Freshman Seminar - *Mathematica* Demo

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What is *Mathematica*?

Simple answer: *Mathematica* is a system for doing computation.

In[151]:=

```
$Version
```

Out[151]=

14.3.0 for Mac OS X ARM (64-bit) (July 8, 2025)

Baseball

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

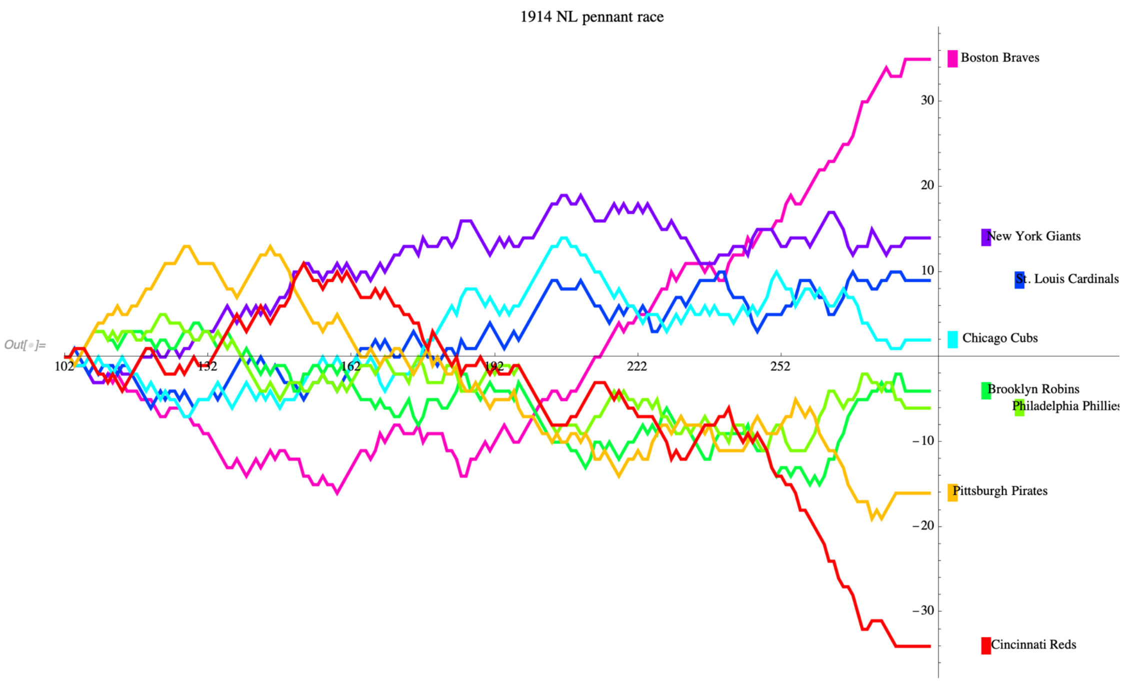
In[152]:=

```
Import[
 "/Users/ken_l/Library/Mobile Documents/com~apple~CloudDocs/__hold/NL1914.png"]
```

Import: File /Users/ken_l/Library/Mobile Documents/com~apple~CloudDocs/__hold/NL1914.png not found during Import.

Out[ ]=

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



Out[152]=

$Failed

How to Begin

Start typing : You get an input cell

In[212]:=

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

Out[212]=

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

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

In[∘]:=

```
solve x^2–5x+1=0
Solve[x^2 - 5*x + 1 == 0, {}]
```

Out[213]=

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

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

solve x^2-5x+1=0 for x

Input interpretation

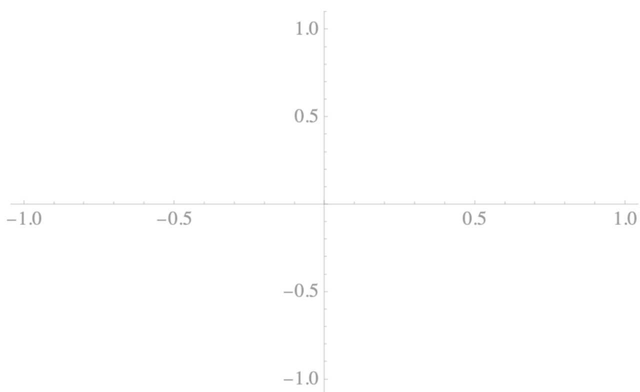
solve	$x^2 - 5x + 1 = 0$	for	x

Result — 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[135]=

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,
- $T_0 = 90°C$ is the initial temperature of the coffee,
- $T_{\text{room}} = 30°C$ 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:

Mathematica

```
(* 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]
```

Paste snippet above into a Mathematica Notebook and evaluate it:

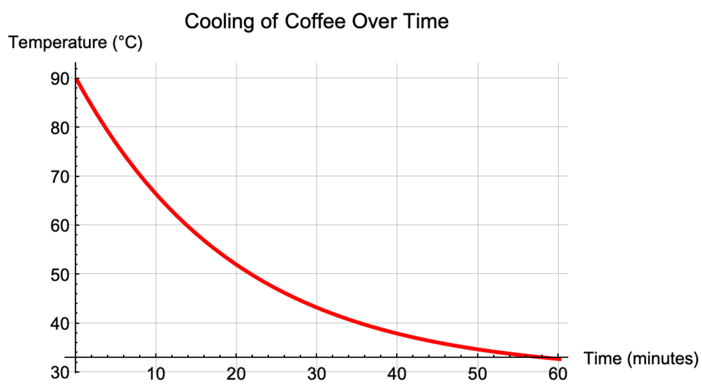
In[153]:=

```
(*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]
```

Out[157]=



A few examples from courses most math majors take.

Precalculus/Trig

In[158]:=

```
Solve[2 x^2 + 5 x - 7 == 0, x]
```

Out[158]=

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

In[159]:=

```
c Sin[a x + b]
```

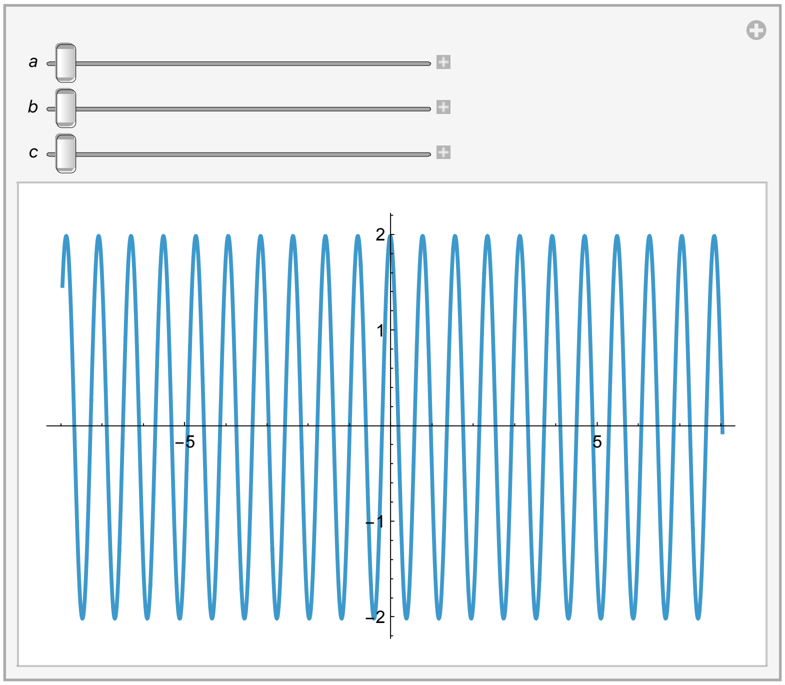
Out[159]=

$$c \sin(a\, x + b)$$

In[160]:=

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

Out[160]=



In[161]:=

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

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

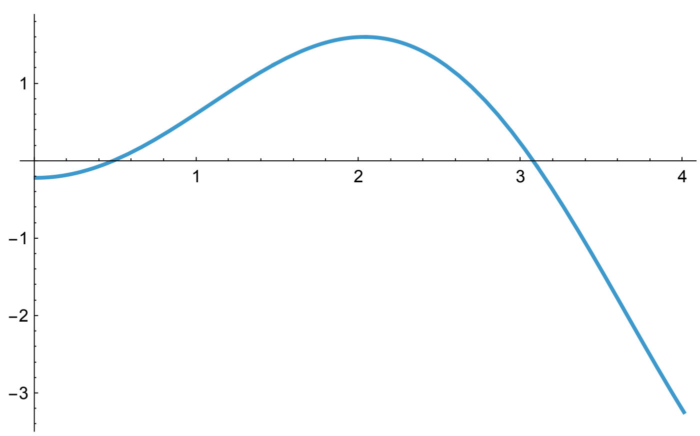
Out[161]=

$$\text{Solve}\left[x \sin(x) = \frac{1}{5}, x\right]$$

In[162]:=

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

Out[162]=



In[163]:=

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

Out[163]=

$\{x \to 0.455053\}$

In[164]:=

```
FindRoot[x Sin[x] == 1 / 5, {x, 3}]
```

Out[164]=

$\{x \to 3.07654\}$

Calculus I/IA/IB

Differentiate and plot a function.

In[165]:=

```
f = Function[x, x Sin[x]]
```

Out[165]=

$x \longmapsto x \sin(x)$

In[166]:=

```
f′
```

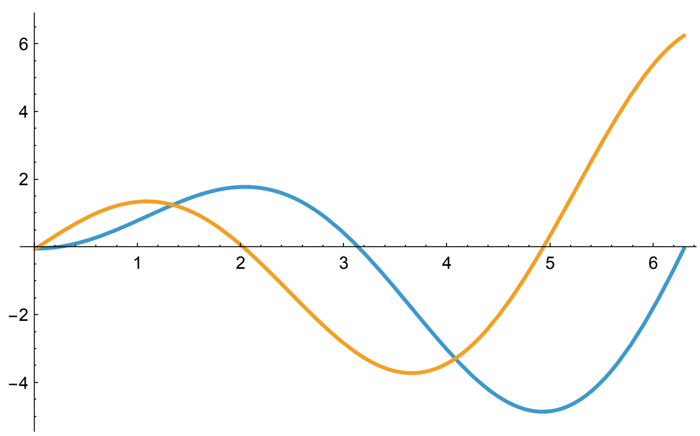
Out[166]=

$x \longmapsto 1 \sin(x) + x \cos(x)$

In[167]:=

```
Plot[{Tooltip[f[x]], Tooltip[f'[x]]}, {x, 0, 2 Pi}]
```

Out[167]=



Calculus II

Integrate an expression, indefinite and definite.

In[168]:=

```
y = x ^ 2 E ^ (-x)
```

Out[168]=

$e^{-x} x^2$

In[169]:=

```
Integrate[y, x]
```

Out[169]=

$$e^{-x}\left(-x^2-2\,x-2\right)$$

In[170]:=

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

Out[170]=

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

Evaluate an infinite series.

In[171]:=

```
Sum[(2 / 3) ^n, {n, 0, ∞}]
```

Out[171]=

$$3$$

A Taylor series

In[172]:=

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

Out[172]=

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

Calculus III

In[173]:=

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

In[175]:=

```
u.v
```

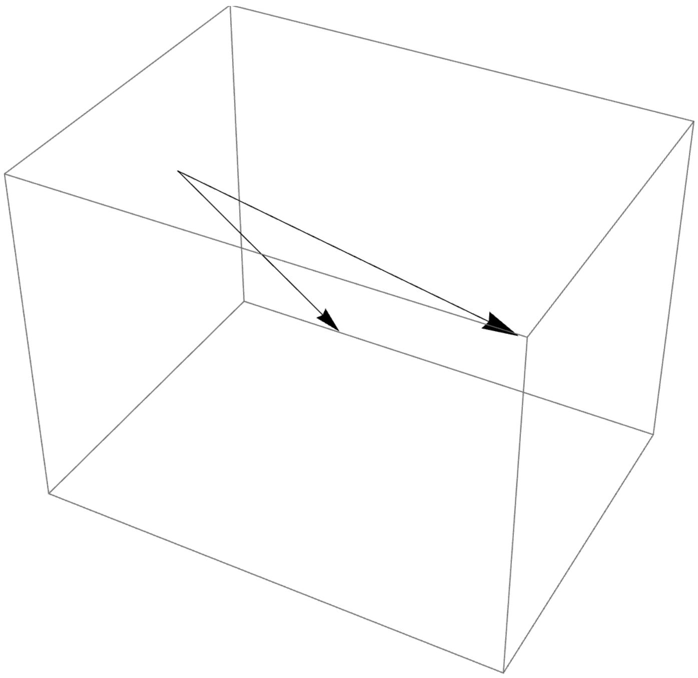
Out[175]=

$$0$$

In[176]:=

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

Out[176]=



In[177]:=

```
Clear[x, y]
```

In[178]:=

```
z = x^2 - y^2
```

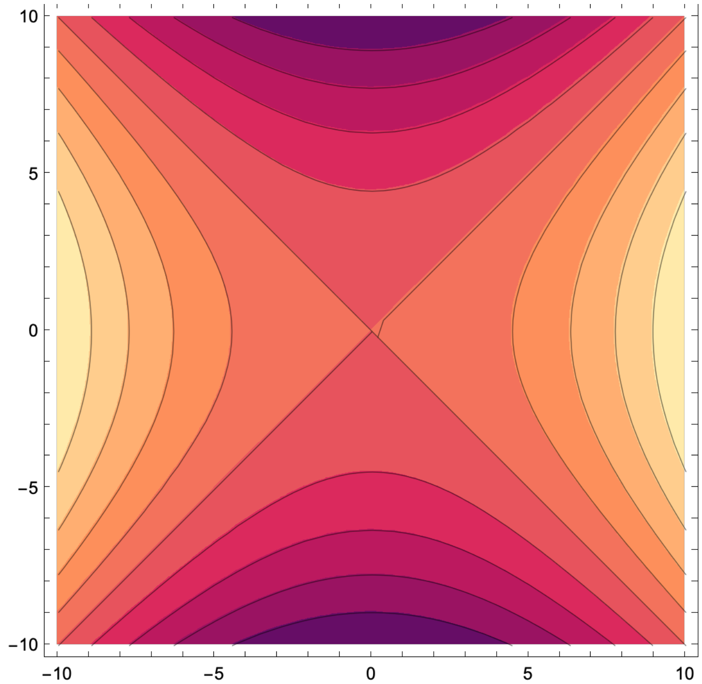
Out[178]=

$x^2 - y^2$

In[179]:=

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

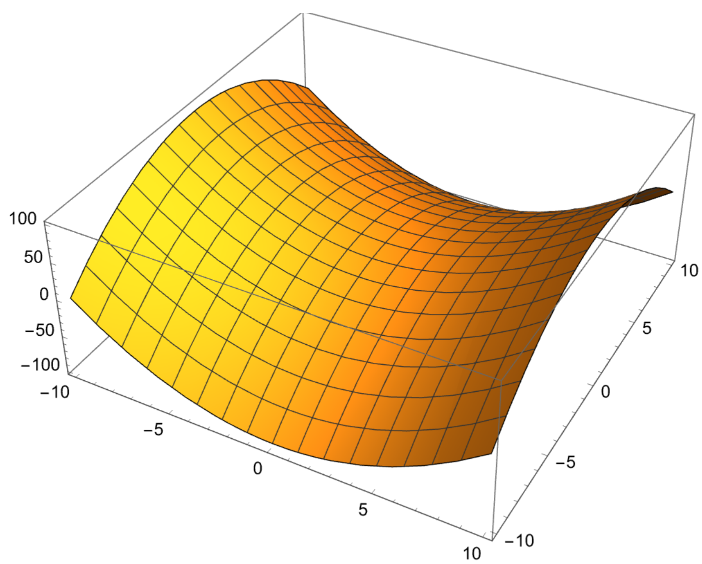
Out[179]=



In[180]:=

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

Out[180]=



Discrete Structures

Binary digits of a number

In[181]:=

```
IntegerDigits[1234567, 2]
```

Out[181]=

{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[182]:=

```
Binomial[52, 5]
```

Out[182]=

2 598 960

A recursive definition of the Fibonacci sequence.

In[183]:=

```
Clear[f]
```

In[184]:=

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

In[186]:=

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

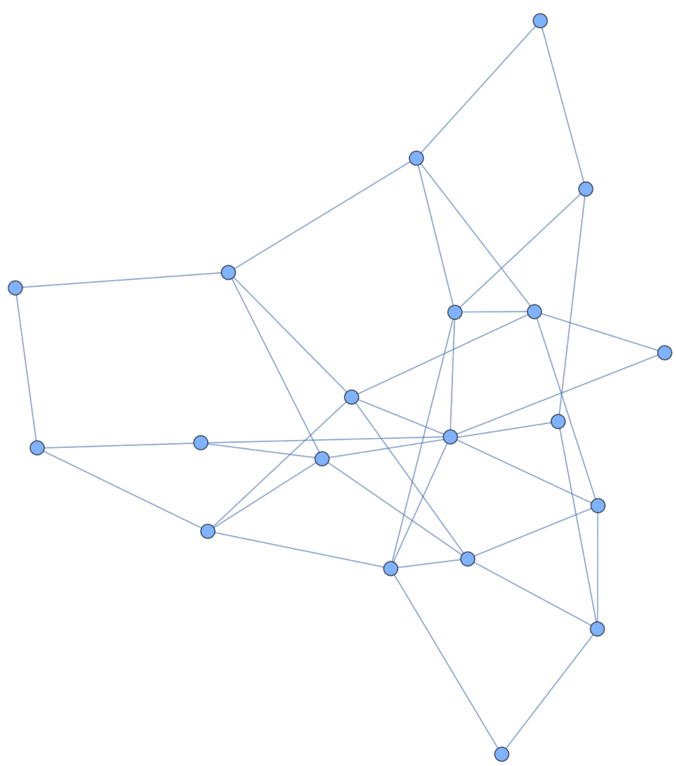
Out[186]=

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

In[187]:=

```
RandomGraph[BernoulliGraphDistribution[20, 1/5]]
```

Out[187]=



Linear Algebra

Linear Equations

In[188]:=

```
Clear[x, y, z]
```

In[189]:=

```
Solve[{x + y + z == 4, x + 2 y - z == 5, x - y - z == 0}, {x, y, z}]
```

Out[189]=

$$\left\{\left\{x \to 2, y \to \frac{5}{3}, z \to \frac{1}{3}\right\}\right\}$$

Matrix Equations

In[190]:=

$$A = \begin{pmatrix} 2 & -1 & 0 \\ -1 & 3 & -1 \\ 0 & -1 & 4 \end{pmatrix}$$

Out[190]=

$$\begin{pmatrix} 2 & -1 & 0 \\ -1 & 3 & -1 \\ 0 & -1 & 4 \end{pmatrix}$$

In[191]:=

```
Solve[A.{x, y, z} == {3, 4, 5}, {x, y, z}]
```

Out[191]=

$$\{\{x \to 3, y \to 3, z \to 2\}\}$$

In[192]:=

```
Inverse[A]
```

Out[192]=

$$\begin{pmatrix} \frac{11}{18} & \frac{2}{9} & \frac{1}{18} \\ \frac{2}{9} & \frac{4}{9} & \frac{1}{9} \\ \frac{1}{18} & \frac{1}{9} & \frac{5}{18} \end{pmatrix}$$

Differential Equations

In[193]:=

```
Clear[x, t]
```

In[194]:=

```
DSolve[x'[t] == -2 x[t] + t^2, x[t], t]
```

Out[194]=

$$\left\{\left\{x(t) \to \frac{1}{4}\left(2 t^2 - 2 t + 1\right) + c_1 e^{-2 t}\right\}\right\}$$

In[195]:=

```
DSolve[{x'[t] == -2 x[t] + t^2, x[0] == 1}, x[t], t]
```

Out[195]=

$$\left\{\left\{x(t) \to \frac{1}{4} e^{-2 t}\left(2 e^{2 t} t^2 - 2 e^{2 t} t + e^{2 t} + 3\right)\right\}\right\}$$

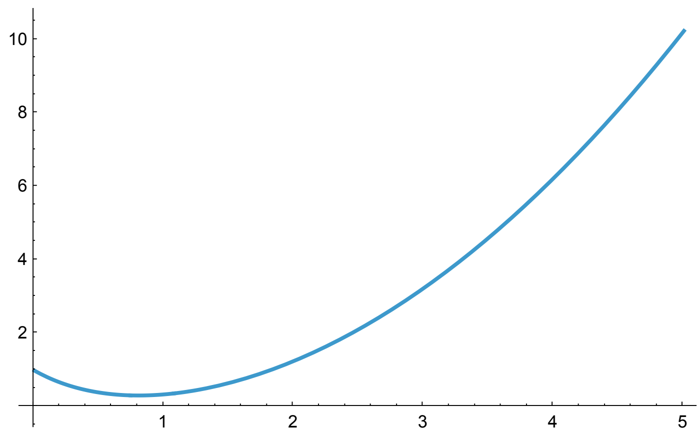
In[196]:=

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

In[197]:=

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

Out[197]=



Probability & Statistics

Distribution of probabilities for the roll of a fair die:

In[198]:=

```
roll = DiscreteUniformDistribution[{1, 6}]
```

Out[198]=

DiscreteUniformDistribution[{1, 6}]

In[199]:=

```
RandomVariate[roll]
```

Out[199]=

4

In[200]:=

```
PDF[roll]
```

Out[200]=

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

In[201]:=

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

In[202]:=

```
{twodice, twodice, twodice}
```

Out[202]=

{6, 10, 5}

In[203]:=

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

In[204]:=

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

Out[204]=

6.9981

In[205]:=

```
Histogram[data]
```

Out[205]=