

# **Modeling Data in Excel**

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## **Introduction:**

- **Motivation:** Develop and enhance the skills and abilities needed to formulate, compute, and evaluate certain mathematical formulas and their corresponding variations by fully utilizing the spreadsheets of Microsoft Excel, a useful and efficient program with various tools and functions. The aim is to effectively create, develop, and solve qualitative mathematical models, and present and display the results using charts, tables, and graphs. In this case, we are modeling data to build a cone.
  
- **Objectives:**
  1. Calculate the area and volume of the cone (under a variable radius) using Excel tools.
  2. Displaying and illustrating the results on a graph.
  3. Using MathType to present formulas and equations.

## **Organization:**

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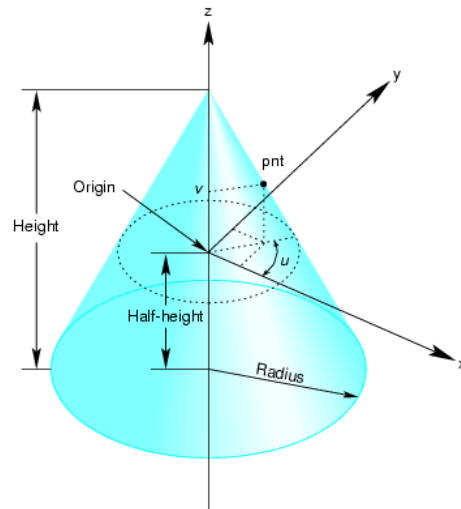
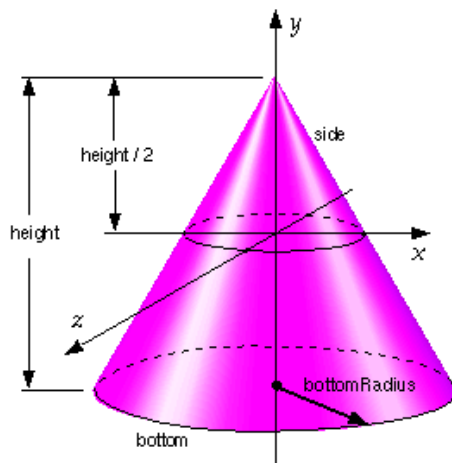
## Work Description:

### ○ **Background:**

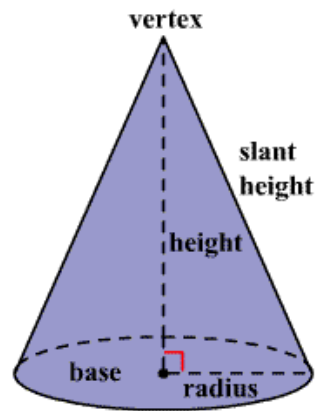
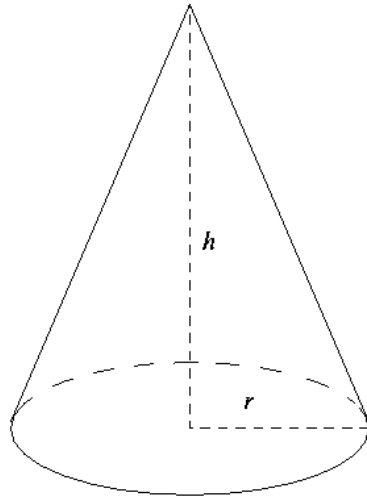
A cone is a three-dimensional geometric shape that tapers smoothly from a flat (circular, usually) base to a point called the vertex.

A right cone is defined as a cone with its vertex above the center of its base. In general, a cone is a pyramid with a circular cross section. A cone is an object which can either be solid, or hollow (e.g. traffic cones and ice-cream cones). The most common type of cones is a right cone and as a result we usually use the term 'cone' to denote a 'right cone', unless otherwise specified (i.e. oblique cone). A cone looks like a circular base converging to one point, the vertex.

Below are a few figures which represent a (right) cone, and its dimensions such as its height, slant height, and radius:



In basic 2D:



Some real-life, everyday cone applications (e.g. traffic cones and ice-cream cones):



○ **Cone Modeling Process:**

- **Cone equations:**

The *volume* of the cone is:

$$V = \frac{1}{3}Bh$$

The *area of the (circular) base* of the cone is:

$$B = \pi r^2$$

Hence, by substitution, the formula for the *volume* of the cone is:

$$V = \frac{1}{3} \pi r^2 h$$

Note: The formula for the volume of an oblique cone is the same as that of a right cone.

The formula for the *total surface area* of the cone is:

$$T_{SA} = \pi r(r + s)$$

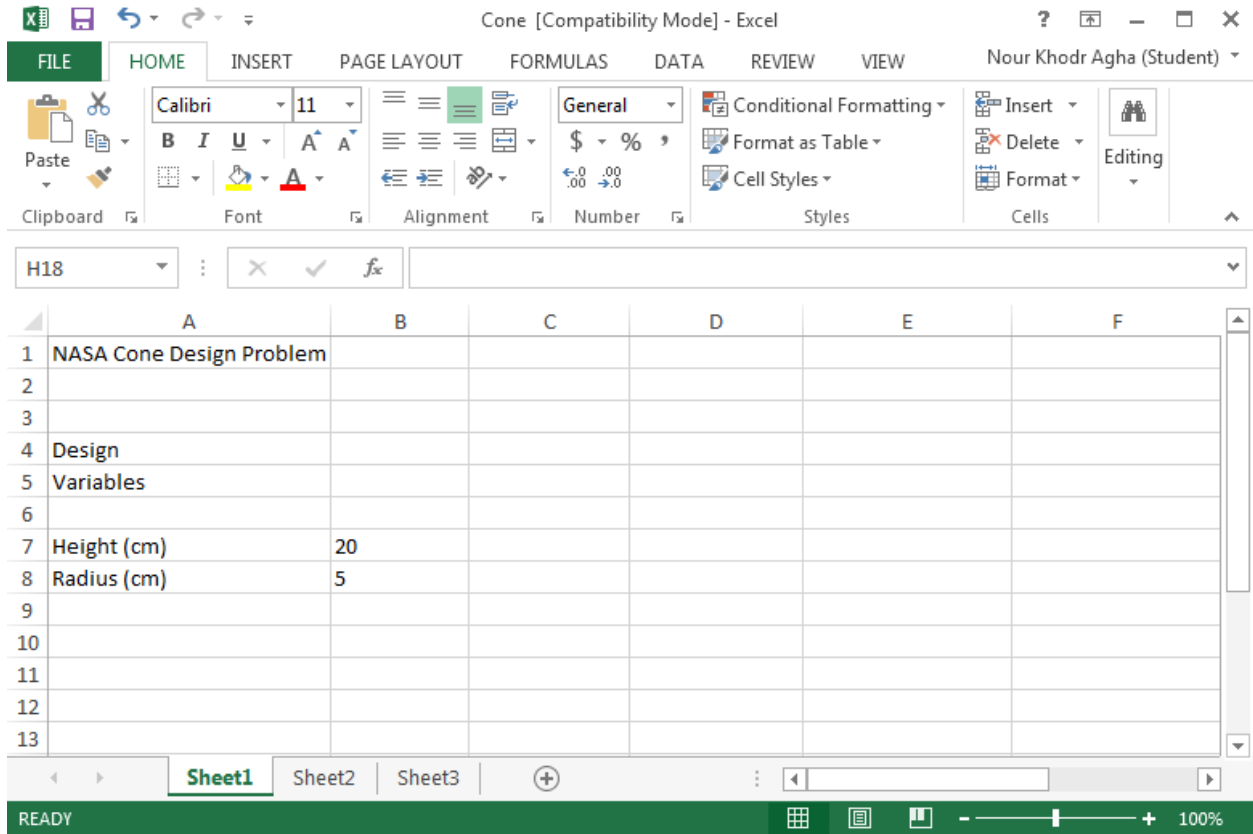
where  $s = \sqrt{h^2 + r^2}$  is the *slant height*.

The sum of the *area of the base* of the cone  $\pi r^2$  and the *area of the curved surface* of the cone  $\pi r s$  is equal to the *total surface area* of the cone.

Note: In the following section, what is referred to as 'the area' of the cone is the area of the curved surface of the cone.

- **Model development:**

The Microsoft Excel spreadsheet should be arranged and organized to appear in an easy-on-the-eye way, thus simplifying its reading, interpretation, and apprehension. Consequently, we have reserved the left-hand side of the spreadsheet solely for the purpose of titling, naming, and defining and inputting variables such as the height and radius of the cone. This is shown below:

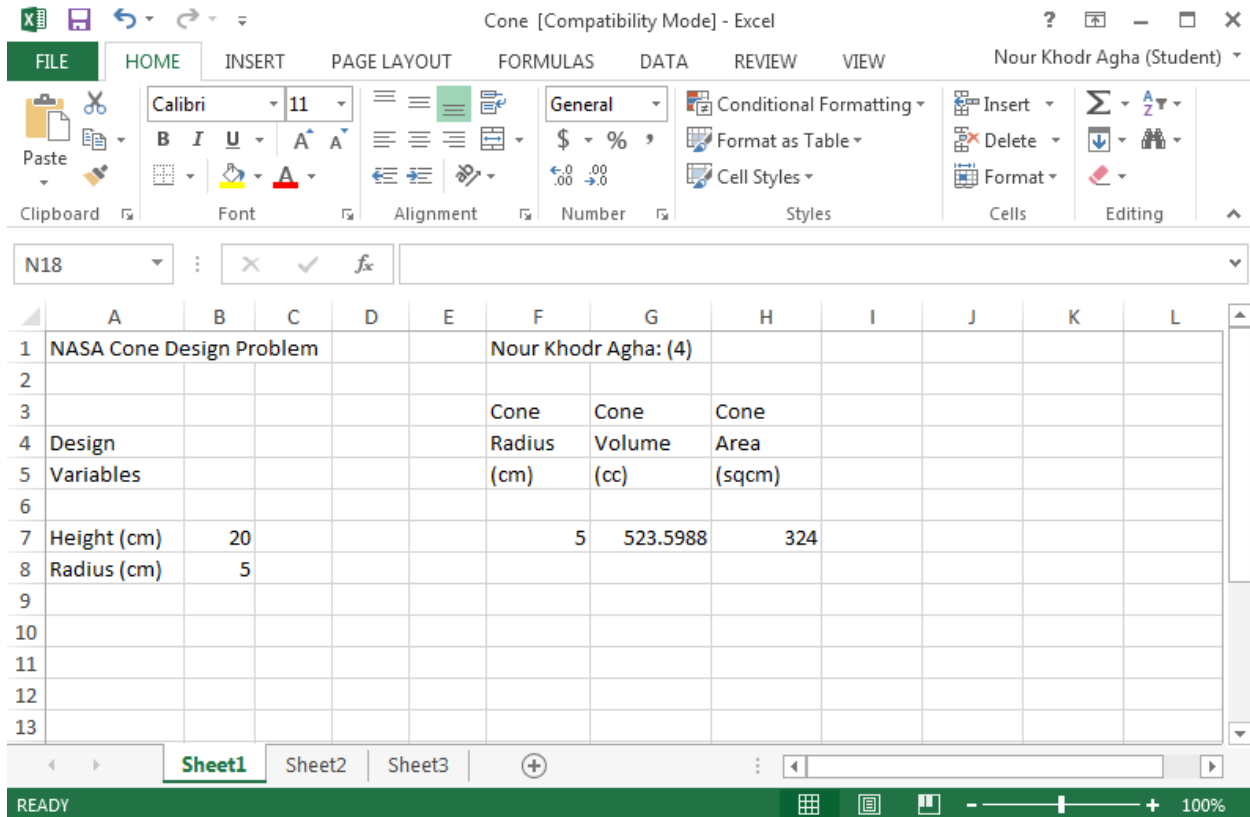


The right-hand side will be reserved for the author's name and section, in addition to outputs and results such as the area and the volume of the cone. In order to do the latter part, and after naming the cone's radius and its corresponding volume and area (along with their units), the formulae should be entered for the volume and the area in G7 and H7 respectively as follows:

$$=(1/3)*pi()*B7*F7^2 \text{ (in G7, for the volume).}$$

$$=pi()*F7*(B7^2+F7^2)^0.5 \text{ (in H7, for the area).}$$

This is how the spreadsheet should look like now:



We notice that changing the input in the variables on the left-hand side such as the height (in B7) and radius (in F7) of the cone yields an observable change on the right-hand side in the volume and the area of the cone in cells G7 and H7 respectively.

This is because the outputs of cells G7 and H7 are controlled by or dependent on the inputs of cells B7 and F7, due to the formulas inserted in the former two cells which contain the values of the latter two cells as variables.

- **Typical types of applications:**

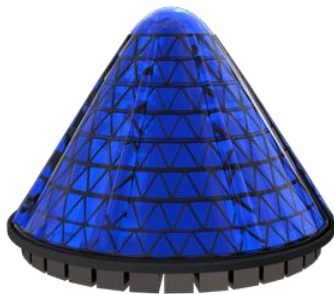
Some typical types of cone applications in technology are:



- 'Cone beam computed tomography (CBCT)', for 3D X-ray medical imaging, which is based on voxels (volume pixels), and is recently being used in dentistry (particularly in the fields of endodontics and orthodontics).
- High quality loudspeakers and subwoofers, in which cones play a pivotal role in sound and bass production; the larger their area, the larger the output level is.
- Electrical CPT(U) (cone penetration testing) used in geotechnical engineering to determine soil properties and stratigraphy.
- Cone-shaped solar spin cells:

This new exciting, revolutionary, and innovative piece of solar technology, which has been discovered recently, generates 20 times more power than normal flat solar panels using the same area of PV (photovoltaic) cells and is extremely energy-efficient and cheap (cheaper than coal, which is currently considered as the cheapest power source for most of the world). The company which came up with this technology, V3, says that its panels can produce power for 8 cents per kW/h. Since normal solar panels are constantly flat, there's only one time of the day through a certain direct angle where they can capture maximum sunlight (due to the sun's rotation). However, the design of cone-shaped solar cells enables them to capture concentrated sunlight at all angles through their surface area, thus receiving maximum sunlight throughout the whole day, and, as a result, the maximum amount of electrons in the cells are excited. Due to the heat, these cone-shaped solar cells spin (using a very small amount of their own solar-generated power) in order to cool off. Also, they take up very little space as opposed to flat solar panels. If this type of solar technology is proven to be successful, cone-shaped solar spin cells are considered to be the future of power.

From a visual perspective, here are some images of cone-shaped solar spin cells:



- **Tools:**

In this section, some useful Excel tools will be discussed and elaborated.

Namely, some of such tools are *relative* and *absolute addresses*. Since we are varying the radius and finding the resulting volume and area, it is not a good idea to keep on inputting different values for the radius – it would be a tedious task. Hence, it is much more practical to use a formula-copying feature which has an updating capability by entering the appropriate formulas into the cells; providing flexibility. This is what is known as Excel's *relative address* feature.

For instance, let's say that we enter this formula into cell C1:  $=B1+B2$ . If we expand this formula to cells C2, C3, and C4 by using 'fill handle', we obtain in cell C2:  $=B2+B3$ , C3:  $=B3+B4$ , C4:  $=B4+B5$ , and so on (if we expand further). The formulas in this case are not fixed, and are varying relatively; this is why it is called the *relative address* feature.

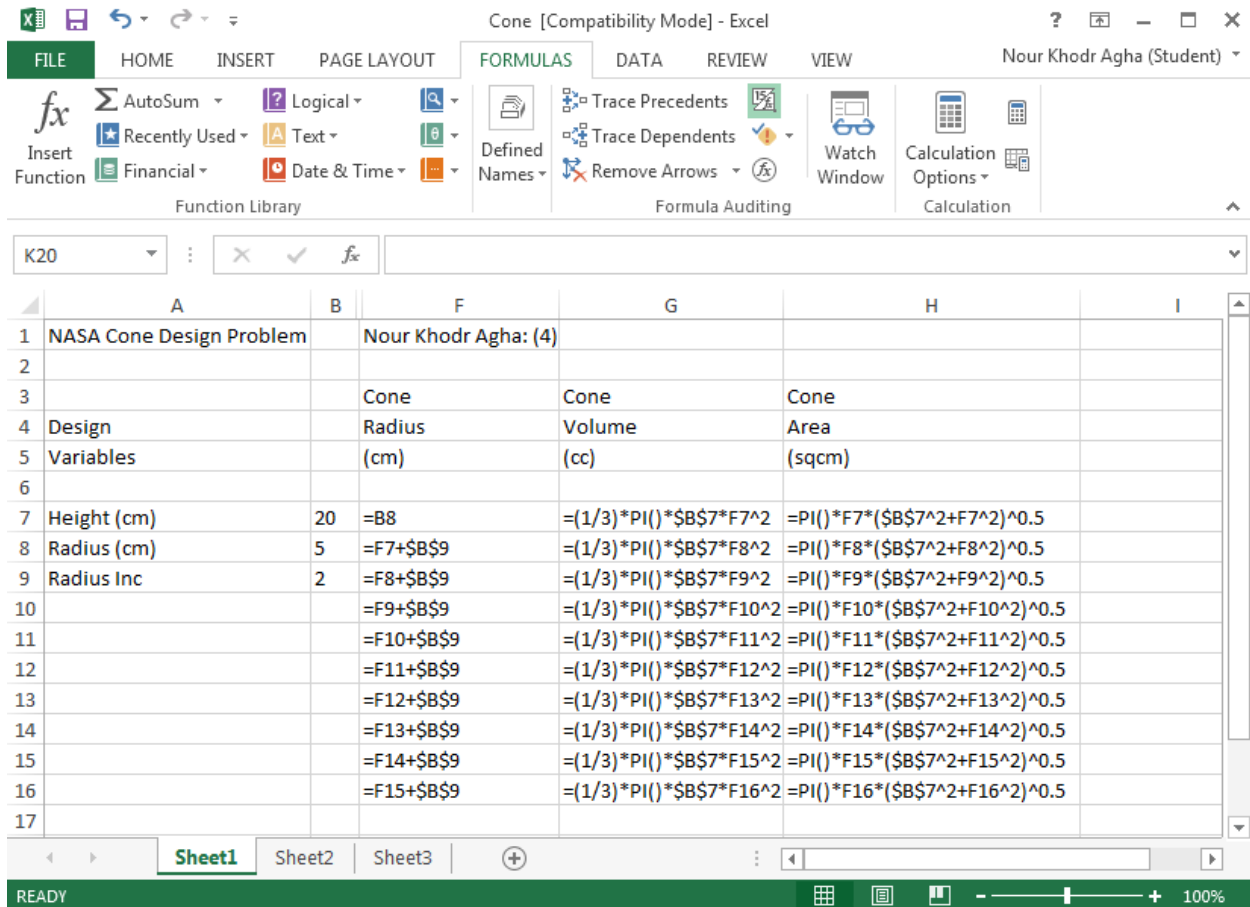
However, if we want to make B1 fixed, we use the *absolute address* feature. This is done by putting '\$' in front of B, to specify it as the absolute column, and '\$' in front of 1, to specify it as the absolute row. The formula in cell C1 thus becomes:  $=\$B\$1+B2$ . Cell B1 is now absolute and fixed (i.e. C1:  $=\$B\$1+B2$ , C2:  $=\$B\$1+B3$ , C3:  $=\$B\$1+B4$ , C4:  $=\$B\$1+B5$ ...). Alternatively, we can give cell B1 a name by typing it into the Name Box, and the name will always be an absolute address.

To proceed in our application, we enter the formula in cell F7 as:  $=B8$  (since in cell F7 we need the (same) value of the radius in cell B8). We define the Radius Inc (an increment for the radius) and its value, and apply the concept mentioned above by making the cell (B9) containing its value absolute ( $=\$B\$9$ ) and entering the formula into cell F8 as:  $=F7+\$B\$9$ , and then we expand the column down to row 16 (using 'fill handle').

Since we are varying the radius only, the height (in cell B7) should be fixed. Similarly (by applying the same concept), we adjust the formulas in cells G7 (for the volume) and H7 (for the area) so that they appear as  $=(1/3)*PI()*\$B\$7*F7^2$  and

$=PI()*F7*(\$B\$7^2+F7^2)^{0.5}$  respectively, and then expand each column down to row 16.

After clicking on 'Show Formulas' in the 'Formulas' tab, this is what our spreadsheet will look like:



**Note:** In the *Home* tab, under the *Format* menu, we click on *AutoFit Column Width* so that the formulas are displayed fully and clearly.

We now need to plot the *volume* and *area* of the cone against its *radius*. One of Excel's essential tools is its charts, and we will utilize this tool and its functions to generate a chart.

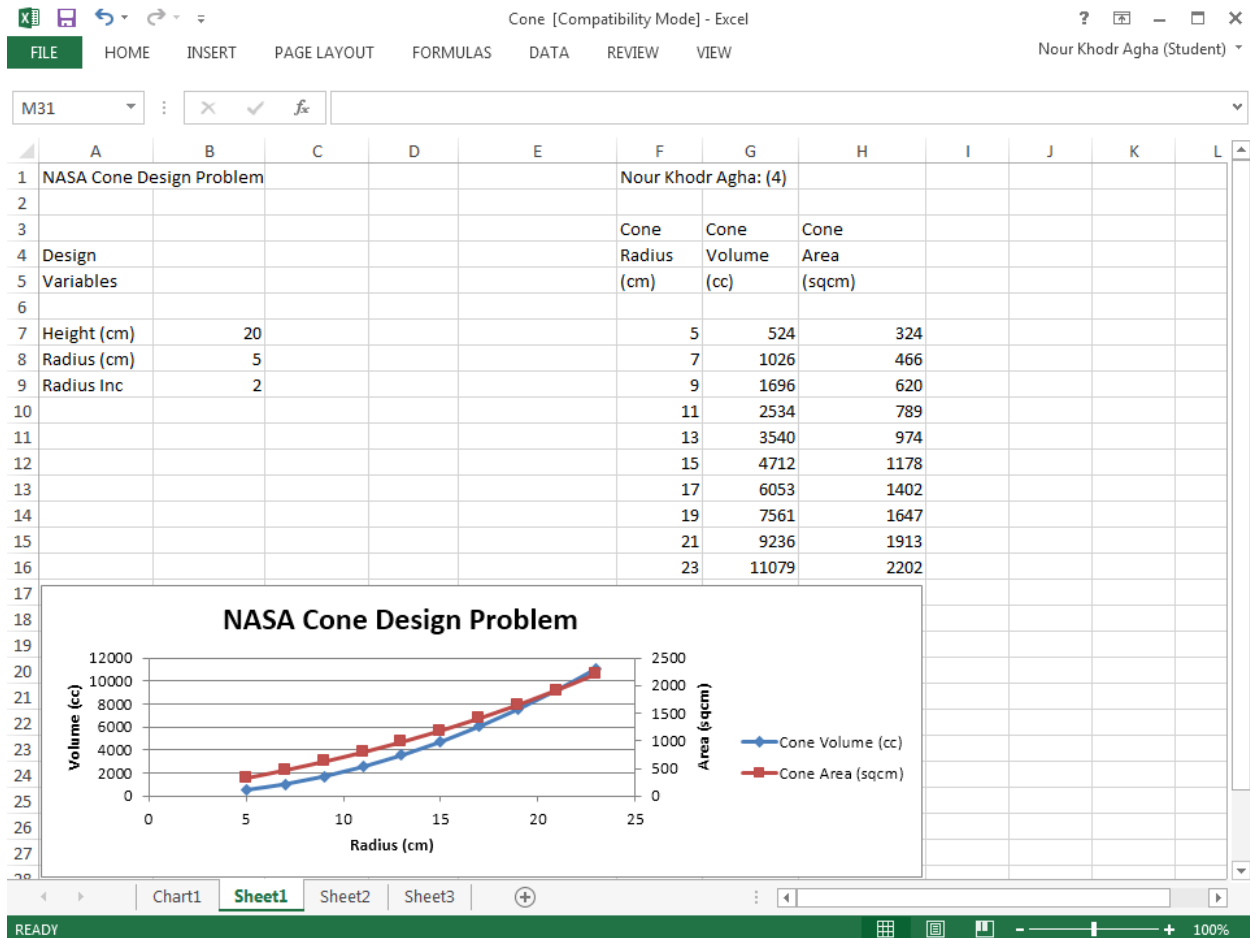
In order to create an *XY (Scatter)* chart, we go to the 'Insert' tab and under the 'Scatter' menu we select 'Scatter with Straight Lines and Markers' and click on 'Select Data' (in

the *Design* tab) to add the values that will form our chart. To do that, we click on cell F3 and drag down to cell H16, highlighting (inside dotted lines) the required cells containing the data that will serve as inputs for the chart. However, to avoid having the *volume* and *area* curve plotted with respect to the same y-axis, we click on the *area* curve and choose '*Format Selection*' from the '*Layout*' tab and then (under *Series Options*) select '*Secondary Axis*'. Now, after separating them, we have two y-axes; the *volume* curve is plotted with respect to the one on the left (primary axis), while the *area* curve is plotted with respect to the one on the right (secondary axis) – each curve is, of course, as a function of the *radius* (on the x-axis).

In the '*Layout*' tab, under the '*Chart area*' menu, we fill in the appropriate titles (and units, where necessary) in the *Chart Title*, *Axis Titles* (*Horizontal Axis* and *Vertical Axis*, using *rotated titles* for the latter), and *Legend*.

- **Results:**

Finally, our Microsoft Excel spreadsheet will appear as shown below:



Note: The significant digits of the columns are adjusted so that the values displayed are integers (using *Increase/Decrease Decimal* in the *Home* tab).

- Discussion:

1. The chart (or graph) shows an increase in the *volume* and *area* of the cone as the *radius* increases.
2. By studying the graph, as the *radius* increases, we are able to approximate the value of the *volume* and the *area*. Also, we can find the value of the *volume* given the *area*, and vice versa.
3. The *volume* and *area* curves tend to converge towards each other (when the *radius* is a little greater than 20) to meet at a point, and then they tend to diverge away from each other.

## **Conclusion:**

Microsoft Excel is a very useful program which, using simple means, tools, and techniques, allows the user to perform mathematical tasks such as creating and solving mathematical models. It computes and calculates certain inputs by using formulas, and provides the user with a dynamic display of the outputs and results in the form of spreadsheets, tables, graphs, charts and figures. In this experiment of finding the volume and area of the cone; through graphical interpretation, we were able to discover that they are proportional to the cone's radius by studying and analyzing the clear results. Hence, Excel is a very powerful and efficient tool for data modeling.

## **References:**

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- [www.math.com/school/subject3/lessons/S3U4L4DP.html](http://www.math.com/school/subject3/lessons/S3U4L4DP.html)
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- [www.mathsteacher.com.au/year10/ch14\\_measurement/18\\_cone/20cone.htm](http://www.mathsteacher.com.au/year10/ch14_measurement/18_cone/20cone.htm)
- [www.andrews.edu/~calkins/math/webtexts/geom09.htm](http://www.andrews.edu/~calkins/math/webtexts/geom09.htm)

### *Cone technological applications:*

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- [www.barefacedbass.com/technical-information/speaker-size-frequency-response.htm](http://www.barefacedbass.com/technical-information/speaker-size-frequency-response.htm)
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### *Images:*

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