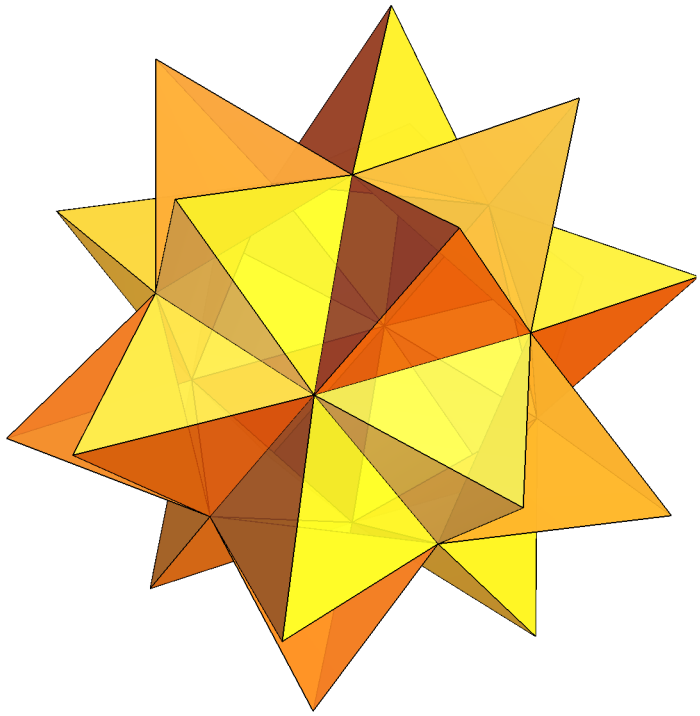
An Introduction to Mathematica and the Wolfram Language for Engineers

image of mathematica logo

image of mathematica logo

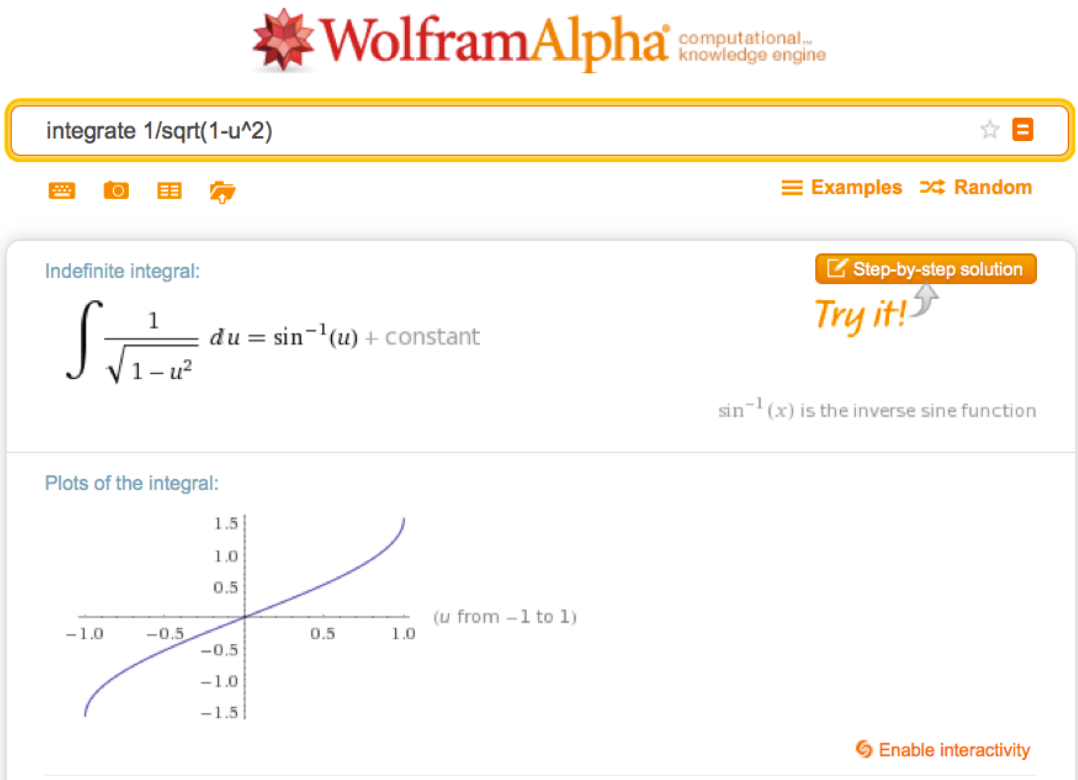
```
Entity["Polyhedron", "MathematicaPolyhedron"][image]
```



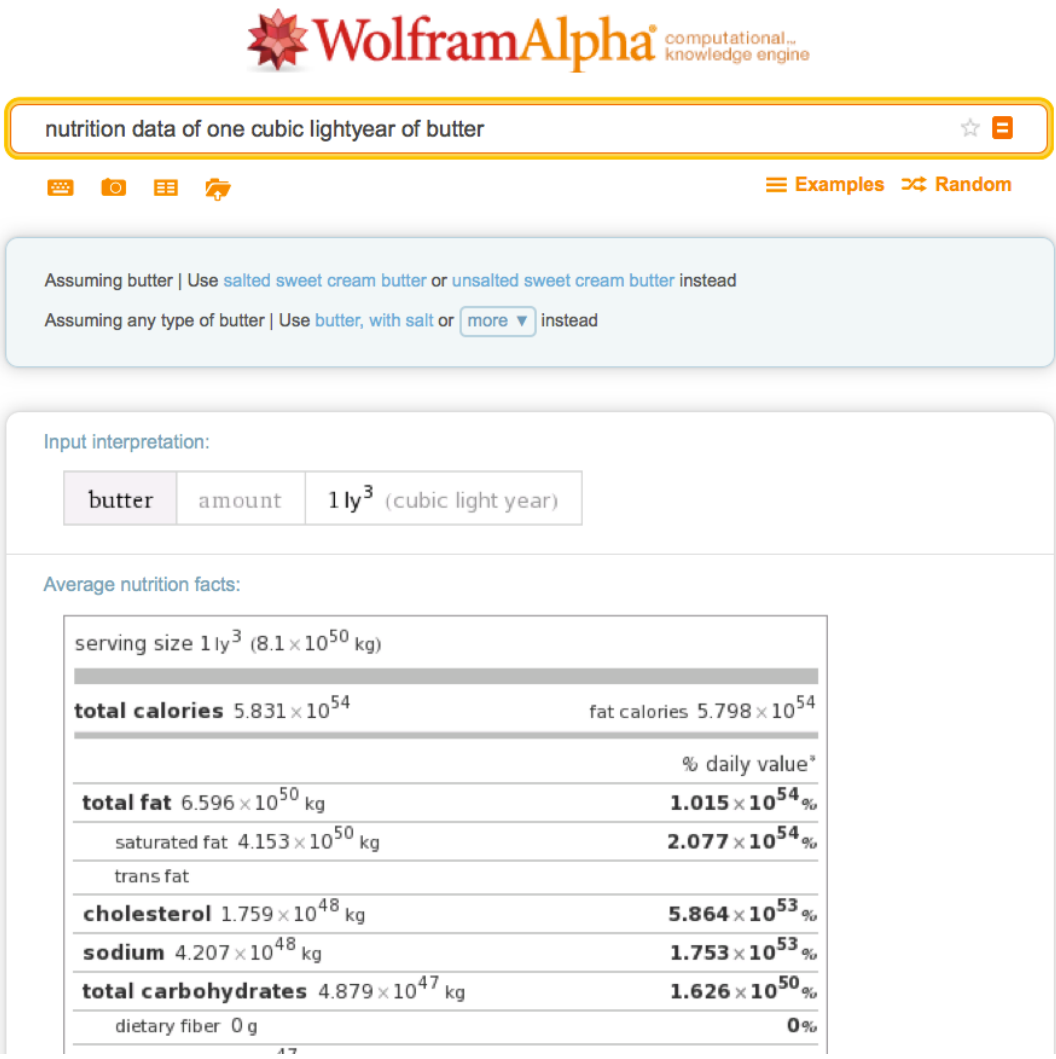
Justin Pearson

Mar 22, 2016

What is Mathematica?


WolframAlpha computational knowledge engine
integrate 1/sqrt(1-u^2)
Examples
Random
Indefinite integral:
Step-by-step solution
Try it!
$\int \frac{1}{\sqrt{1-u^2}}\, du = \sin^{-1}(u) + \text{constant}$
$\sin^{-1}(x)$ is the inverse sine function
Plots of the integral:
1.5
1.0
0.5
−1.0
−0.5
0.5
1.0
−0.5
−1.0
−1.5
(u from −1 to 1)
Enable interactivity

link

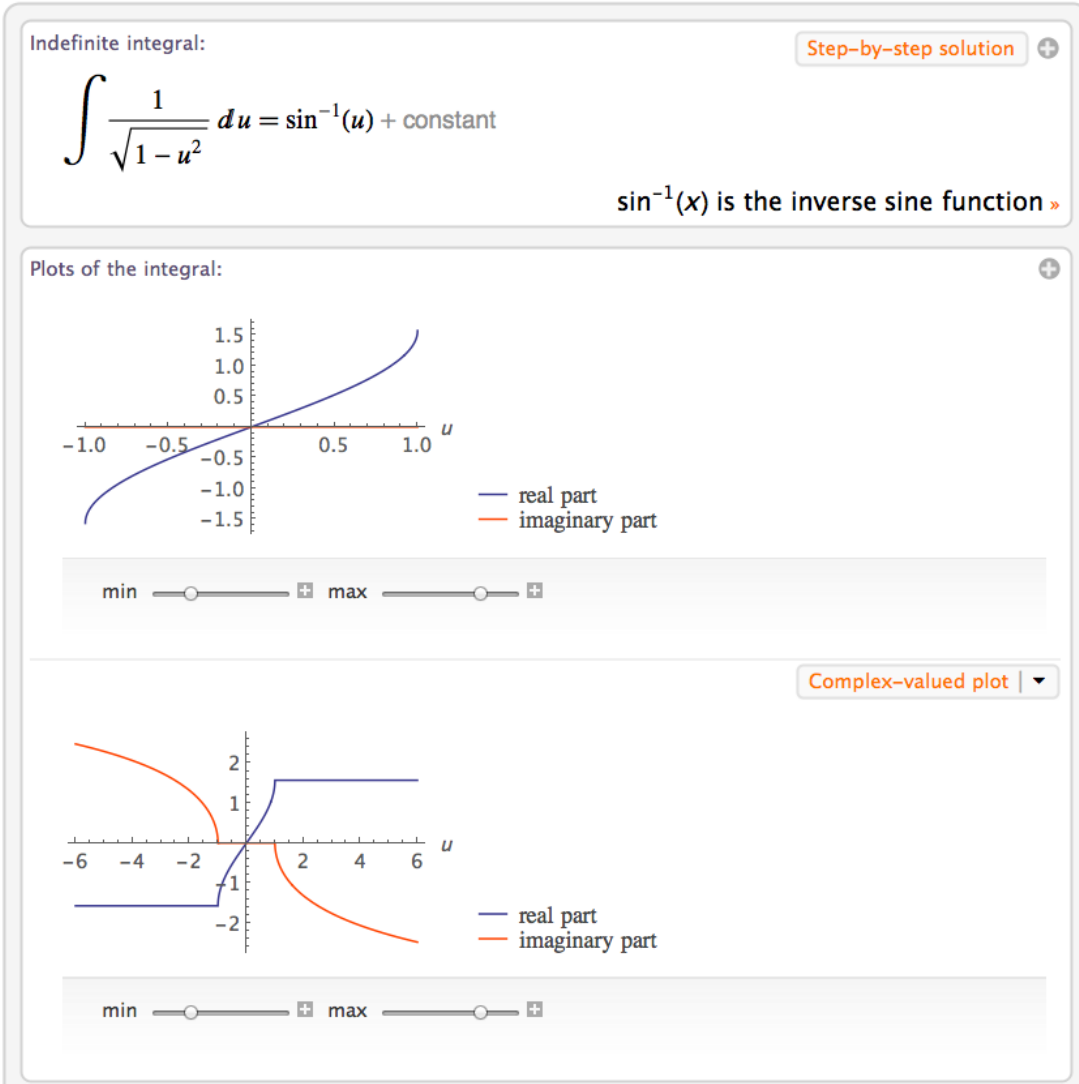

WolframAlpha computational... knowledge engine
nutrition data of one cubic lightyear of butter
Examples
Random
Assuming butter | Use salted sweet cream butter or unsalted sweet cream butter instead
Assuming any type of butter | Use butter, with salt or more ▼ instead
Input interpretation:
butter
amount
1 ly^3 (cubic light year)
Average nutrition facts:
serving size 1 ly^3 (8.1×10^50 kg)
total calories 5.831×10^54
fat calories 5.798×10^54
% daily value*
total fat 6.596×10^50 kg
1.015×10^54 %
saturated fat 4.153×10^50 kg
2.077×10^54 %
trans fat
cholesterol 1.759×10^48 kg
5.864×10^53 %
sodium 4.207×10^48 kg
1.753×10^53 %
total carbohydrates 4.879×10^47 kg
1.626×10^50 %
dietary fiber 0 g
0 %

link

W|A is powered by the Wolfram Language

Call W|A from within the Wolfram Lanauage:

```
WolframAlpha["integrate 1/sqrt(1-u^2)"]
```



Or do the integral from within M:

```
Integrate[1/Sqrt[1-u^2], u]
```

```
ArcSin[u]
```

$$\int \frac{1}{\sqrt{1-u^2}}\, du$$

```
ArcSin[u]
```

… but there's more

to the Wolfram Language than ‘just’ W|A.

What everyone knows about Mathematica

Symbolic manipulation

```
Solve[a x^2 + b x + c == 0, x]
```

$$\left\{\left\{x \to \frac{-b - \sqrt{b^2 - 4\,a\,c}}{2\,a}\right\}, \left\{x \to \frac{-b + \sqrt{b^2 - 4\,a\,c}}{2\,a}\right\}\right\}$$

Solve math problems

```
DSolve[{
  x''[t] + 3 x'[t] + 2 x[t] == 0,
  x[0] == 1, x'[0] == 0}, x[t], t]
```

$$\left\{\left\{x[t] \to e^{-2\,t}\left(-1 + 2\,e^{t}\right)\right\}\right\}$$

Weird symbolic output

$$\int_{-\infty}^{\infty} \frac{\mathrm{Sin}[x]}{x}\,dx$$

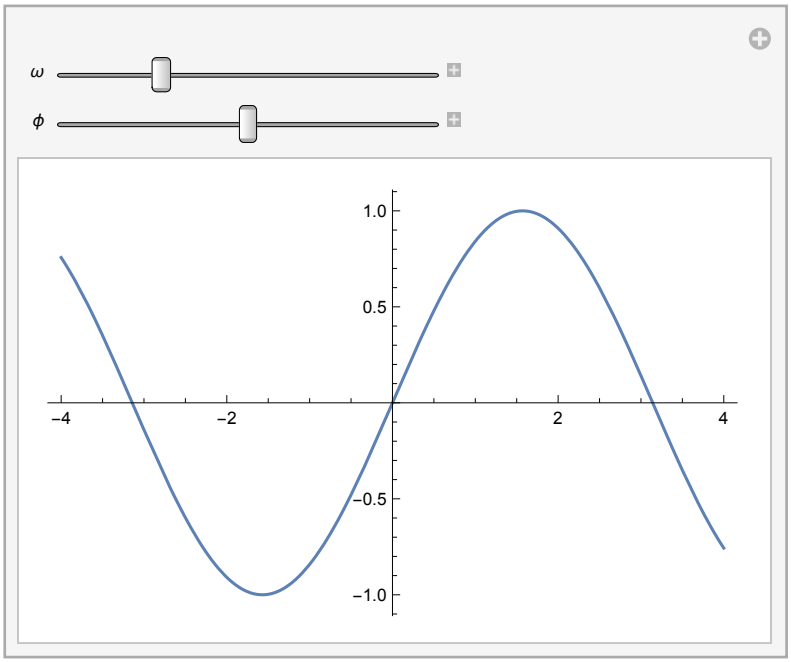
π

$$\int_{-\infty}^{\infty} \frac{\mathrm{Sin}[a\,x]}{x}\,dx$$

ConditionalExpression[π Sign[a], a $\in$ Reals]

Easy interactive interface

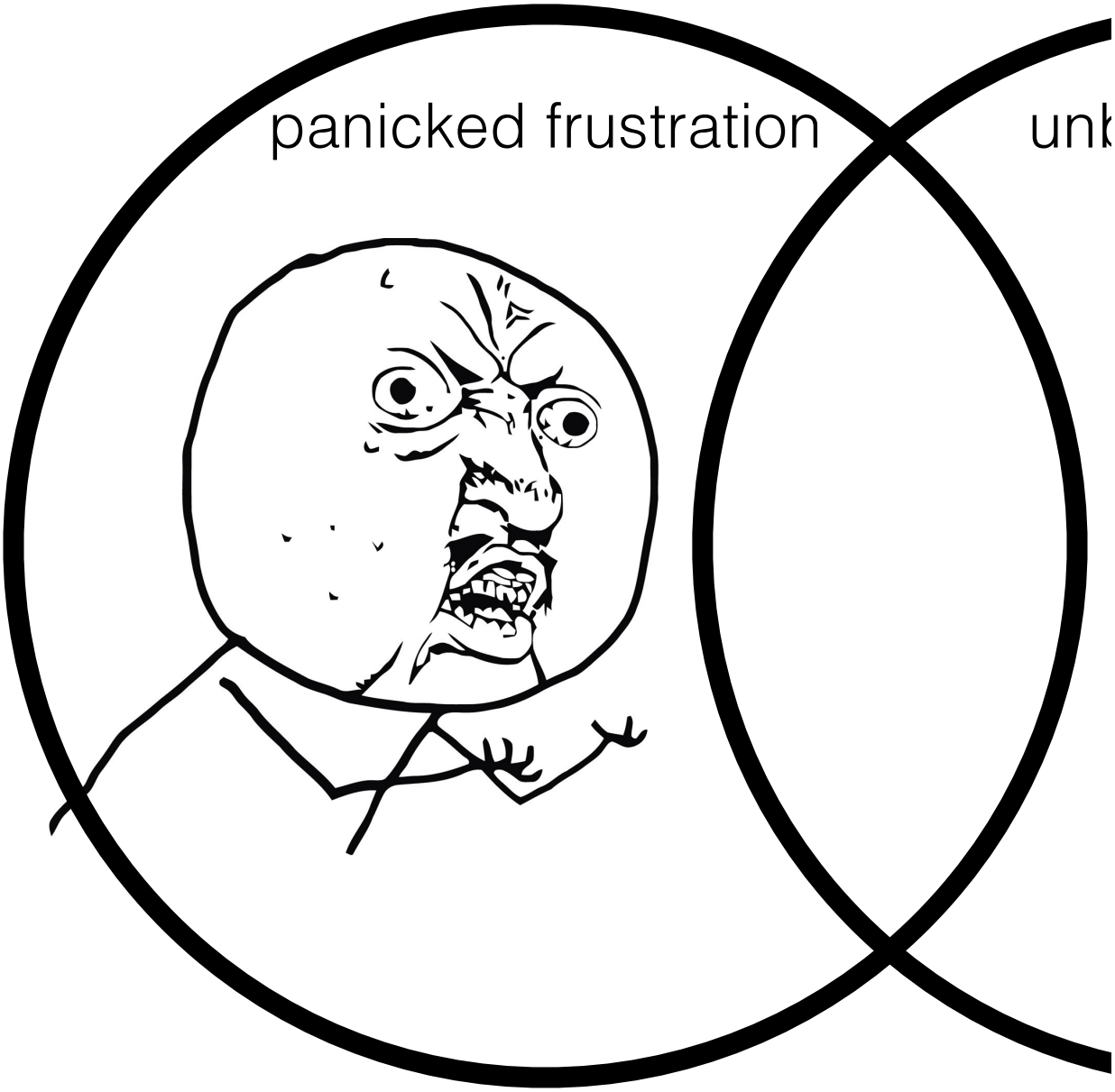
```
Manipulate[Plot[Sin[ω t + ϕ], {t, -4, 4}], {{ω, 1}, 0, 4}, {{ϕ, 0}, -4, 4}]
```



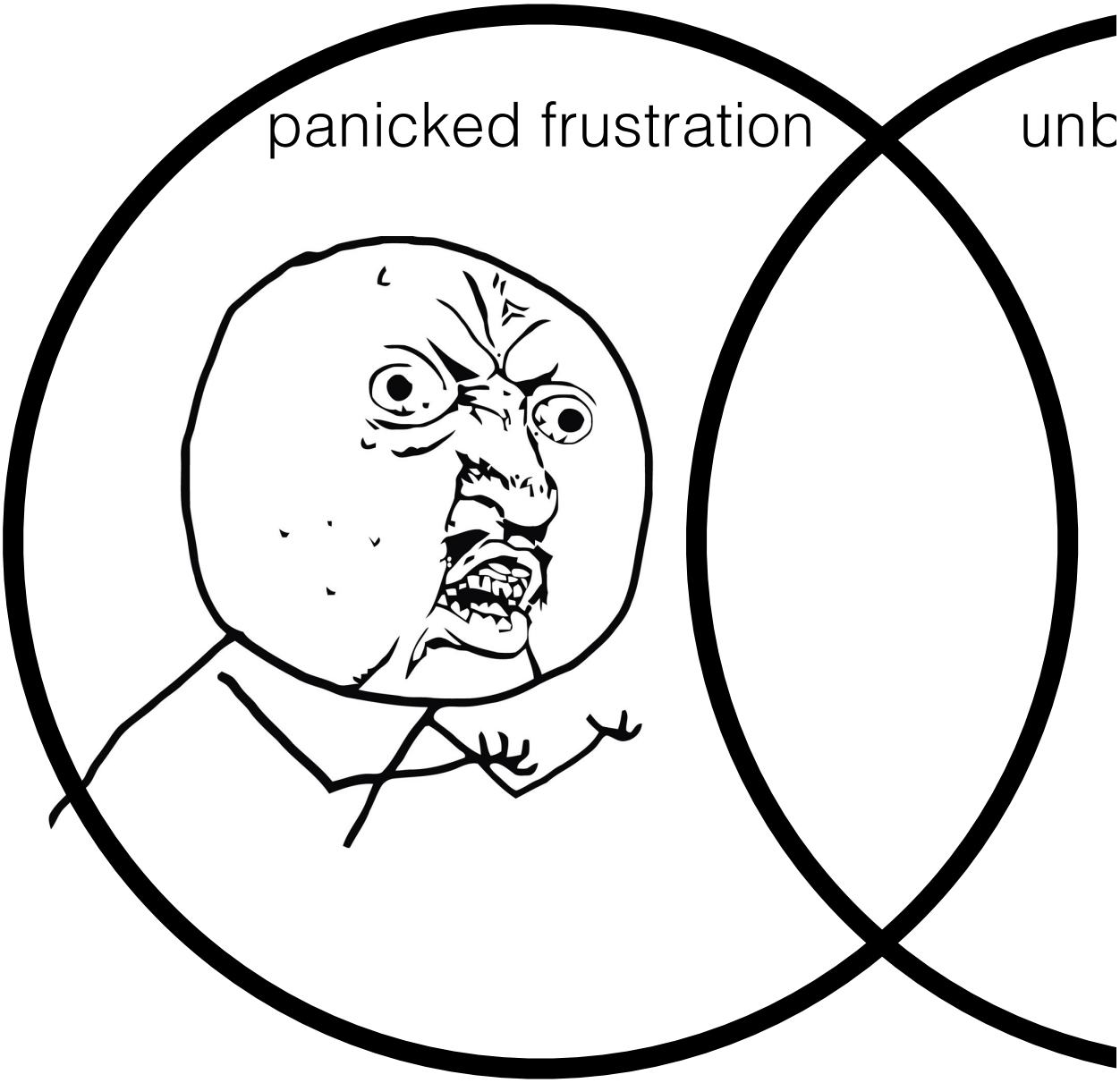
“Mathematica” and “The Wolfram Language”

Need help on this slide.

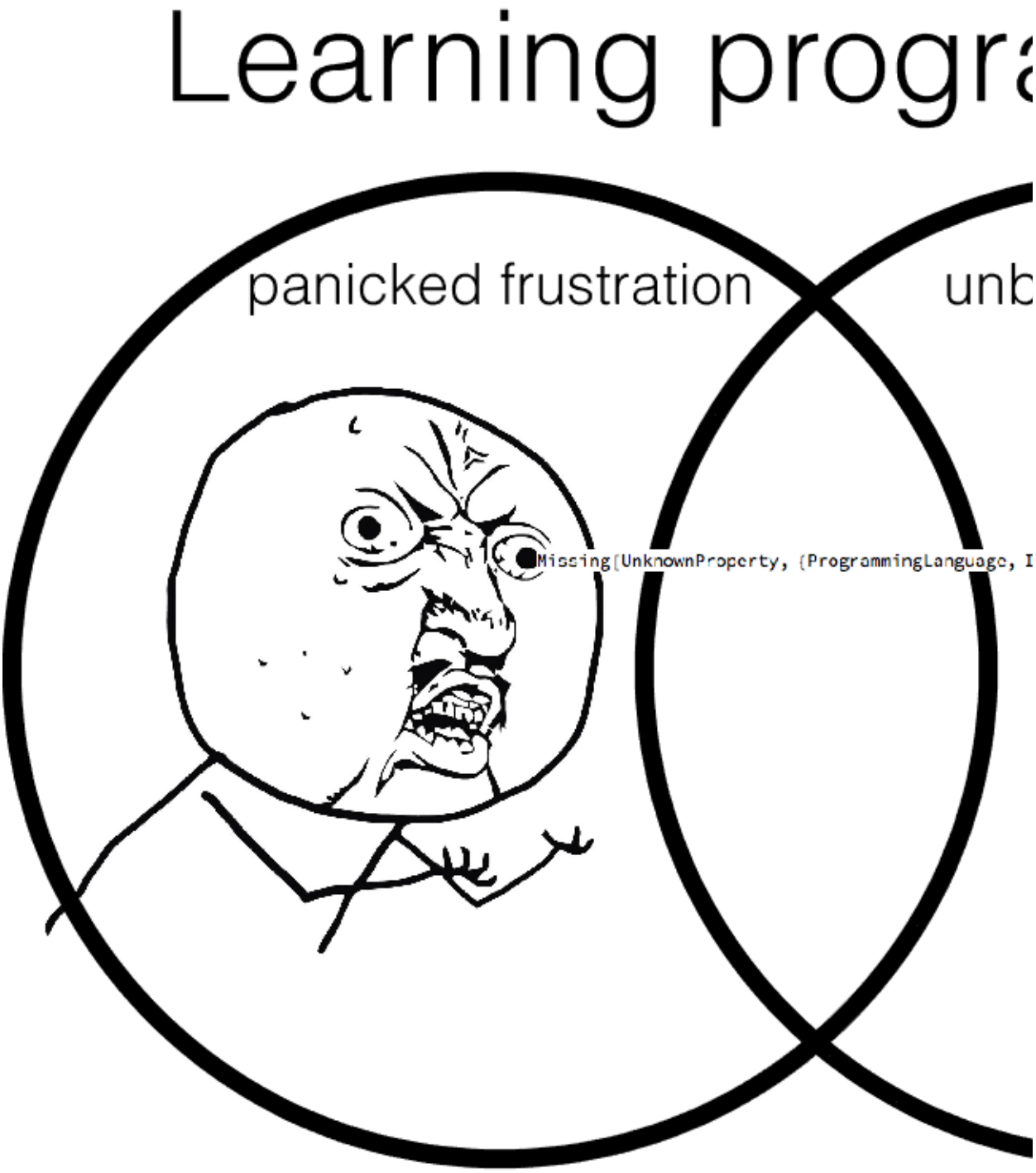
```
im =
```



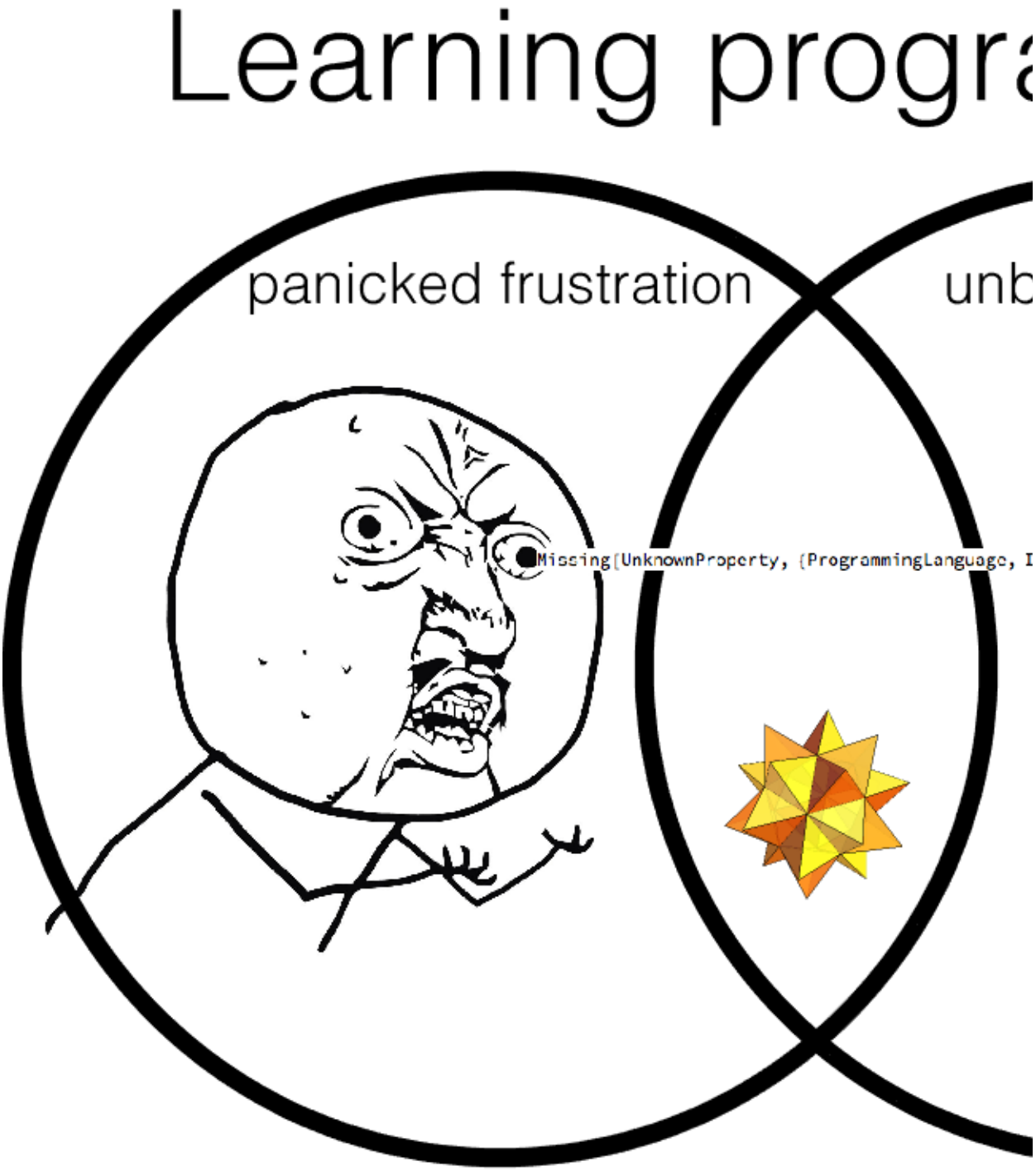
Learning progra



```
ImageCompose[im, Rasterize@WolframAlpha["image of matlab logo", "Result"]]
```

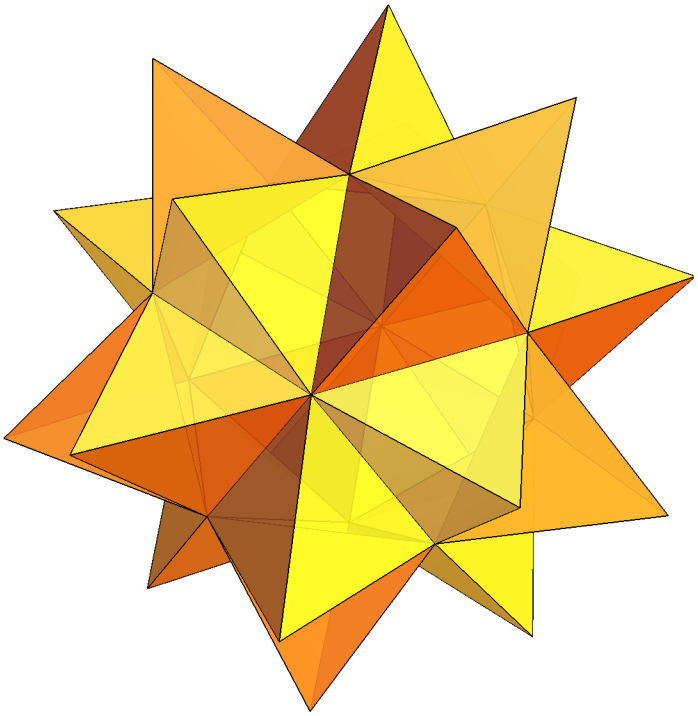


```
ImageCompose[%, Rasterize[WolframAlpha["image of mathematica logo", "Result"],
  ImageSize → 120], Scaled[{0.5, 0.3}]]
```



Why should I

```
WolframAlpha["image of mathematica logo", "Result"]
```



if I already have to

```
WolframAlpha["image of matlab logo", "Result"]
```

```
Missing[UnknownProperty, {ProgrammingLanguage, Image}]
```

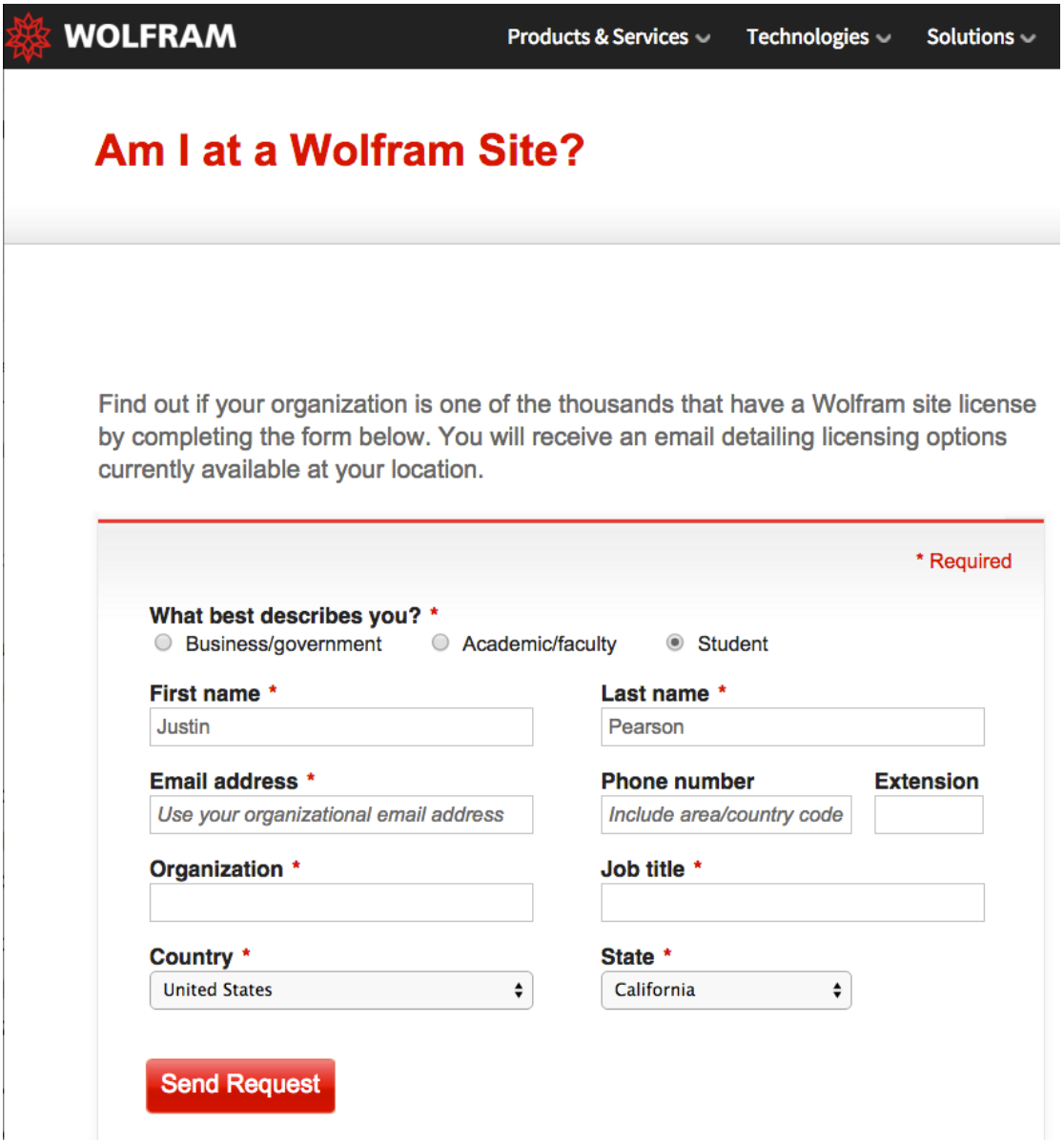
1. Money

2. Knowledge

3. Power

1. Money

Many schools make Mathematica **free** for students on their **personal computers**:



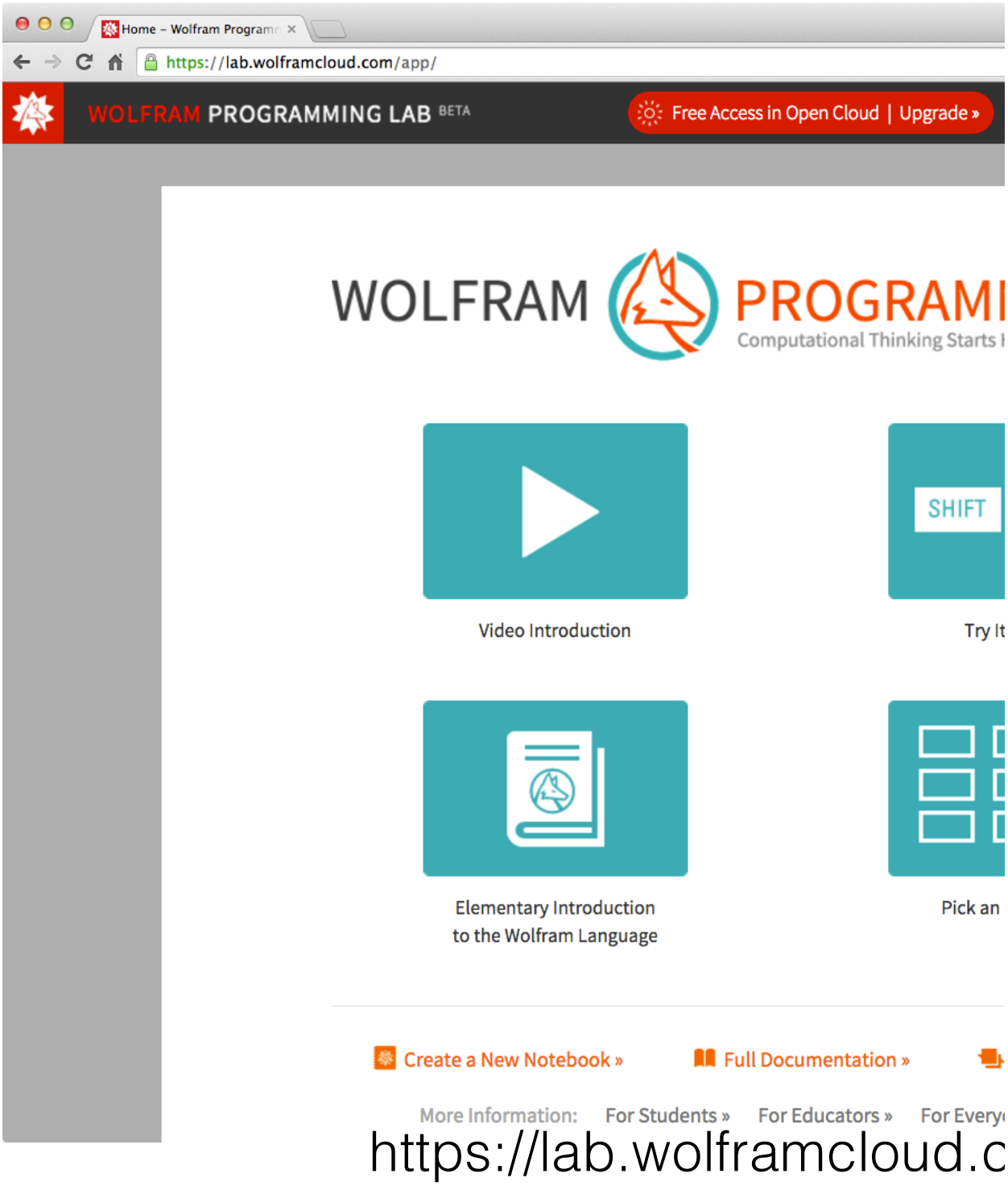
link

You get a lot of functionality in a single program:

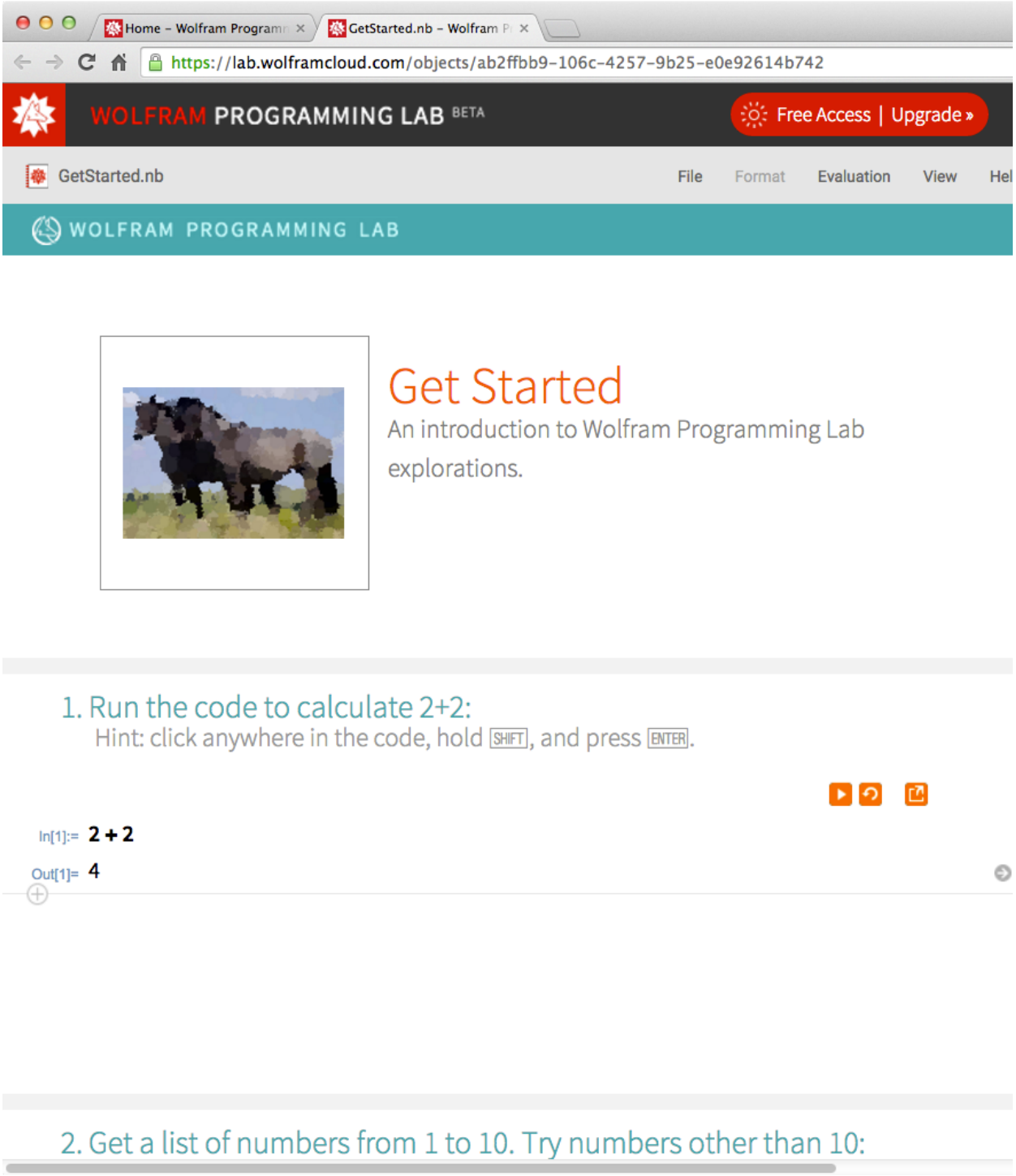
Mathematica doesn't use the "toolbox" model:

http://www.walkingrandomly.com/?p=4679

Can try it free online:



link


Home – Wolfram Programm
GetStarted.nb – Wolfram P
https://lab.wolframcloud.com/objects/ab2ffbb9-106c-4257-9b25-e0e92614b742
WOLFRAM PROGRAMMING LAB BETA
Free Access | Upgrade »
GetStarted.nb
File
Format
Evaluation
View
Hel
WOLFRAM PROGRAMMING LAB
Get Started
An introduction to Wolfram Programming Lab explorations.
1. Run the code to calculate 2+2:
Hint: click anywhere in the code, hold SHIFT, and press ENTER.
In[1]:= 2 + 2
Out[1]= 4
2. Get a list of numbers from 1 to 10. Try numbers other than 10:

1. Money

- Free
- No toolboxes to buy
- Can try online (no install)

1. Money

- Free
- No toolboxes to buy
- Can try online (no install)

2. Knowledge

3. Power

2. Knowledge

Mathematica helps with homework:

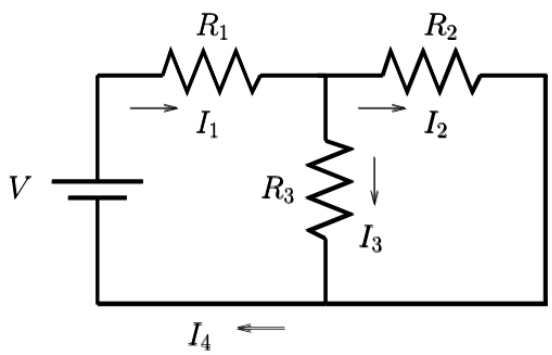
Circuit analysis:

1. (5 points) For the DC circuit shown here, Kirchhoff's Rules and Ohm's Law tell us the following relationships between the currents I_1, I_2, I_3, I_4, the resistances R_1, R_2, R_3, and the voltage V provided by the battery:

$$\begin{aligned} I_2 + I_3 &= I_1 \\ I_2 + I_3 &= I_4 \\ I_1 R_1 + I_3 R_3 &= V \\ I_1 R_1 + I_2 R_2 &= V \end{aligned}$$

Write a function `find_current.m` which takes as inputs the values for V, R_1, R_2, and R_3, and returns as output a column vector containing the values of the currents I_1, I_2, I_3, I_4, in that order.

Please submit the file `find_current.m`.



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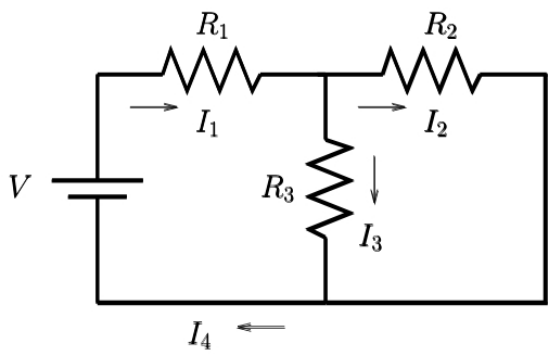

Circuit Analysis Homework Problem

Johnny A. Student

Problem statement

(Image pasted from homework pdf)

1. (5 points) For the DC circuit shown here, Kirchhoff's Rules and Ohm's Law tell us the following relationships between the currents I_1, I_2, I_3, I_4, the resistances R_1, R_2, R_3, and the voltage V provided by the battery:

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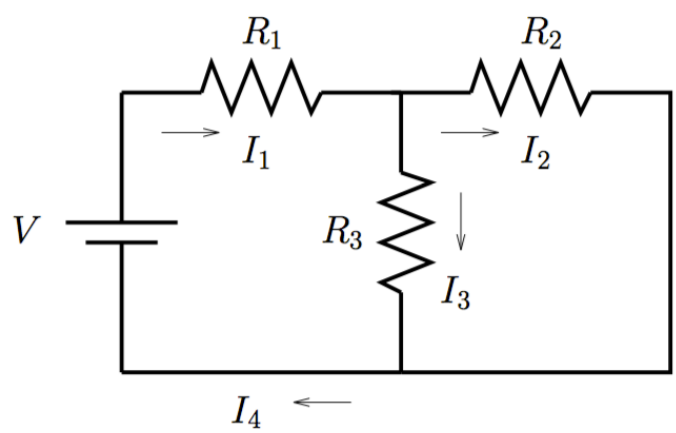


Matlab answer

```
function I = find_current (V, R1, R2, R3)

% matrix for Kirchhoff' s rules
A = [-1 × 1 × 1 × 0;
   0 × 1 × 1 - 1;
   R1 0 R3 0;
   R1 R2 0 × 0];

% righthand side for Kirchhoff' s rules
b = [0; 0; V; V];

% solve for currents
I = A\b;

end
```

Linear algebra method

$$\begin{aligned} I_2 + I_3 &= I_1 \\ I_2 + I_3 &= I_4 \\ I_1 R_1 + I_3 R_3 &= V \\ I_1 R_1 + I_2 R_2 &= V \end{aligned}$$

```
eqns = {
  I2 + I3 == I1,
  I2 + I3 == I4,
  I1 R1 + I3 R3 == V,
  I1 R1 + I2 R2 == V
 }
```

```
{I2 + I3 == I1, I2 + I3 == I4, I1 R1 + I3 R3 == V, I1 R1 + I2 R2 == V}
```

Get the matrix coefficients:

```
{b, A} = CoefficientArrays[eqns, {I1, I2, I3, I4}];
b = -b;
MatrixForm[A]
MatrixForm[b]
```

$$\begin{pmatrix} -1 & 1 & 1 & 0 \\ 0 & 1 & 1 & -1 \\ R1 & 0 & R3 & 0 \\ R1 & R2 & 0 & 0 \end{pmatrix}$$

$$\begin{pmatrix} 0 \\ 0 \\ V \\ V \end{pmatrix}$$

Solve for the currents:

Symbolic matrix inverses:

```
Inverse[A] // MatrixForm
```

$$\begin{pmatrix} \frac{R2\,R3}{-R1\,R2-R1\,R3-R2\,R3} & 0 & -\frac{R2}{-R1\,R2-R1\,R3-R2\,R3} & -\frac{R3}{-R1\,R2-R1\,R3-R2\,R3} \\ -\frac{R1\,R3}{-R1\,R2-R1\,R3-R2\,R3} & 0 & \frac{R1}{-R1\,R2-R1\,R3-R2\,R3} & \frac{-R1-R3}{-R1\,R2-R1\,R3-R2\,R3} \\ -\frac{R1\,R2}{-R1\,R2-R1\,R3-R2\,R3} & 0 & \frac{-R1-R2}{-R1\,R2-R1\,R3-R2\,R3} & \frac{R1}{-R1\,R2-R1\,R3-R2\,R3} \\ \frac{-R1\,R2-R1\,R3}{-R1\,R2-R1\,R3-R2\,R3} & \frac{R1\,R2+R1\,R3+R2\,R3}{-R1\,R2-R1\,R3-R2\,R3} & -\frac{R2}{-R1\,R2-R1\,R3-R2\,R3} & -\frac{R3}{-R1\,R2-R1\,R3-R2\,R3} \end{pmatrix}$$

This is like inv(A)*b

```
Inverse[A].b // Simplify
```

$$\left\{\frac{(R2+R3)\,V}{R2\,R3+R1\,(R2+R3)}, \frac{R3\,V}{R2\,R3+R1\,(R2+R3)}, \frac{R2\,V}{R2\,R3+R1\,(R2+R3)}, \frac{(R2+R3)\,V}{R2\,R3+R1\,(R2+R3)}\right\}$$

This is like A\b (more efficient):

```
LinearSolve[A, b] // Simplify
```

$$\left\{\frac{(R2+R3)\,V}{R2\,R3+R1\,(R2+R3)}, \frac{R3\,V}{R2\,R3+R1\,(R2+R3)}, \frac{R2\,V}{R2\,R3+R1\,(R2+R3)}, \frac{(R2+R3)\,V}{R2\,R3+R1\,(R2+R3)}\right\}$$

Plug in V=5v, $R_i = 100\Omega$:

```
% /. {V → 5, R1 → 100, R2 → 100, R3 → 100}
```

$$\left\{\frac{1}{30}, \frac{1}{60}, \frac{1}{60}, \frac{1}{30}\right\}$$

Define a function to plug these vars in.
No need to define it in a separate m-file :)

```
findCurrents[V_, R1_, R2_, R3_] = %%
```

$$\left\{\frac{(R2+R3)\,V}{R2\,R3+R1\,(R2+R3)}, \frac{R3\,V}{R2\,R3+R1\,(R2+R3)}, \frac{R2\,V}{R2\,R3+R1\,(R2+R3)}, \frac{(R2+R3)\,V}{R2\,R3+R1\,(R2+R3)}\right\}$$

```
findCurrents[5, 100, 100, 100]
```

$$\left\{\frac{1}{30}, \frac{1}{60}, \frac{1}{60}, \frac{1}{30}\right\}$$

```
N[%]
```

{0.0333333, 0.0166667, 0.0166667, 0.0333333}

Solve directly for currents $I_{1,2,3,4}$

Why not solve directly for the currents?

```
Solve[eqns, {I1, I2, I3, I4}]
```

$$\left\{\left\{I1 \to -\frac{-R2\,V - R3\,V}{R1\,R2 + R1\,R3 + R2\,R3}, I2 \to \frac{R3\,V}{R1\,R2 + R1\,R3 + R2\,R3}, I3 \to \frac{R2\,V}{R1\,R2 + R1\,R3 + R2\,R3}, I4 \to \frac{(R2 + R3)\,V}{R1\,R2 + R1\,R3 + R2\,R3}\right\}\right\}$$

```
% /. {V → 5, R1 → 100, R2 → 100, R3 → 100}
```

$$\left\{\left\{I1 \to \frac{1}{30}, I2 \to \frac{1}{60}, I3 \to \frac{1}{60}, I4 \to \frac{1}{30}\right\}\right\}$$

```
N[%]
```

{{I1 → 0.0333333, I2 → 0.0166667, I3 → 0.0166667, I4 → 0.0333333}}

Summary:

elec-currents-2.nb

Solve for currents $I_{1,2,3,4}$

Nice header

$$
\begin{aligned}
I_2 + I_3 &= I_1 \\
I_2 + I_3 &= I_4 \\
I_1 R_1 + I_3 R_3 &= V \\
I_1 R_1 + I_2 R_2 &= V
\end{aligned}
$$

Copy/paste problem stmt from pdf

In[94]:=

```
soln = Solve[
  {
   I2 + I3 == I1,
   I2 + I3 == I4,
   I1 R1 + I3 R3 == V,
   I1 R1 + I2 R2 == V
  }, {I1, I2, I3, I4}]
```

Express concept more directly

in & out adjacent

Out[94]=

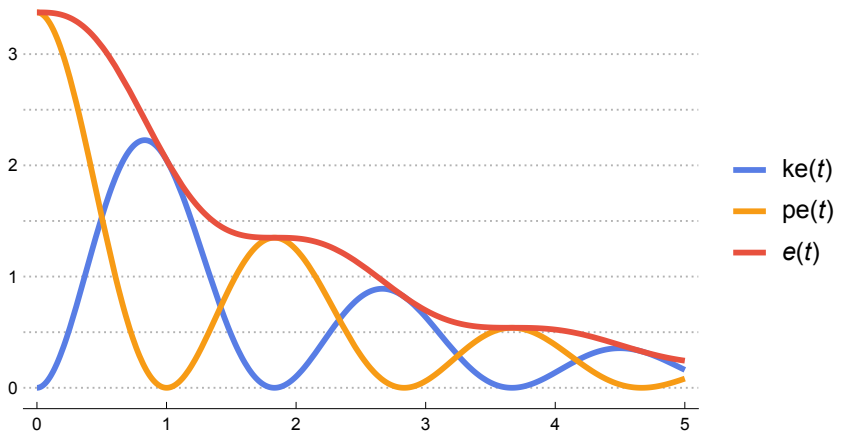
$$\left\{\left\{I1 \to -\frac{-R2\ V - R3\ V}{R1\ R2 + R1\ R3 + R2\ R3},\right.\right.$$

200%

2. Knowledge

Mathematica helps with homework:

ODE problem:



Homework problem with Ordinary Differential Equations:

1. Download the programs `spring_main.m` and `spring.m`. The first calls the latter through `ode23` to solve the ordinary differential equation

$$m\frac{d^2x}{dt^2} + b\frac{dx}{dt} + kx = 0$$

with parameter values

$$m = 1, \qquad b = 0.5, \qquad k = 3$$

and initial conditions

$$x(0) = 1.5, \qquad x'(0) = 0.$$

(Here we are assuming that the equilibrium x value is 0.)

Edit `spring_main.m` so that after the call to `ode23`, it makes a single figure in which the kinetic energy

$$KE = \frac{1}{2}m\left(\frac{dx}{dt}\right)^2$$

is plotted as a function of time in blue, the potential energy

$$PE = \frac{1}{2}kx^2$$

is plotted as a function of time in red, and the total energy

$$E = KE + PE$$

is plotted as a function of time in green. The time interval for these plots should be from 0 to 10. All three curves should be on the same figure. Your figure must include the label 't' on the horizontal axis, a title, and a legend which indicates which line corresponds to

Solving ODEs in Matlab is weird:

Matlab: $mx'' + bx' + kx = 0$

Pick $x_1 := x$, $x_2 := x'$ so that $x_1' = x' = x_2$, $x_2' = x'' = -\frac{1}{m}(bx' + kx)$

2nd-order -> vec 1st order

Then

```
function Xdot = f(t,X)
globals m b k
x1 = X(1);
x2 = X(2);

Xdot = zeros(size(X));
Xdot(1) = x2;
Xdot(2) = -1/m*(b*x2+k*x1)
```

encapsulate RHS in .m file

Then

```
ode45(@f,[0,2],[1;0;0])
```

numerically integrate w/ fn handle

ODE homework problem

Johnny A. Student

Part I

1. Download the programs **spring_main.m** and **spring.m**. through **ode23** to solve the ordinary differential equation

$$m\frac{d^2x}{dt^2} + b\frac{dx}{dt} + kx = 0$$

with parameter values

$$m = 1, \qquad b = 0.5, \qquad k = 3$$

and initial conditions

$$x(0) = 1.5, \qquad x'(0) = 0.$$

(Here we are assuming that the equilibrium x value is 0.)

```
Clear["Global`*"]
```

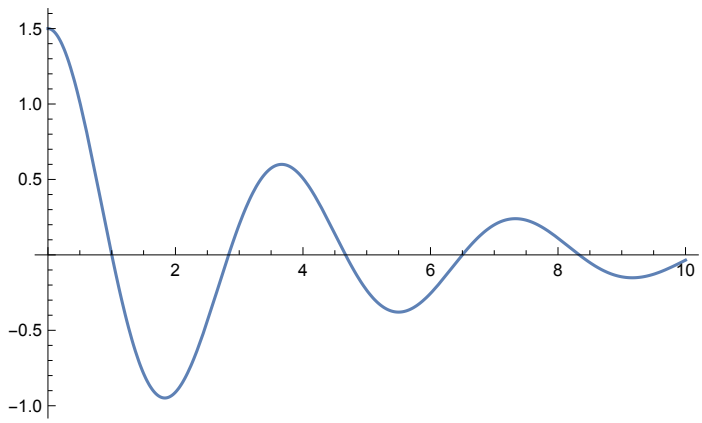
```
m = 1; b = 1/2; k = 3;
x0 = 3/2;
v0 = 0;
```

```
DSolve[
 {
  m x''[t] + b x'[t] + k x[t] == 0,
  x[0] == x0,
  x'[0] == v0
 },
 x[t], t]
```

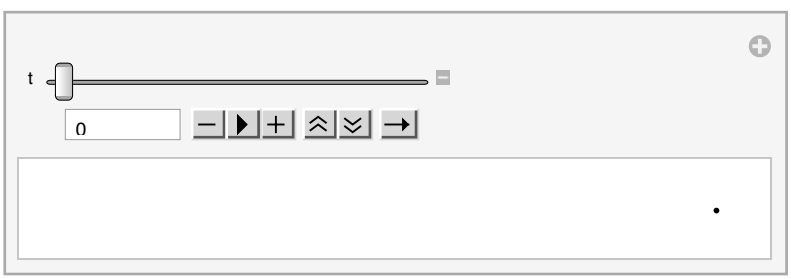
$$\left\{\left\{x[t] \to \frac{3}{94} e^{-t/4} \left(47 \operatorname{Cos}\left[\frac{\sqrt{47}\, t}{4}\right] + \sqrt{47} \operatorname{Sin}\left[\frac{\sqrt{47}\, t}{4}\right]\right)\right\}\right\}$$

```
x[t_] = %[[1, 1, 2]];
```

```
Plot[x[t], {t, 0, 10}]
```




```
Manipulate[
 Graphics[Point[{x[t], 0}],
  PlotRange → {{-1.6, 1.6}, {-.1, .1}}
 ], {t, 0, 10, Appearance → "Open"}, SaveDefinitions → True]
```



```
Manipulate[
 Graphics[{
   PointSize[0.05],
   Point[{x[t], 0}],
   Line[{{0, 0}, {x[t], 0}}]},
  PlotRange → {{-1.6, 1.6}, {-.1, .1}}
 ], {t, 0, 10, Appearance → "Open"}, SaveDefinitions → True]
```

Edit **spring_main.m** so that after the call to **ode23**, it makes a single figure the kinetic energy

$$KE = \frac{1}{2} m \left(\frac{dx}{dt}\right)^2$$

is plotted as a function of time in blue, the potential energy

$$PE = \frac{1}{2} k x^2$$

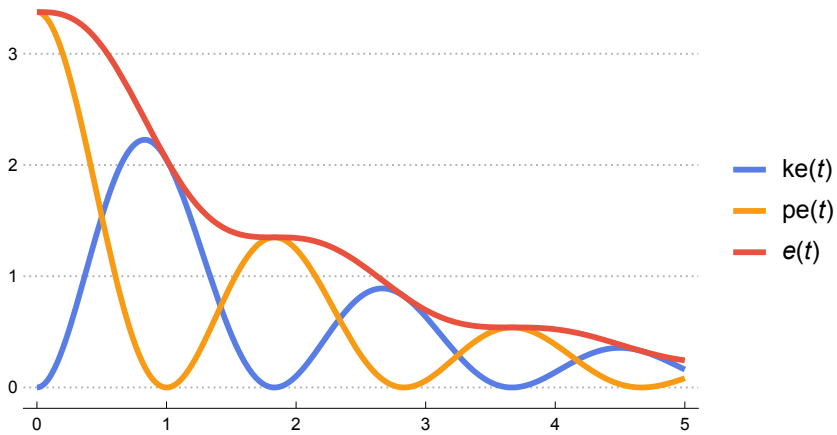
is plotted as a function of time in red, and the total energy

$$E = KE + PE$$

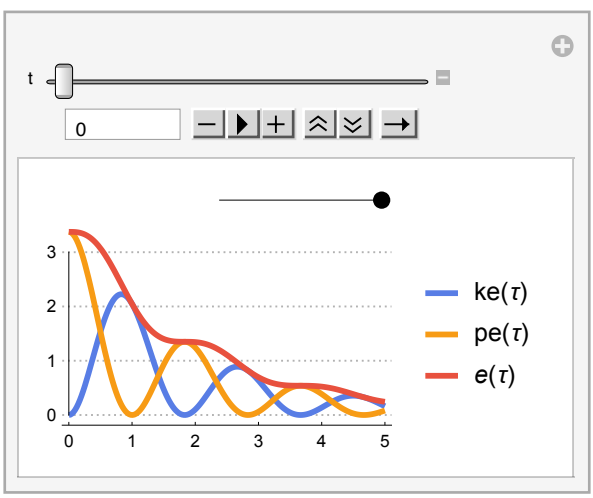
is plotted as a function of time in green. The time interval for these plots shoul 0 to 10. All three curves should be on the same figure. Your figure must include

```
ke[t_] = 1/2 m x'[t]^2;
pe[t_] = 1/2 k x[t]^2;
e[t_] = ke[t] + pe[t];
```

```
Plot[{ke[t], pe[t], e[t]}, {t, 0, 5},
 PlotLegends → "Expressions", PlotTheme → "Business"]
```




```
Manipulate[
 Column@{Graphics[{
     PointSize[0.05],
     Point[{x[t], 0}],
     Line[{{0, 0}, {x[t], 0}}]}],
    PlotRange → {{-1.6, 1.6}, {-.1, .1}},
    ImageSize → Small
   ],
   Plot[{ke[τ], pe[τ], e[τ]}, {τ, 0, 5},
    Epilog → Line[{{t, 0}, {t, 3}}],
    PlotLegends → "Expressions", PlotTheme → "Business"]
  }, {t, 0, 5, Appearance → "Open"}, SaveDefinitions → True]
```




```
Export["~/Desktop/odeplot.pdf", %]
```

```
~/Desktop/odeplot.pdf
```

ODEs, part 2

2. Download the program **animate.m**. A simple pendulum consists of a mass m hanging from a string of length L, which hangs from a pivot. The differential equation for a damped pendulum is given by

$$mL\frac{d^2\theta}{dt^2} + b\frac{d\theta}{dt} + mg\sin\theta = 0$$

where θ is the angle relative to the downward direction, g is the acceleration due to gravity, and b is the coefficient of damping.

Let's take the parameter values to be

$$M = 1, \qquad L = 2, \qquad b = 0.5, \qquad g = 10.$$

Write a Matlab program called **pendulum_main.m** which solves this differential equation over the time interval from 0 to 20 for the following three sets of initial conditions:

$$\theta(0) = 0.5, \qquad \theta'(0) = 0$$

$$\theta(0) = 3.14, \qquad \theta'(0) = 0$$

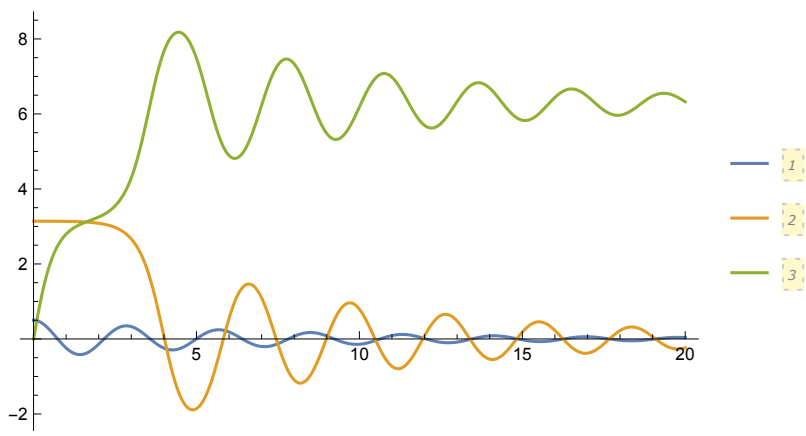
$$\theta(0) = 0, \qquad \theta'(0) = 5$$

```
m = 1; L = 2; b = .5; g = 10;

ics = {
    {θ[0] == 0.5, θ'[0] == 0},
    {θ[0] == 3.14, θ'[0] == 0},
    {θ[0] == 0, θ'[0] == 5}
  };
```

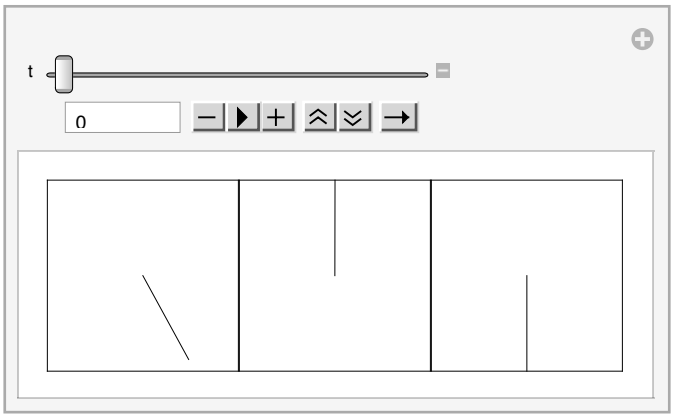
```
fns = Table[
  NDSolve[{m L θ''[t] + b θ'[t] + m g Sin[θ[t]] == 0, ic},
    θ[t], {t, 0, 20}][[1, 1, 2, 0]],
  {ic, ics}
 ]
```

```
{InterpolatingFunction[ Domain: {{0., 20.}} Output: scalar ],
 InterpolatingFunction[ Domain: {{0., 20.}} Output: scalar ],
 InterpolatingFunction[ Domain: {{0., 20.}} Output: scalar ]}
```

```
Plot[{
  fns[[1]][t],
  fns[[2]][t],
  fns[[3]][t]}, {t, 0, 20}, PlotLegends → Automatic]
```



```
Manipulate[Row[
  Graphics[
     Line[{{0, 0}, {Sin[#[t]], -Cos[#[t]]}}],
     PlotRange → {{-1, 1}, {-1, 1}},
     ImageSize → Tiny, Frame → True, FrameTicks → None
    ] & /@ fns], {t, 0, 10, Appearance → "Open"}, SaveDefinitions → True]
```



Summary:

```
DSolve[
 {
  m x''[t] + b x'[t] + k x[t] == 0,
  x[0] == x0,
  x'[0] == v0
 },
 x[t], t]
```

Code

$$\left\{\left\{x[t] \to \frac{3}{94} e^{-t/4} \left(47 \operatorname{Cos}\left[\frac{\sqrt{47}\, t}{4}\right] + \sqrt{47} \operatorname{Sin}\left[\frac{\sqrt{47}}{4}\right.\right.\right.\right.$$

Visualize solutions

1. Money

- Free
- No toolboxes to buy
- Can try online (no install)

2. Knowledge

- Write nicer hw
- Code more directly
- Deeper understanding

3. Power

Wolfram Mathematica
Comparative Analyses

More about *Mathematica* »

Built on powerful core principles, *Mathematica*'s scope has expanded at an increasing rate over two decades—making it now a system of unique breadth and depth, simply without parallel in the world in software.

Mathematica's unified architecture allows it to integrate a remarkable range of areas normally served only by disparate specialized software systems—and to make possible cross-connections that define whole new levels of functionality.

Through its unique technology approach, *Mathematica* is able to deliver more capabilities, more conveniently, more efficiently, and at lower cost, across an impressive range of software categories—and to interoperate synergistically with practically every type of software. Read on to see how *Mathematica* compares to other systems.

Audio Synthesis Software
(Max/MSP, Csound, SuperCollider, ...)

Calculator Software
(MathCAD, TK Solver, Nspire, ...)

Computer Algebra Systems
(Maple, Derive, Reduce, ...)

Data Visualization Packages
(IDL, PV-Wave, AVS, ...)

Development Environments
(Visual Studio, Xcode, Eclipse, ...)

Document Processing Systems
(Documentum, IBM FileNet Content Manager, LivelinkECM-eDocs Suite, ...)

Educational Programming Languages
(Logo, Basic, Mindstorms, ...)

Format Conversion Packages
(GraphicConverter, Switch, ReaConverter, ...)

Graphing Calculators
(TI, HP, Casio, ...)

Graph Visualization
(GraphViz, Tom Sawyer, yWorks, ...)

Grid Computing
(MPI, PVM, OpenMP, ...)

Interface Building Systems
(Visual Basic, Tcl/Tk, Swing, ...)

Mathematical Tables
(Abramowitz & Stegun, Gradshteyn & Ryzhik, DLMF, ...)

Mathematical Typesetting
(TEX, MathType, MathML, ...)

Math Education Software
(Geometer's Sketchpad, Cabri, Math Blaster, ...)

Number Theory Packages
(PARI/GP, Magma, Kant, ...)

Numerical Matrix Systems
(Matlab, O-Matrix, Scilab, ...)

Optimization Software
(CPLEX, LINDO, KNITRO, ...)

Plotting Packages
(Origin, SigmaPlot, Kaleidagraph, ...)

Presentation Software
(PowerPoint, Impress, ...)

Programming Languages
(C, C++, Java, ...)

Report Generation
(Crystal Reports, Cognos BI, Oracle Discoverer, ...)

Research Languages
(Lisp, Scheme, ML, ...)

Scientific Data Sources
(NIST, CRC, CAS, ...)

Scripting Languages
(Perl, Python, Ruby, ...)

Simulation Systems
(Simulink, Modelica, VisSim, ...)

Spreadsheets
(Excel, OpenOffice Calc, ...)

Statistics Packages
(SAS, SPSS, S-PLUS, ...)

Subroutine Libraries
(NAG, IMSL, LAPACK, ...)

3D Graphics Systems
(Maya, LightWave 3D, 3ds Max, ...)

100,000 examples

Can edit / copy examples

PlotLabel

`PlotLabel`
is an option for graphics functions that specifies an overall label for a plot.

▸ **Details**

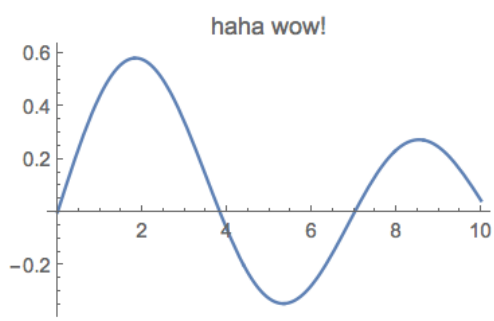
▾ **Examples** (9)

▾ **Basic Examples** (3)

Use any Wolfram Language notation for labels:

In[1]:=
```
Plot[BesselJ[1, x], {x, 0, 10}, PlotLabel → "haha wow!"]
```

Out[1]=

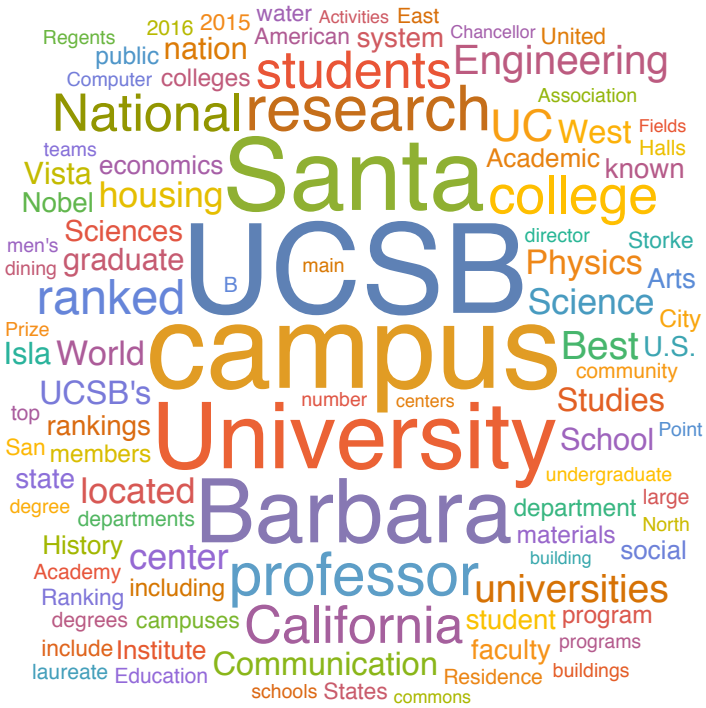


Web Apps example

```
WikipediaData["UCSB"];
StringTake[%, 300]
```

```
The University of California, Santa Barbara (commonly referred to as UC Santa
  Barbara or UCSB) is a public research university and one of the 10 campuses
  of the University of California system. The main campus is located on a
  1,022-acre (414 ha) site near Goleta, California, United States, 8 miles (
```

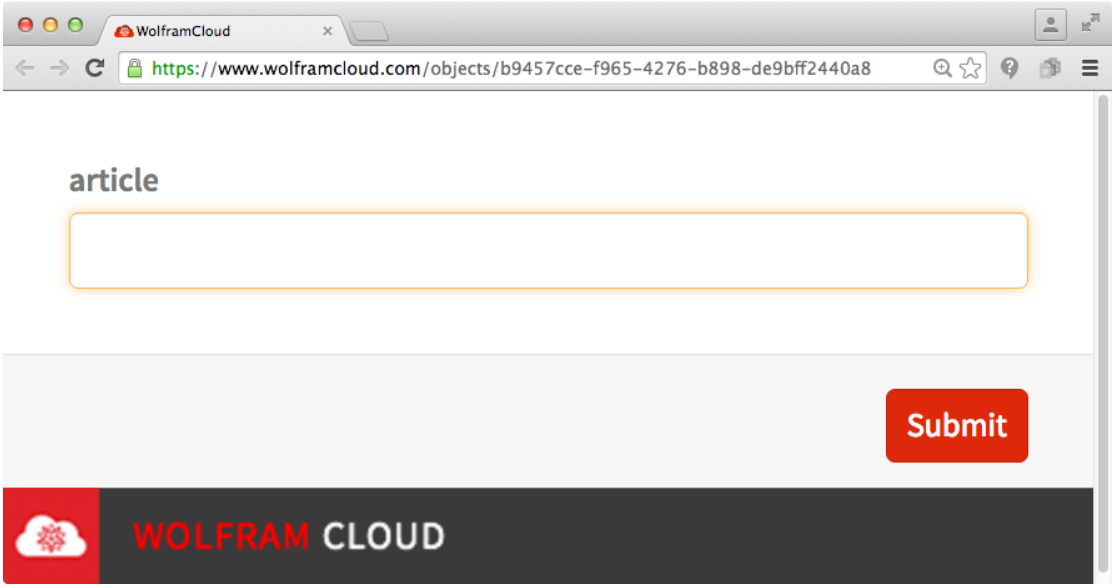
```
WikipediaData["UCSB"] // DeleteStopwords // WordCloud
```

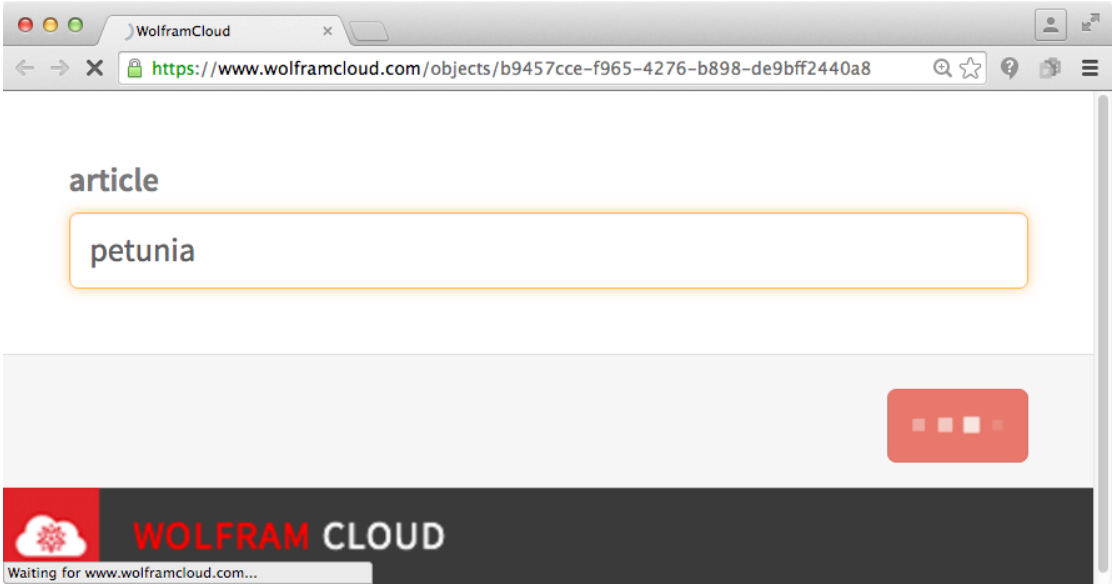


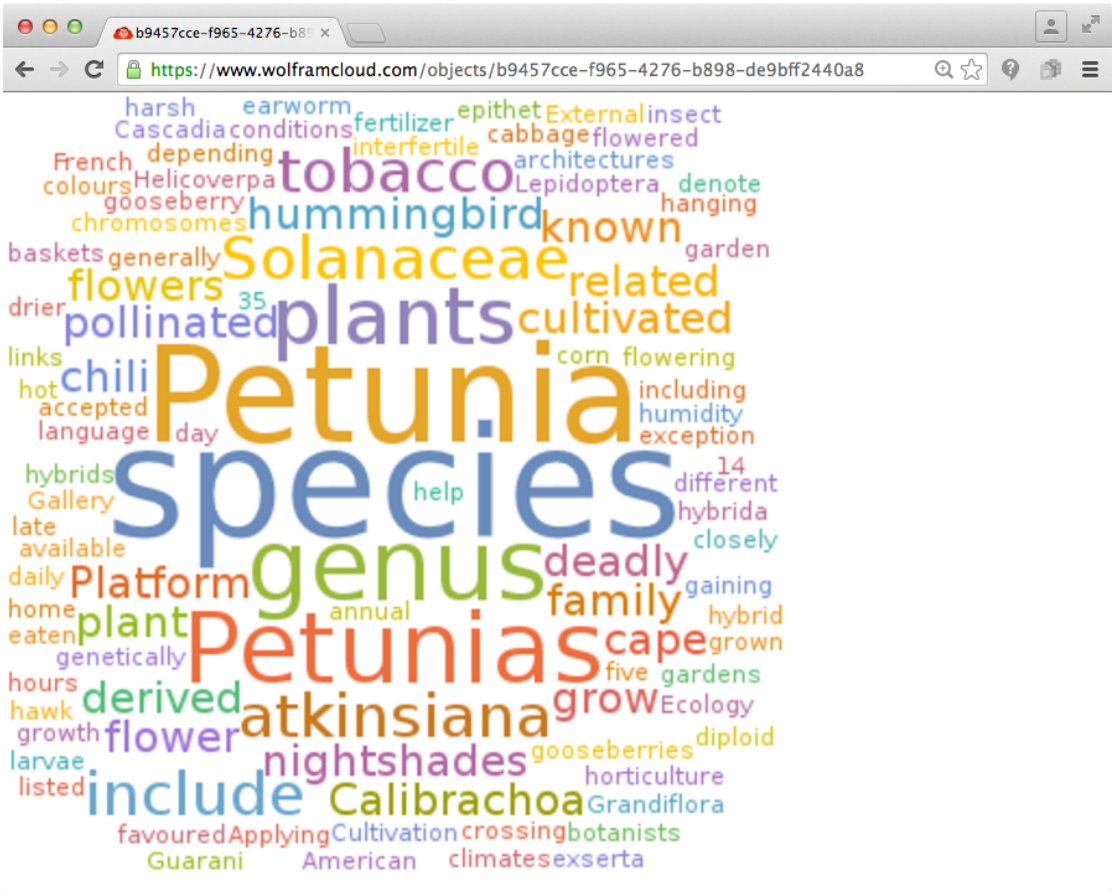

```
form = FormFunction[{"article" → "String"},
   (WikipediaData[#["article"]] // DeleteStopwords // WordCloud) &,
   "PNG"];
```

```
CloudDeploy[form, Permissions → "Public"]
```

```
CloudObject[
 https://www.wolframcloud.com/objects/122bf6e8-6b7d-4846-8bba-fcf3fa64b141]
```

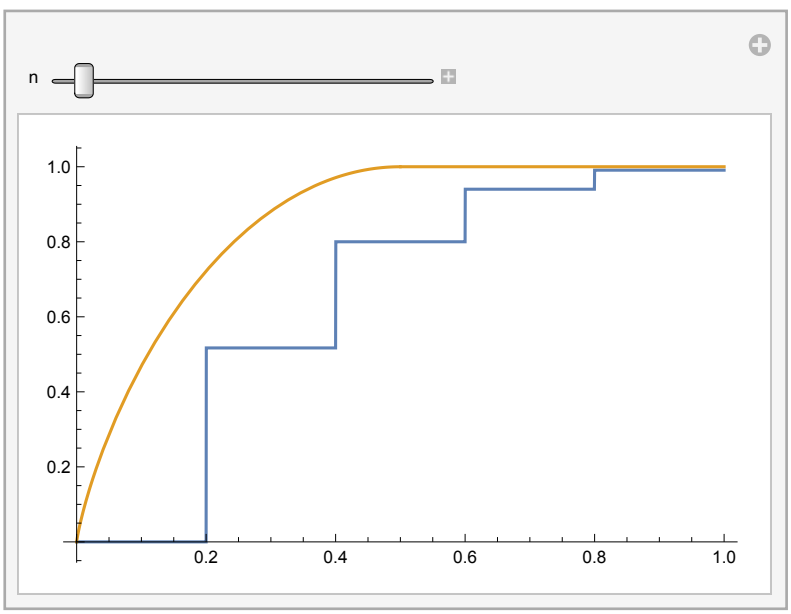

WolframCloud
https://www.wolframcloud.com/objects/b9457cce-f965-4276-b898-de9bff2440a8
article
Submit
WOLFRAM CLOUD


WolframCloud
https://www.wolframcloud.com/objects/b9457cce-f965-4276-b898-de9bff2440a8
article
petunia
WOLFRAM CLOUD
Waiting for www.wolframcloud.com...


b9457cce-f965-4276-b8
https://www.wolframcloud.com/objects/b9457cce-f965-4276-b898-de9bff2440a8
harsh
earworm
epithet
External
insect
Cascadia
conditions
fertilizer
cabbage
flowered
interfertile
French
depending
tobacco
architectures
colours
Helicoverpa
Lepidoptera
denote
gooseberry
hanging
chromosomes
hummingbird
known
baskets
generally
Solanaceae
garden
flowers
related
drier
35
pollinated
plants
cultivated
links
corn
flowering
hot
chili
Petunia
including
accepted
humidity
language
day
exception
hybrids
14
Gallery
help
different
late
hybrida
available
closely
daily
Platform
genus
deadly
gaining
home
family
hybrid
eaten
plant
annual
Petunias
cape
grown
genetically
five
gardens
hours
derived
grow
Ecology
hawk
atkinsiana
growth
flower
diploid
larvae
nightshades
gooseberries
horticulture
listed
include
Calibrachoa
Grandiflora
favoured
Applying
Cultivation
crossing
botanists
Guarani
American
climates
exserta
species

Helps with my research

```
H[q_] := -q * Log2[q] - (1 - q) * Log2[1 - q]
Manipulate[
 Plot[{
   1/n Log2@ Sum[Binomial[n, i], {i, 0, ⌊n γ⌋}],
   H[Min[γ, 1 / 2]]
  }, {γ, 0, 1}],
 {{n, 5}, 1, 100, 1}, SaveDefinitions → True]
```



The fact that an M-of-N encoder refrains from sending "expensive" codewords effectively reduces its ability to transmit information: A codeword sent from an M-of-N encoder conveys $\log_2 L(N, M, S)$ bits of information, whereas a codeword from an encoder without the M-of-N constraint conveys $\log_2 L(N, N, S) = N \log_2(S+1)$ bits.

The first lemma, proved in the appendix, shows that the set of M-of-N encoders is "complete" in the sense that every encoder with average cost per symbol not exceeding a finite threshold γ is actually an M-of-N encoder for N sufficiently large and $M \approx \gamma N$.

Lemma 1: For any encoder/decoder pair with average cost per symbol not exceeding $\gamma \in [0,1]$, and every constant $\epsilon > 0$, there exist $M \in \mathbb{R}_{\geq 0}$ and $N \in \mathbb{N}_{>0}$ with $M < N\gamma(1+\epsilon)$ such that the encoder/decoder pair is an M-of-N encoder. □

The next lemma establishes a relationship between the number of codewords $L(N, M, S)$ available to an M-of-N encoder and the function f defined in (6).

Lemma 2: For any $N \in \mathbb{N}_{>0}$, $S \in \mathbb{N}_{\geq 0}$ and $\gamma \in [0,1]$, the function L defined in (9) and the function f defined in (6) satisfy

$$\frac{\ln L(N, N\gamma, S)}{N \ln(S+1)} \leqslant f(\gamma, S), \tag{10}$$

with equality holding only when $\gamma = 0$ or $\gamma = 1$. Moreover, we have asymptotic equality in the sense that

$$\lim_{N\to\infty} \frac{\ln L(N, N\gamma, S)}{N \ln(S+1)} = f(\gamma, S). \tag{11}$$

□

The left and right sides of (10) are plotted in Figure 4.

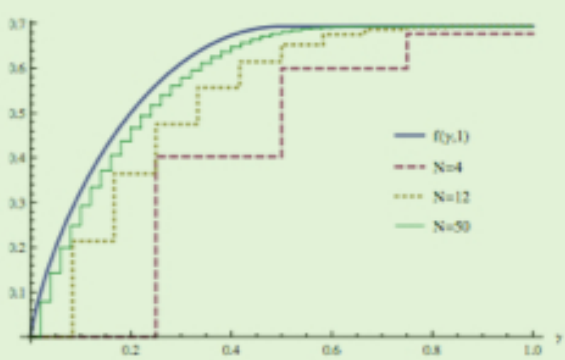


Fig. 4. A plot of $f(\gamma, S)$ and $\ln L(N, N\gamma, S)/N \ln(S+1)$ versus γ for $S = 1$ and $N = 4, 12, 50$.

Proof of Lemma 2. In this proof we use the base-2 logarithm to match the notation of an information theoretic theorem that we invoke. In any case, changing the logarithm base does not change the fraction in (10) and (11). Let $N \in \mathbb{N}_{>0}$ and $S \in \mathbb{N}_{\geq 0}$ be arbitrary. First we prove (10) for $\gamma \in \left(0, \frac{S}{S+1}\right]$. Applying the Binomial Theorem to the identity $1 = (\gamma + (1-\gamma))^N$, we obtain

$$1 = \sum_{i=0}^{N} \binom{N}{i} \gamma^i (1-\gamma)^{N-i}$$

Since each term in the summation is positive, keeping only the first $\lfloor N\gamma \rfloor$ terms yields the inequality

$$1 > \sum_{i=0}^{\lfloor N\gamma \rfloor} \binom{N}{i} \gamma^i (1-\gamma)^{N-i} \tag{12}$$

Next, a calculation presented as Lemma 6 in the appendix reveals that

$$\gamma^i (1-\gamma)^{N-i} \geqslant 2^{-N H(\gamma)} \frac{S^i}{S^{N\gamma}} \tag{13}$$

for all $N, S \in \mathbb{N}_{>0}$, $\gamma \in \left(0, \frac{S}{S+1}\right]$, and $i \in [0, N\gamma]$. Using this in (12) and taking $\log_2$ of both sides yields

$$\frac{\log_2 L(N, N\gamma, S)}{N} < H(\gamma) + \gamma \log_2 S. \tag{14}$$

By the definition of f, we have $\log_2(S+1) f(\gamma, S) = H(\gamma) + \gamma \log_2 S$ when $\gamma \in \left[0, \frac{S}{S+1}\right]$. Thus, (14) proves the strict inequality in (10) for $\gamma \in \left(0, \frac{S}{S+1}\right]$. Next, suppose $\gamma \in \left(\frac{S}{S+1}, 1\right)$ and observe from (9) that $L(N, M, S)$ is a sum of positive terms whose index reaches $\lfloor M \rfloor$, hence $L(N, N\gamma, S)$ is strictly less than $L(N, N, S)$ for any $\gamma < 1$. We conclude that

$$\begin{aligned} \frac{\log_2 L(N, N\gamma, S)}{N} &< \frac{\log_2 L(N, N, S)}{N} \\ &= \log_2(S+1) && (15) \\ &= \log_2(S+1) f(\gamma, S), && (16) \end{aligned}$$

where the equality in (15) follows simply from the fact that $L(N, N, S)$ is the number of all possible codewords of length N and hence equals $(S+1)^N$, and (16) follows from the definition of f when $\gamma \in (\frac{S}{S+1}, 1)$. This concludes the proof of the strict inequality in (10) for $\gamma \in (0,1)$. The proof of (10) for $\gamma = 0$ follows merely from inspection of (10), and the $\gamma = 1$ case follows from the equality in (15).

Next we prove the asymptotic result (11) using information-theoretic methods. First we prove (11) for $\gamma \in [0, \frac{S}{S+1})$. Consider a random variable X parameterized by $S \in \mathbb{N}_{\geq 0}$ and $\gamma \in [0, \frac{S}{S+1})$ which takes values in $\mathcal{X} := \{0, 1, \ldots, S\}$ with probabilities given by

$$\begin{aligned} \mathbb{P}(X = 0) &:= (1-\gamma) \\ \mathbb{P}(X = i) &:= \gamma/S \qquad i = \{1, 2, \ldots, S\}. \end{aligned}$$

Following our convention, we call 0 the "free" symbol and $1, \ldots, S$ the "nonfree" symbols. To lighten notation we write $p(x) := \mathbb{P}(X = x), x \in \mathcal{X}$. The entropy of the random variable X is

$$H(X) := -\sum_{i=0}^{S} p(i) \log_2 p(i) = H(\gamma) + \gamma \log_2 S, \tag{17}$$

where we have overloaded the symbol H so that $H(\gamma) := -\gamma \log_2 \gamma - (1-\gamma) \log_2 (1-\gamma)$ is the entropy of a Bernoulli random variable with parameter γ.

Find cheap concert tickets

Wolfram Mathematica 8.0 - [stubhub_ticket_analysis.nb *]

File Edit Insert Format Cell Graphics Evaluation Palettes Window Help

stubhub_ticket_analysis.nb *

Wolfram Mathematica | HOME EDITION

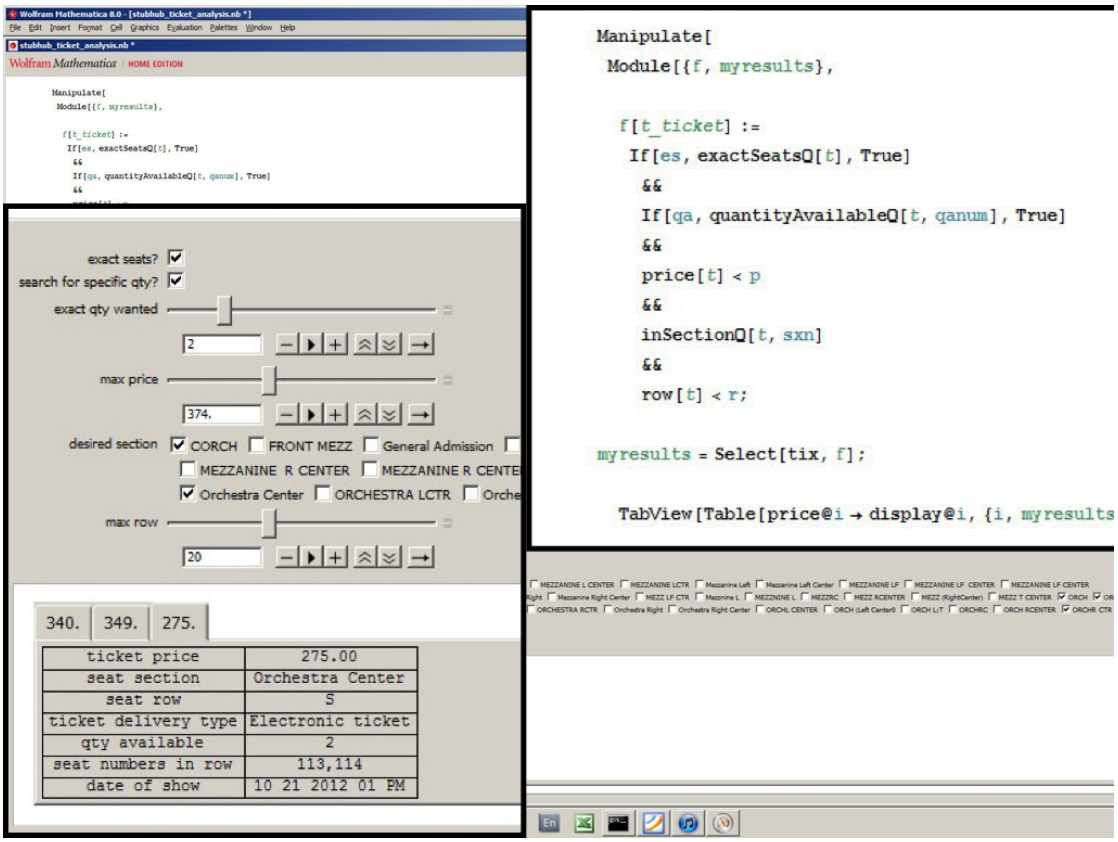
```
Manipulate[
 Module[{f, myresults},

  f[t_ticket] :=
   If[es, exactSeatsQ[t], True]
    &&
    If[qa, quantityAvailableQ[t, qanum], True]
    &&
    price[t] < p
    &&
    inSectionQ[t, sxn]
    &&
    row[t] < r;

myresults = Select[tix, f];

  TabView[Table[price@i → display@i, {i, myresults}]]

 ],

 (* Parameters *)
 {{es, True, "exact seats?"}, {True, False}},
 {{qa, True, "search for specific qty?"}, {True, False}},
 {{qanum, 2, "exact qty wanted"}, 1, 6, 1},
 {{p, 300, "max price"}, 0, 1000},
 {{sxn, {"Orchestra Center", "Orchestra Left Center", "Orchestra Right Center"}, "desired section"}, allSloppySections, ControlType → Chec
 {{r, 25, "max row"}, 1, 2*26, 1}]
```

Out[512]=

exact seats? ☑
search for specific qty? ☑
exact qty wanted 2
max price 374.
desired section ☑ CORCH ☐ FRONT MEZZ ☐ General Admission ☐ MEZ ☐ mezz ☐ MEZZ ☐ MEZZANINE ☐ Mezzanine Center ☐ MEZZANINE L CENTER ☐ MEZZANINE LCTR ☐
☐ MEZZANINE R CENTER ☐ MEZZANINE R CENTER ☐ MEZZANINE R/CTR ☐ MEZZANINE RCTR ☐ Mezzanine Right ☐ Mezzanine Right Center ☐ MEZZ LF CTR ☐
☑ Orchestra Center ☐ ORCHESTRA LCTR ☐ Orchestra Left ☐ Orchestra Left Center ☐ ORCHESTRA LF CENTER ☐ ORCHESTRA RCTR ☐ Orchestra Right ☐ Orchestr
max row 20

340. | 349. | 275.

ticket price	275.00
seat section	Orchestra Center
seat row	S
ticket delivery type	Electronic ticket
qty available	2
seat numbers in row	113,114
date of show	10 21 2012 01 PM


Wolfram Mathematica 8.0 - [stubhub_ticket_analysis.nb *]
File Edit Insert Format Cell Graphics Evaluation Palettes Window Help
stubhub_ticket_analysis.nb *
Wolfram Mathematica HOME EDITION
exact seats?
search for specific qty?
exact qty wanted
2
max price
374.
desired section
CORCH
FRONT MEZZ
General Admission
MEZZANINE R CENTER
Orchestra Center
ORCHESTRA LCTR
max row
20
340.
349.
275.
ticket price 275.00
seat section Orchestra Center
seat row S
ticket delivery type Electronic ticket
qty available 2
seat numbers in row 113,114
date of show 10 21 2012 01 PM
Manipulate[
Module[{f, myresults},
f[t_ticket] :=
If[es, exactSeatsQ[t], True]
&&
If[qa, quantityAvailableQ[t, qanum], True]
&&
price[t] < p
&&
inSectionQ[t, sxn]
&&
row[t] < r;
myresults = Select[tix, f];
TabView[Table[price@i → display@i, {i, myresults

Conclusion

- Free
- Express ideas clearly and cleanly
- Powerful and useful
  ... in college and beyond

Good luck!!