Examples of two- and three-dimensional graphics in Smath Studio
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Plotting a single function of x:

1 - Click on point in your worksheet where upper left corner of graph will go
2 - Click on the "2D" option in the "Functions" palette or use the "Insert > Graph > 2D" menu option
3 - Type the function name in the placeholder below the graph

In this example we plot the function: \( f(x) = \sin(x) \)

Changing the size of the graph window:

Click on the graph window, then drag one of the three black handlers in the graph window to adjust its size
Moving the axes about the graph window:

1. Click on the "Move" option in the "Plot" palette
2. Click on the graph window and drag the mouse in the direction where you want to move the axes.

Scaling (zooming) the graph:

To zoom the x-axis only:
1. Click on "Scale" in the "Plot" palette
2. Click on the graph window
3. Hold down the "Shift" key
4. Roll the mouse wheel up or down

To zoom both axes by zooming one axis at a time. In this case, I zoomed the x axis first, and then the y axis.
Plotting various functions simultaneously:

1 - create a 2D graph
2 - click on the function placeholder (lower left corner) to select it
3 - click on the "Equation System" option in the "Functions" palette to produce a minimum of two function entries
4 - Type the two functions to be plotted

Note: the first function listed is plotted using a blue line, the second one uses a red line

Plotting a function using vectors:

Vectors of x and y data are created using ranges, example:
Create x vector as follows
Type: x : range - p cnt1-G, p cnt1-G,
- p cnt1-G + p cnt1-G / 20

Calculate the length of vector = n

Fill out y vector using a for loop. Click "for" in the "Programming" palette, then use:
range 1, n

Use sub-indices, e.g., y [ k ... etc.
Form augmented matrix \( M \) with vectors \( x \) and \( y \), place \( M \) in graph as a function name:

< --- The graph was zoomed in and the axes moved by using the following procedures:

1 - To zoom x-axis only: click on "Scale" in the "Plot" palette, hold the "Control" key, and use the mouse wheel
2 - To zoom y-axis only: click on "Scale" in the "Plot" palette, hold the "Shift" key and use the mouse wheel
3 - To move axes, drag mouse across graph window

Using points or lines for a plot:

Using the sparse data in matrix \( M \) we reproduce the graph above, but then we selected the "Graph by points" option in the "Plot" palette to produce the graph shown to the left.

You can click the option "Graph by lines" option in the "Plot" palette to return to the default graph format of continuous lines.

Matrices can be used for plotting parametric plots:

\[
\begin{align*}
t & = -\pi, -\frac{\pi}{50}, \ldots, \pi \\
n & = \text{length}(t) \\
\text{for } k & = 1 \ldots n \\
\begin{align*}
x_k & = \sin(3 \cdot t_k) \\
y_k & = 2 \cdot \cos(2 \cdot t_k)
\end{align*}
\end{align*}
\]

Define the vector of the parameter \( t \)
Determine length of vector \( t = n \)
Calculate vectors of \( x = x(t) \) and \( y = y(t) \)
Produce matrix of \((x, y)\) and plot it
Polar plots can be produced using vectors and matrices:

\[ \theta := 0, \frac{\pi}{50} \ldots 2\pi \]
\[ n := \text{length}([\theta]) \]
for \( k \in 1 \ldots n \)
\[ r_k := 2 \left( 1 + 2 \cdot \sin(\theta_k) \right) \]
for \( k \in 1 \ldots n \)
\[ xx_k := r_k \cdot \cos(\theta_k) \]
\[ yy_k := r_k \cdot \sin(\theta_k) \]
\[ P := \text{augment}(xx, yy) \]

Generate vector of \( \theta \) between 0 and \( 2\pi \)
Determine length of vector \( \theta \)
Generate values of \( r = f(\theta) \)
Generate coordinates:
\[ x = r \cos(\theta) \]
\[ y = r \sin(\theta) \]
Produce matrix of \((x, y)\) and plot it
Using graphs in solving equations:

In this example we seek the solution(s) for the equation:

\[ x^2 + 1 = x^3 + 2 \times x - 5 \]

A solution can be found by determining the intersection of the functions:

\[ f(x) = x^2 + 1 \quad g(x) = x^3 + 2 \times x - 5 \]

Using graphics and zooming the intersection we estimate the solution to be close to \( x = 1.80 \)

The exact solution can be found using:

\[ \text{solve} \left\{ x^2 + 1 = x^3 + 2 \times x - 5, \ x \right\} \approx 1.776 \]

Three-dimensional graphs - surfaces:

Use the option "3D" in the "Functions" palette, and enter the function \( f(x,y) \) in the placeholder. The result is a 3D surface, in this case, a plane. The original plot is shown above. Use the "Rotate" option in the "Plot" palette to change the surface view.
This figure uses the option "Graph by Lines" in the "Plot" palette (default).

This figure uses the option "Graph by Points" in the "Plot" palette.

Use the "Move" option in the "Plot" palette to move the location of the origin in the graphics window.

Use the "Scale" option in the "Plot" palette, click on the graph, and drag the mouse over it to zoom in or out.

Note: Use the "Refresh" option in the "Plot" menu to recover the original version of any plot.
The following examples use more complex surfaces:

\[
sin(x)
\]

\[
5 - (x^2 + y^2)
\]

\[
x \cdot y
\]

\[
x - y
\]

\[
x + y
\]

\[
\frac{x+y}{x+y}
\]

The type of 3D graphs of surfaces produced by SMath Studio are referred to as wireframe plots.

The following examples show more than one surface plot together in 3D:
A space curve is defined by a matrix of three columns corresponding to coordinates $x$, $y$, and $z$ of the curve.

Create a vector $t$ with values of the parameter that will produce $x = x(t)$, $y = y(t)$, and $z = z(t)$.

Determine the length of vector $t$

Generate vectors $x$, $y$, and $z$ using a "for" loop

Build matrix $M$ with coordinates $(x,y,z)$

Plot matrix $M$ in a 3D plot
**Drawing a surface and a space curve:**

Use the "Equation System" option in the "Plot" palette, and enter the equation of the surface (e.g., $x+y$) and the matrix that represents the space curve (e.g., $M$)

\[
\begin{align*}
x + y \\
M
\end{align*}
\]

**Plotting 2 space curves:**

In this example two straight lines in 3D are produced by using linear parametric equations.

\[
t = -2, -1.9, ..., 2
\]
\[
n = \text{length}(t)
\]
\[
n = 40
\]

for \( k = 1 \) to \( n \)

\[
\begin{align*}
x_1 &= 1 + 5 \cdot t_k \\
y_1 &= 1 + 4 \cdot t_k \\
z_1 &= 1 + 8 \cdot t_k
\end{align*}
\]

\[
P = \text{augment}(x_1, y_1, z_1)
\]

for \( k = 1 \) to \( n \)

\[
\begin{align*}
x_2 &= 1 + 3 \cdot t_k \\
y_2 &= 1 + t_k \\
z_2 &= t_k
\end{align*}
\]

\[
Q = \text{augment}(x_2, y_2, z_2)
\]

Individual plots of curves given by matrices \( P \) and \( Q \).
<--- Join plot of lines given by matrices P and Q