needs to know how you got those results. That should include all the assumptions you made and the steps you took to get a result. Presenters should be able to answer questions about their subject, and listeners should help by asking questions that will help clear up any parts that are confusing or different than what the listener expected.

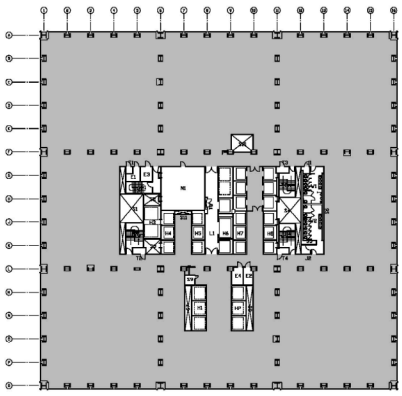
Written communication is also important. The communication isn't always a formal report, but often is a brief summary with the important steps, data, and results. When we record and report information about a problem we use software tools, especially word processing and spreadsheets. These will be found on most computers, so it's helpful for us to know how to use them to communicate our results.

**BACKGROUND INFORMATION**

In analyzing a question about a building you probably need to know the dimensions of the building - length, width, and height. One mile is 5280 feet or 1760 yards. A yard can be useful because when approximating it is close to one meter, 0.914 m to be more exact. The typical height between floors in a commercial building is about 12 feet or about 4 meters.

Inside the building one can ask about the volume or the floor area. If a building is perfectly rectangular then the volume is length times width times height. The floor area is equal to the area of one floor (length times width) times the number of floors. For non-rectangular buildings that are smaller at the top, one has to estimate how large the average floor is.

Here is a typical floor plan from the Tower. Notice the amount of space used for elevators and rest rooms. There must also be space for halls, storage, and conference rooms. It's not all office space.



Planners for city water works assume that each person uses 100 gallons of water each day. There are 1000 liters in a cubic meter ($m^3$) and about 264 gallons per $m^3$. The water used includes drinking, toilets, and services like heating and air conditioning.

**PROBLEM SOLVING**

**Part A. Making a Rough Guess**

1. Assign group members to be persons A, B (and C).
2. Make an individual guess without math for the answers to the problem.
3. Share those answers with your group and discuss who might be closest.
4. Working as a group, list at least three steps to solve the problem of the number of people in the Tower.
5. Determine a formula for estimating the volume and floor area of the building. Estimate the effect of the irregular shape of the Tower.
6. Find values for both the estimated volume and area.
7. Determine a formula for estimating the amount of space needed for each person to work in the building.
8. Find an estimate of the number of people working in the Tower.
9. Make a presentation of the steps and results (person A); Record your results and those of the other groups (person B); Ask questions of other presenters (person C).

**Part B. How Much Water?**

10. Work as a group to identify what steps need to be taken to go from the result of part B to determine an estimate of the amount of water used by the building.
11. Estimate a value for the amount of water used by a person during the work day.
12. Use the result of part B to estimate the water used by the Tower during the work day.
13. Determine a formula to convert your result from C.11. to liters per minute.
14. Make a presentation of the steps and results (person B); Record your results and those of the other groups (person A); Ask questions of other presenters (person C).

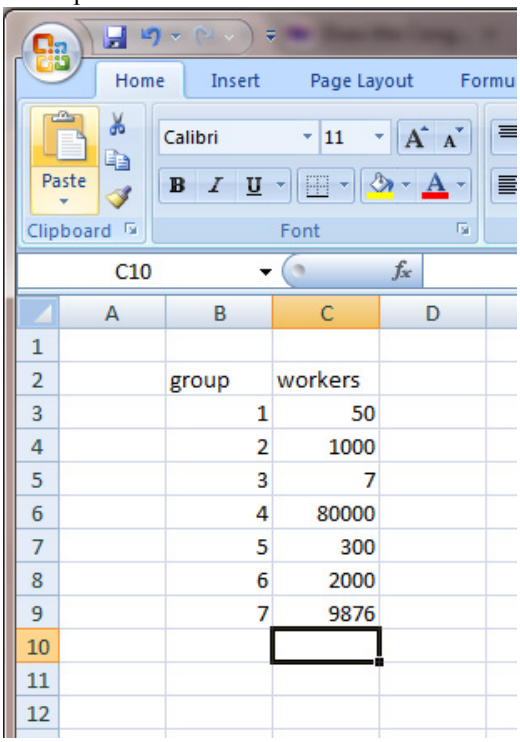
## COMPUTER SKILLS

The lab computers have both Word and Excel available. There is no internet in the lab, so bring a USB drive to store your work. Each person in the group should separately do this exercise in the lab. Let the TA know when it is complete, so that you can get credit and answer any questions from the TA.

1. Open a blank document in Word.
2. Type the title for the lab. Use the style "Title" in the home tab for this.
3. Type the date of the lab. Use the style "Subtitle."
4. Type your name followed by the names of your lab partners. Also use "Subtitle."
5. Write a paragraph describing your work in part A (person A, C) of the problem solving, or in part B (person B). Use the style "Normal."
6. Draw a diagram of a ground floor (person A), middle floor (person C), or upper floor (person B). Shade in the fraction of area that roughly represents the floor space used to estimate the amount of space needed for each worker in the Tower. Leave white a fraction of the area that is for service room such as restrooms and elevators.

7. Select the **Insert** tab, then click on **Shapes** in the *Illustrations* section. Then select the rectangle or cross as appropriate and draw it in your word document similar to the diagram above. You can use the handles on the sides of the object to change the width and height. You can move it by dragging the object in the document. The shaded area can be one or more smaller rectangles placed on top of the first rectangle.
8. Type a caption after the diagram that describes it.
9. Leave the Word document open, and open Excel in a new window.
10. Label one column *group* and the next column *workers* (person A) or *water in liters* (person B, C).

11. In the group column, insert the values from 1 to 7 (or as many groups are in your lab section) in steps of 1. In the other column insert the data you recorded during the presentation. For example:




12. To make it look like a table, hold down your left mouse button, and drag the mouse so that you select the heading and numbers. On the **Home** tab, in the *Font* section, select the **Borders** tool (you will have to hover over the tool to see it labeled). Select **All Borders**.
13. Select just the heading and from the **Borders** tag select **Thick Bottom Border**. It should look like this.

| group | workers |
|---|---|
| 1 | 50 |
| 2 | 1000 |
| 3 | 7 |
| 4 | 80000 |
| 5 | 300 |
| 6 | 2000 |
| 7 | 9876 |

14. Select the entire table, and copy and paste it into your Word document and add a caption after the table.
15. Let the TA check you on your work (each member must do this separately).
16. Save the file and turn it in for grading.