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GRAPHING CIRCLES, PARABOLAS, AND HYPERBOLAS USING SECOND-ORDER LINEAR EQUATIONS IN EXCEL

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Abstract: Second-order linear equations in the plane, i.e., geometric shapes such as circles, parabolas, and hyperbolas, are of significant importance in mathematical and scientific research, as well as in various other fields. The graphs of these shapes are used to model natural phenomena, the motion of mechanical and optical systems, and engineering and astronomy problems. Visualizing these shapes using Excel or other graphing software helps in understanding their properties more clearly.

Keywords: Second-order equation, circle, parabola, hyperbola, center, radius, geometric shapes, mathematical formula, graphs.

Introduction. Second-order linear equations in the plane (circle, parabola, hyperbola) are geometric shapes that hold significant importance in mathematics, science, and various fields.

A circle: The general equation of a circle has the following form:

$$Ax^2+Ay^2+ 2Dx+2Ey+F = 0 \qquad (1)$$

Usually, equation (4) is transformed into the normal form of the circle equation:

$$x^2+u^2 = R^2 \qquad (2)$$

In this equation, the center's coordinates are at the origin, and the radius is denoted by R.

$$(x - a)^2+(u - b)^2 = R^2 \qquad (3)$$

This is the equation of a circle with the center at (a;b). The process of constructing a circle differs from that of constructing a parabola or hyperbola, as the equation needs to be transformed into the form y=f(x).

Construct a circle equation $x^2+y^2=R^2$ for $x=[-3(0.2)3]$ and $R=3$.

Solution:

Open a blank Excel sheet. Enter the data: To construct the circle, create a table of values for x and y. In column A, assign values to the variable x, and in column B, assign the corresponding y values.

- In cell A1, write "Argument."
- In cell B1, write "Circle."
- In cell A2, enter the starting value of x=−3, and in cell A3, enter x=−2.8.

Select cells A2 and A3, and use the AutoFill feature to populate the rest of column A until x=3. Now, calculate the corresponding y-values based on the equation

$$y = \sqrt{R^2 - x^2} \qquad (4)$$

Select cell B2, and click the "fx" button on the toolbar.

In the function wizard, select the "Mathematical" category and choose the "SQRT" function.

In the function dialog box, enter the expression 9-A2*A2 and click "OK."

Copy the function from cell B2 and use AutoFill to apply it to the remaining cells in column B. The resulting table should look as shown in figure 6 (a fragment of the table is shown in the image).

	A	B
1	Argument	Circle
2	-3	0
3	-2,8	1,077033
4	-2,6	1,496663
5	-2,4	1,8
6	-2,2	2,0396078
7	-2	2,236068
8	-1,8	2,4

Calculated values of the circle

Determining the type of chart: On the standard toolbar, click the "Master Chart" button. A dialog box for "Master Chart (Step 1 of 4)" will appear, showing the chart type options. Select the "Chart Type" as "Graph," and for the view, choose "Graph with Markers" (the middle chart on the left side of the dialog box). Click the "Next" button.

Specifying the data range: In the "Master Chart (Step 2 of 4): Source Data" dialog box, select the "Data Range" section and indicate the data range in the "Data Range" field. Use the mouse to drag from cell B2 to cell B32 to define the data interval. The "Series in" field will show "Columns."

Entering labels for the X-Axis: To add labels for the X-axis, go to the "Master Chart (Step 2 of 4): Source Data" dialog box, and in the "Axis Labels Range" field, place the cursor. Then, use the mouse to select the table range from A2 to A32.

In the "Series Name" field, enter "Circle." Click the "Next" button.

Adding titles: In the "Master Chart (Step 3 of 4): Chart Parameters" dialog box, enter the parameters for the chart—specifically the chart title and axis labels. In the "Chart Title" field under the "Title" section, enter "Half Circle Chart"; for the X-axis (Category), enter "Argument"; and for the Y-axis (Values), enter "Values." To display a legend in the chart, check the "Add Legend" box in the "Legend" section. Click the "Next" button.

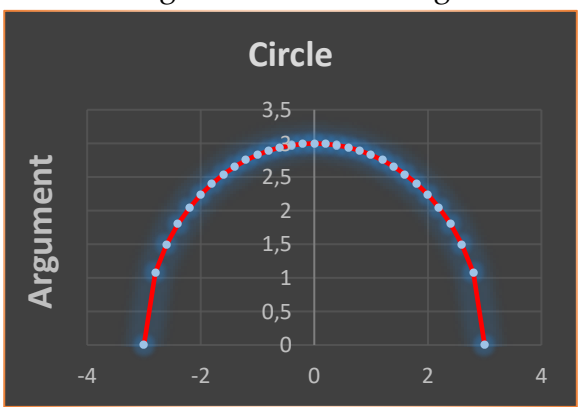

Figure 1

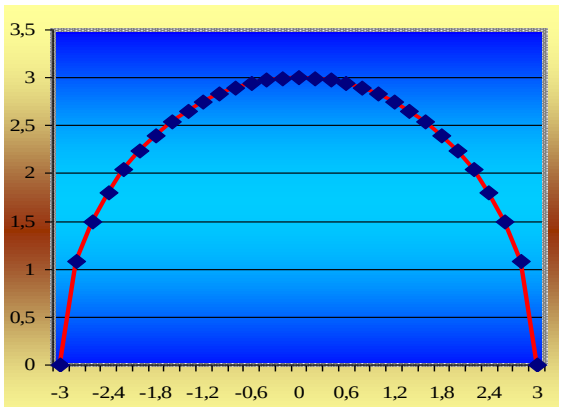

Figure 2

Choosing the placement: In the "Master Chart (Step 4 of 4): Chart Placement" dialog box, select where the chart will be placed. Choose the "Place Chart as Object in Sheet" option. In this example, select "Existing Worksheet." Click the "Finish" button.

Once the chart is ready for display, the "Finish" button is pressed, and the chart will appear on the current sheet (Figure 1,2).

Entering data: To construct the parabola, create a table for the values of x and y. In column A, assign the argument xxx, and in column B, assign the corresponding values for y.

- In cell A1, write "Argument"
- In cell B1, write "Parabola."

In cell A2, enter the starting value of x=−3, and in cell A3, enter x=−2.8x. Select cells A2 and A3, and use the AutoFill feature to populate the remaining cells in column A until x=−1.4x (or the desired range).

Next, calculate the corresponding y-values for the parabola. In cell B2, enter the equation =A2² to calculate y=x². Use the AutoFill feature to fill in the remaining y-values in column B based on the equation.

The resulting table will look like the one shown in Figure1 (a fragment of the table is shown in the image).

	A	B
1	Argument	Parabola
2	-3	9
3	-2,8	7,84
4	-2,6	6,76
5	-2,4	5,76

Calculated values of the parabola

Determining the type of chart: On the standard toolbar, click the "Master Chart" button. A dialog box for "Master Chart (Step 1 of 4)" will appear, showing the chart type options. Select "Chart Type" as "Graph," and for the view, choose "Graph with Markers" (the middle chart on the left side of the dialog box). Click the "Next" button.

Specifying the data range: In the "Master Chart (Step 2 of 4): Source Data" dialog box, select the "Data Range" section, and indicate the data range in the "Data Range" field. Use the mouse to drag from cell B2 to B14 to define the data interval. The "Series in" field will show "Columns."

Entering labels for the X-Axis: To add labels for the X-axis, go to the "Master Chart (Step 2 of 4): Source Data" dialog box, and in the "Axis Labels Range" field, place the cursor. Then, use the mouse to select the table range from A2 to A14.

In the "Series Name" field, enter "Parabola." This name will appear in the legend of the chart. Click the "Next" button.

Adding titles: In the "Master Chart (Step 3 of 4): Chart Parameters" dialog box, enter the parameters for the chart—specifically, the chart title and axis labels. In the "Chart Title" field under the "Titles" section, enter "Parabola Graph"; for the X-axis (Category), enter "Argument"; and for the Y-axis (Values), enter "Values." To display a legend in the chart, check the "Add Legend" box in the "Legend" section. Click the "Next" button.

Choosing the placement: In the "Master Chart (Step 4 of 4): Chart Placement" dialog box, select where the chart will be placed. Choose the "Place Chart as Object in Sheet" option. In this example, select "Existing Worksheet." Click the "Finish" button.

Once the chart is ready for display, press the "Finish" button, and the chart will appear on the current sheet (Figure 3).

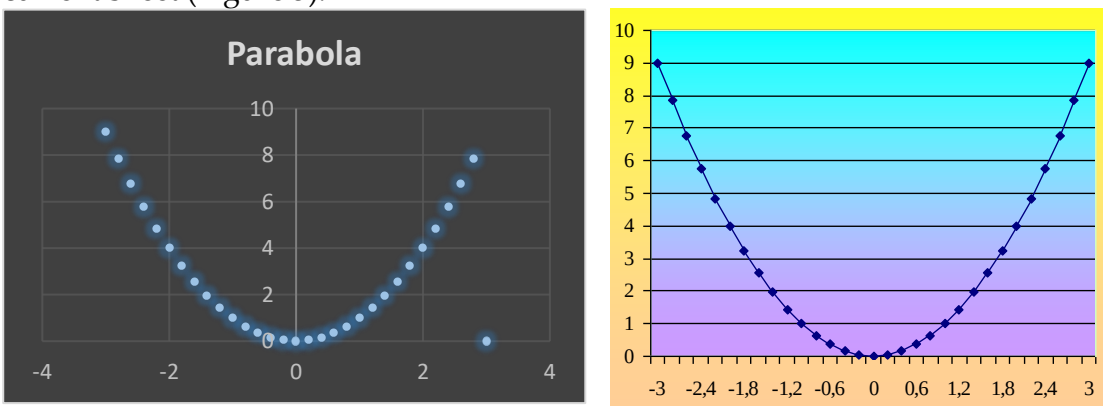

Figure 3. Parabola diagram

Hyperbola. A second-order curve (1) is called a hyperbola if the coefficients A and S have opposite signs, i.e., $AS<0$. The canonical form of the hyperbola equation is as follows:

$$\frac{x^2}{a^2}-\frac{y^2}{b^2}=1;\ c^2-a^2=b^2, a<c$$

Giperbola

Here is the translation of the provided text:

The hyperbola is constructed similarly to the parabola. Example: To plot the hyperbola $y=\frac{1}{x}$ within the range x=[0.1,0.5,10.1].

Solution:

Open a blank Excel sheet. To construct the hyperbola, create a table for the values of x and y. In column A, assign values to the argument x, and in column B, assign values for the function y. In cell A1, write "Argument". In cell B1, write "Hyperbola"

In cell A2, enter the starting value of the argument, x=0.1, and in cell A3, enter x=0.6. Select cells A2 and A3, and then use the AutoFill feature to fill in the remaining cells in column A until cell A22.

Next, in column B, enter the calculated values for the hyperbola based on the given data.

To do this, in cell B2, enter the equation: =1/A2. Use AutoFill to calculate the remaining values of the hyperbola.

The resulting table will look like the one shown in **Figure 4** (a fragment of the table is shown in the image).

	A	B
1	Argument	Giperbola
2	0,1	10
3	0,6	1,666667
4	1,1	0,909091
5	1,6	0,625
6	2,1	0,47619
7	2,6	0,384615
8	3,1	0,322581

Specifying the data range: In the "Master Chart (Step 2 of 4): Source Data" dialog box, select the "Data Range" section, and in the "Data Range" field, specify the data interval by dragging the mouse from cell B2 to B22. The "Series in" field will show "Columns."

Entering labels for the X-Axis: To add labels to the X-axis, go to the "Master Chart (Step 2 of 4): Source Data" dialog box, and in the "Axis Labels Range" field, place the cursor. Then, use the mouse to select the table range from A2 to A22.

In the "Series Name" field, type "Hyperbola." This name will appear in the legend of the chart. Click the "Next" button.

Adding titles: In the "Master Chart (Step 3 of 4): Chart Parameters" dialog box, enter the chart parameters—specifically, the chart title and axis labels. In the "Chart Title" field under the "Titles" section, enter "Hyperbola Graph"; for the X-axis (Category), enter "Argument"; and for the Y-axis (Values), enter "Values." To display a legend in the chart, check the "Add Legend" box in the "Legend" section. Click the "Next" button.

Choosing the placement: In the "Master Chart (Step 4 of 4): Chart Placement" dialog box, specify the placement for the chart. Choose the option "Place chart as an object in the worksheet" and select "Existing Worksheet." In this example, "Existing Worksheet" is selected.

Finishing: Once the chart is ready to be displayed, click the "Finish" button, and the chart will appear on the current sheet (Figure 5).

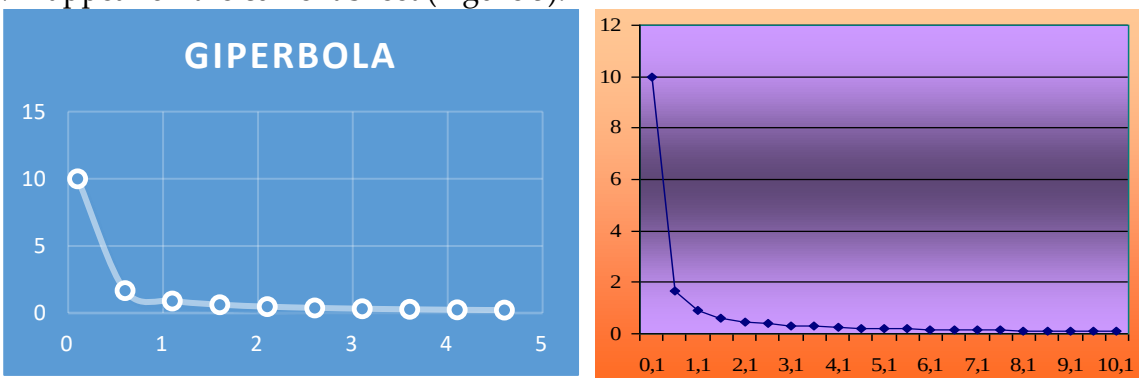

Figure 5. Hyperbola diagram

Conclusion. Demonstrating the applications of these equations through graphical representation in Excel makes the topic more comprehensible and engaging. To plot the graphs in Excel, you can use the aforementioned mathematical equations along with the scatter plot function. For this, it is sufficient to create a data table and calculate the x and y values using the equations.

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