

Freshman Seminar - *Mathematica*

Demo

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What is *Mathematica*?

Simple answer:

Mathematica is a system for doing computation.

In[243]:=

\$Version

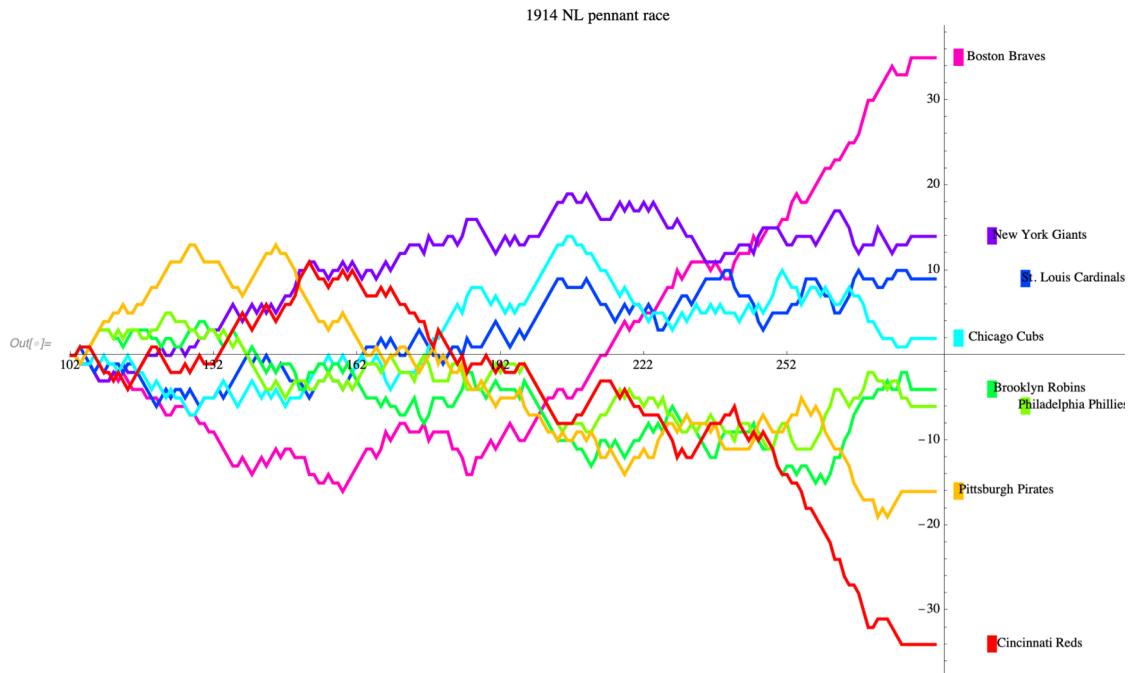
Out[243]=

15.0.0 for Mac OS X ARM (64-bit) (May 19, 2026)

Baseball

You'd need to have an “add-on” called **Baseball** to do this.

Out[]:=

In[]:= `SeasonPlot[1914, "NL"]`

How to Begin

Start typing : You get an input cell

In[244]:=

`Solve[x^2 - 5 x + 1 == 0, x]`

Out[244]=

$$\left\{ \left\{ x \rightarrow \frac{1}{2} (5 - \sqrt{21}) \right\}, \left\{ x \rightarrow \frac{1}{2} (5 + \sqrt{21}) \right\} \right\}$$

Starting with “=” gives you a free-form/natural language input

In[]:=

Out[300]=

$$\left\{ \left\{ x \rightarrow \frac{1}{2} (5 - \sqrt{21}) \right\}, \left\{ x \rightarrow \frac{1}{2} (5 + \sqrt{21}) \right\} \right\}$$

Starting with “==” gives you a Wolfram Alpha query

In[301]:=

 solve $x^2 - 5x + 1 = 0$ for x
Input interpretation 

solve

$x^2 - 5x + 1 = 0$

for

 x

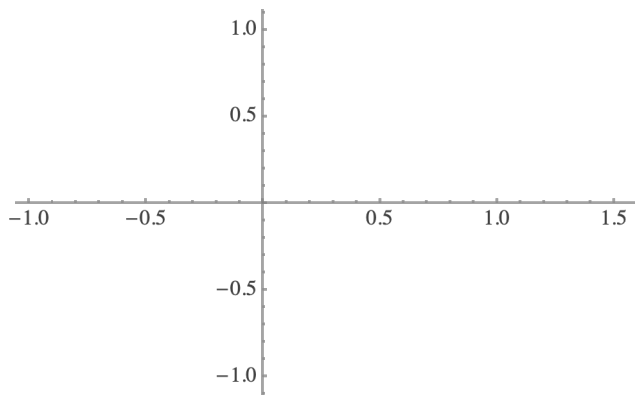
Results

Approximate forms

☒ Step-by-step solution 

$2x + \sqrt{21} = 5$

$2x = 5 + \sqrt{21}$

Plot min  max Number line Sum of roots 

5

Product of roots 

1

WolframAlpha 

AI Support

Using Microsoft M365 Copilot

Out[]=

Mathematica code to show me how my 90 degree C coffee will cool in a 30 degree C room.

 Copilot ⓘ

To model how your **90°C coffee cools in a 30°C room**, we can use **Newton's Law of Cooling**, which states:

$$T(t) = T_{\text{room}} + (T_0 - T_{\text{room}})e^{-kt}$$

Where:

- $T(t)$ is the temperature of the coffee at time t ,
- $T_0 = 90^\circ\text{C}$ is the initial temperature of the coffee,
- $T_{\text{room}} = 30^\circ\text{C}$ is the ambient room temperature,
- k is a cooling constant (depends on the environment),
- t is time (usually in minutes or seconds).

Here's a simple **Mathematica** code snippet to visualize this:

```
1 (* Parameters *)
2 T0 = 90; (* Initial coffee temperature *)
3 Troom = 30; (* Room temperature *)
4 k = 0.05; (* Cooling constant, adjust as needed *)
5
6 (* Newton's Law of Cooling *)
7 T[t_] := Troom + (T0 - Troom) Exp[-k t]
8
9 (* Plot temperature over time *)
10 Plot[T[t], {t, 0, 60},
11  PlotLabel -> "Cooling of Coffee Over Time",
12  AxesLabel -> {"Time (minutes)", "Temperature (°C)"},
13  PlotStyle -> Red,
14  GridLines -> Automatic]
```

    </> Mathematica



Paste snippet above into a Mathematica Notebook and evaluate it:

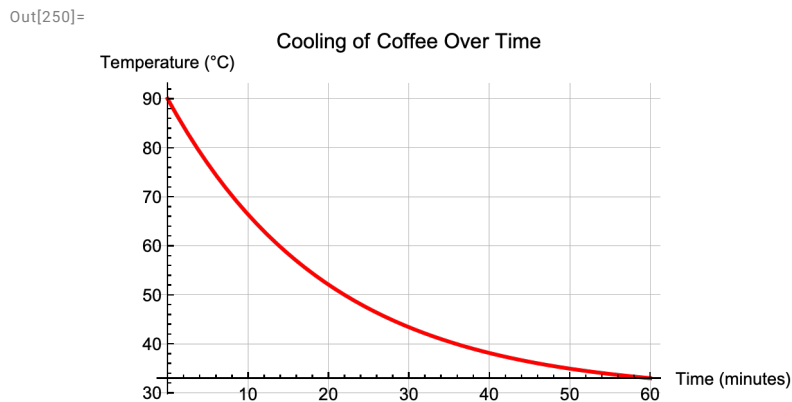
```

In[246]:=
(*Parameters*) T0 = 90; (*Initial coffee temperature*)
Troom = 30; (*Room temperature*)
k = 0.05; (*Cooling constant, adjust as needed*)

(*Newton's Law of Cooling*)
T[t_] := Troom + (T0 - Troom) Exp[-k t]

(*Plot temperature over time*)
Plot[T[t], {t, 0, 60}, PlotLabel → "Cooling of Coffee Over Time",
  AxesLabel → {"Time (minutes)", "Temperature (°C)"},
  PlotStyle → Red, GridLines → Automatic]

```



A few examples from courses most math majors take.

Precalculus/Trig

```

In[251]:=
Solve[2 x ^ 2 + 5 x - 7 == 0, x]

```

Out[251]=

$$\left\{ \left\{ x \rightarrow -\frac{7}{2} \right\}, \{ x \rightarrow 1 \} \right\}$$

```

In[252]:=
c Sin[a x + b]

```

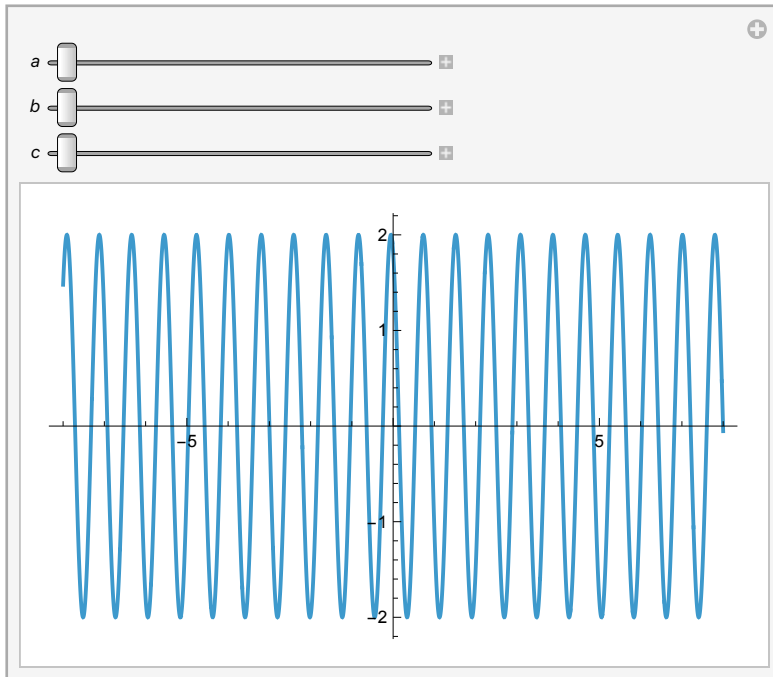
Out[252]=

$$\begin{pmatrix} 0.12 \sin(a x + b) \\ 0.15 \sin(a x + b) \\ 0.19 \sin(a x + b) \end{pmatrix}$$

In[253]:=

```
Manipulate[Plot[c Sin[b + a x], {x, -8, 8}], {a, -8, 8}, {b, -2, 2}, {c, -2, 2}]
```

Out[253]=



In[254]:=

```
Solve[x Sin[x] == 1 / 5, x]
```

 **Solve:** This system cannot be solved with the methods available to Solve. Try Reduce or FindInstance instead.

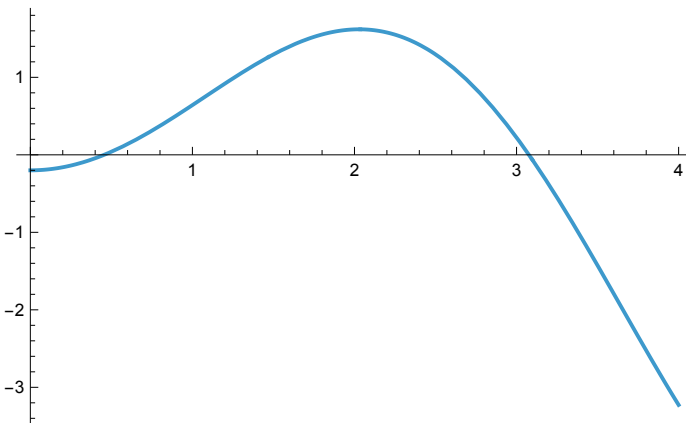
Out[254]=

```
Solve[x Sin[x] == 1 / 5, x]
```

In[255]:=

```
Plot[x Sin[x] - 1 / 5, {x, 0, 4}]
```

Out[255]=



In[256]:=

```
FindRoot[x Sin[x] == 1 / 5, {x, 0.5}]
```

Out[256]=

```
{x -> 0.455053}
```

```
In[257]:= FindRoot[x Sin[x] == 1 / 5, {x, 3}]
Out[257]= {x -> 3.07654}
```

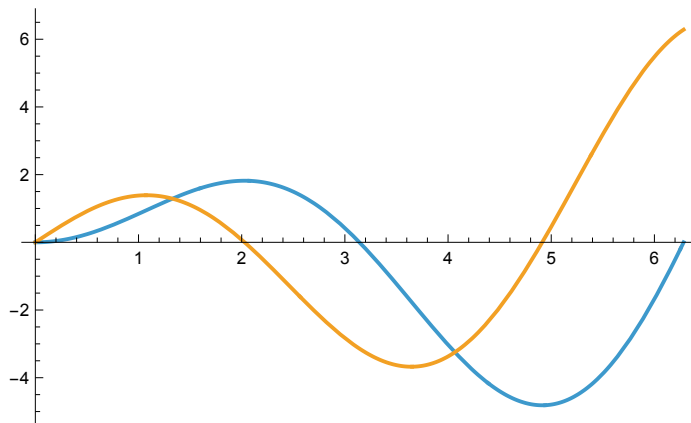
Calculus I/IA/IB

Differentiate and plot a function.

```
In[258]:= f = Function[x, x Sin[x]]
Out[258]= x -> x sin(x)
```

```
In[259]:= f'
Out[259]= x -> 1 sin(x) + x cos(x)
```

```
In[260]:= Plot[{Tooltip[f[x], "f"], Tooltip[f'[x], "f'"]}, {x, 0, 2 Pi}]
Out[260]=
```



Calculus II

Integrate an expression, indefinite and definite.

```
In[261]:= y = x ^ 2 E ^ (-x)
Out[261]= e^{-x} x^2
```

```
In[262]:= Integrate[y, x]
Out[262]= e^{-x} (-x^2 - 2 x - 2)
```

In[263]:=

Integrate[y, {x, 0, 5}]

Out[263]=

$$2 - \frac{37}{e^5}$$

Evaluate an infinite series.

In[264]:=

Sum[(2 / 3) ^ n, {n, 0, ∞}]

Out[264]=

3

A Taylor series

In[265]:=

Series[Cos[x], {x, 0, 4}]

Out[265]=

$$1 - \frac{x^2}{2} + \frac{x^4}{24} + O(x^5)$$

Calculus III

In[266]:=

u = {4, -2, 1};**v** = {1, 1, -2};

In[268]:=

u.v

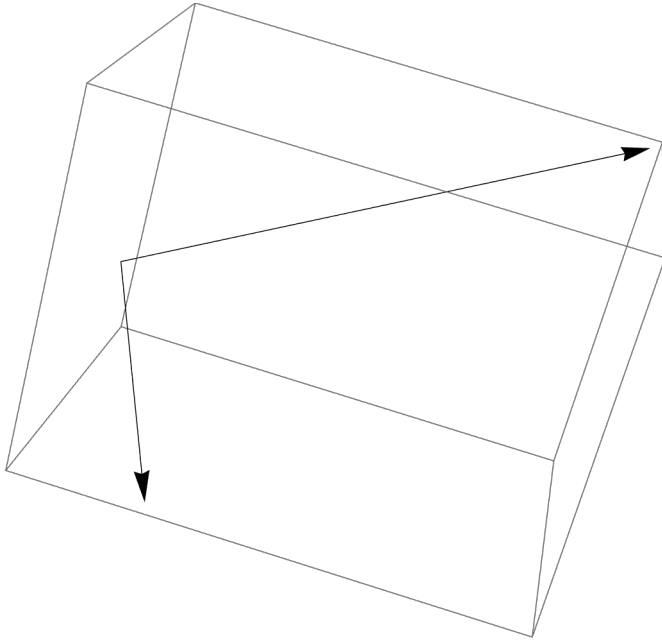
Out[268]=

0

In[269]:=

Graphics3D[{Arrow[{0, 0, 0}, u], Arrow[{0, 0, 0}, v]}]

Out[269]=



In[270]:=

Clear[x, y]

In[271]:=

z = x^2 - y^2

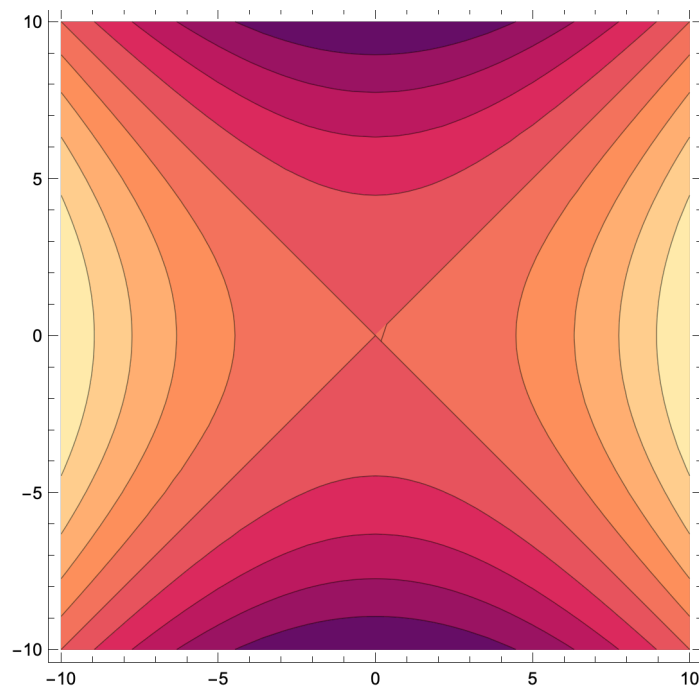
Out[271]=

 $x^2 - y^2$

In[272]:=

ContourPlot[z, {x, -10, 10}, {y, -10, 10}]

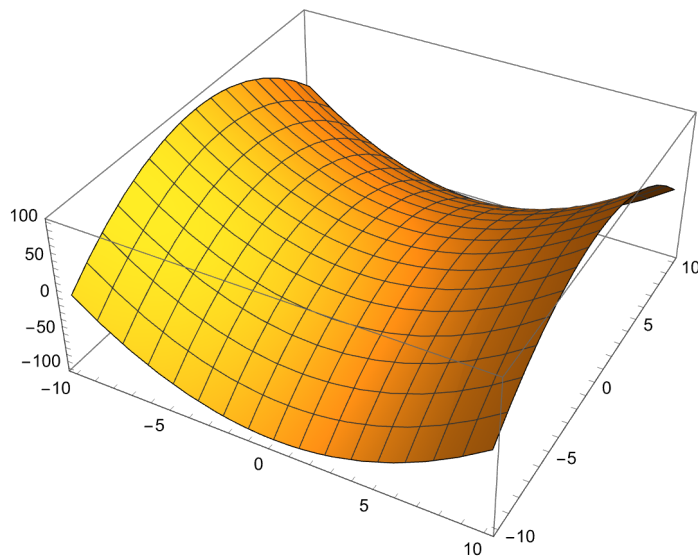
Out[272]=



In[273]:=

Plot3D[z, {x, -10, 10}, {y, -10, 10}]

Out[273]=



Discrete Structures

Binary digits of a number

In[274]:=

IntegerDigits[1234567, 2]

Out[274]=

{1, 0, 0, 1, 0, 1, 1, 0, 1, 0, 1, 1, 0, 1, 0, 0, 0, 0, 1, 1, 1}

The number of possible 5 card poker hands:

In[275]:=

Binomial[52, 5]

Out[275]=

2598960

A recursive definition of the Fibonacci sequence.

In[276]:=

Clear[f]

In[277]:=

f[0] = 0; **f**[1] = 1;**f**[n_] := **f**[n] = **f**[n - 1] + **f**[n - 2]

In[279]:=

Table[**f**[i], {i, 0, 10}]

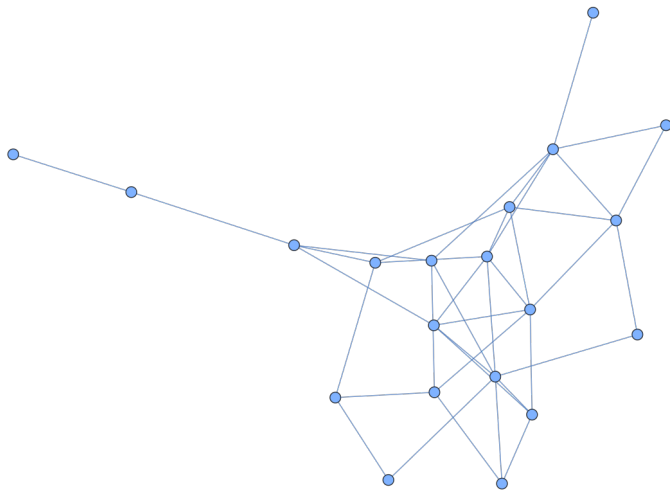
Out[279]=

{0, 1, 1, 2, 3, 5, 8, 13, 21, 34, 55}

In[280]:=

RandomGraph[**BernoulliGraphDistribution**[20, $\frac{1}{5}$]]

Out[280]=



Linear Algebra

Linear Equations

In[281]:=

Clear[x, y, z]

In[282]:= **Solve**[{ $x + y + z == 4$, $x + 2 y - z == 5$, $x - y - z == 0$ }, { x , y , z }]

Out[282]= $\left\{\left\{x \rightarrow 2, y \rightarrow \frac{5}{3}, z \rightarrow \frac{1}{3}\right\}\right\}$

Matrix Equations

In[283]:=
$$A = \begin{pmatrix} 2 & -1 & 0 \\ -1 & 3 & -1 \\ 0 & -1 & 4 \end{pmatrix}$$

Out[283]=
$$\begin{pmatrix} 2 & -1 & 0 \\ -1 & 3 & -1 \\ 0 & -1 & 4 \end{pmatrix}$$

In[284]:= **RowReduce**[A]

Out[284]=
$$\begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

In[285]:= **Solve**[A. $\{x, y, z\} == \{3, 4, 5\}$, { x , y , z }]

Out[285]= $\{\{x \rightarrow 3, y \rightarrow 3, z \rightarrow 2\}\}$

In[286]:= **Inverse**[A]

Out[286]=
$$\begin{pmatrix} \frac{11}{18} & \frac{2}{9} & \frac{1}{18} \\ \frac{2}{9} & \frac{4}{9} & \frac{1}{9} \\ \frac{1}{18} & \frac{1}{9} & \frac{5}{18} \end{pmatrix}$$

Differential Equations

In[287]:= **Clear**[x , t]

In[288]:= **DSolve**[$x' [t] == -2 x[t] + t^2$, $x[t]$, t]

Out[288]= $\left\{\left\{x(t) \rightarrow \frac{1}{4} (2 t^2 - 2 t + 1) + c_1 e^{-2 t}\right\}\right\}$

In[289]:= **DSolve**[{ $x' [t] == -2 x[t] + t^2$, $x[0] == 1$ }, $x[t]$, t]

Out[289]= $\left\{\left\{x(t) \rightarrow \frac{1}{4} e^{-2 t} (2 e^{2 t} t^2 - 2 e^{2 t} t + e^{2 t} + 3)\right\}\right\}$

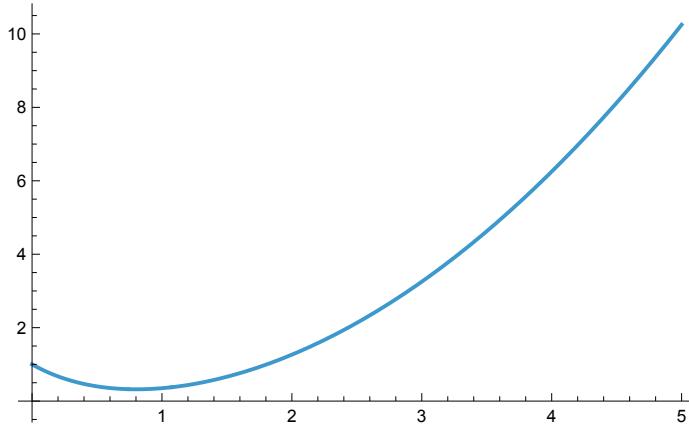
In[290]:=

$$x[t_]:= \frac{1}{4} e^{-2t} (3 + e^{2t} - 2 e^{2t} t + 2 e^{2t} t^2)$$

In[291]:=

Plot[x[t], {t, 0, 5}]

Out[291]=



Probability & Statistics

Distribution of probabilities for the roll of a fair die:

In[292]:=

roll = DiscreteUniformDistribution[{1, 6}]

Out[292]=

DiscreteUniformDistribution[{1, 6}]

In[293]:=

RandomVariate[roll]

Out[293]=

6

In[294]:=

PDF[roll]

Out[294]=

$$\text{Function}\left[x, \begin{cases} \frac{1}{6} & 1 \leq x \leq 6 \\ 0 & \text{True} \end{cases}, \text{Listable}\right]$$

In[295]:=

twodice := Total[RandomVariate[roll, 2]]

In[296]:=

{twodice, twodice, twodice}

Out[296]=

{9, 7, 7}

In[297]:=

data = Table[twodice, {10 000}];

```
In[298]:=
```

```
Mean[data] // N
```

```
Out[298]=
```

```
6.9922
```

```
In[299]:=
```

```
Histogram[data]
```

```
Out[299]=
```

