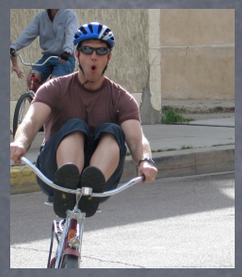
Technology Sampler

Issues for Early Career Mathematicians in Academia

Dana C. Ernst
Plymouth State University
Email: dcernst@plymouth.edu
Web: http://oz.plymouth.edu/~dcernst
Twitter: @danaernst

About Me



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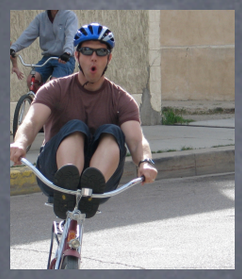

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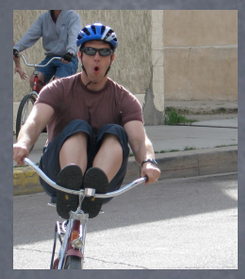

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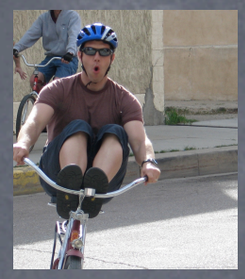

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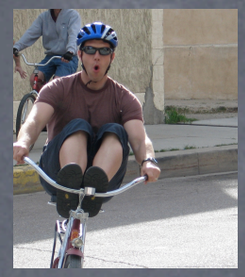

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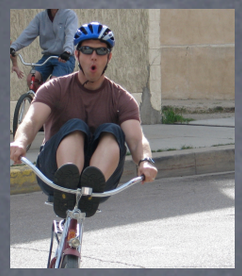

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- I am passionate about technology and incorporate it into my teaching on a regular basis. However...

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- Focus is on breadth, not depth.

Sage

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Sage

sage The Sage Notebook
Version 4.5

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Dana's Playground

last edited on April 06, 2010 12:30 PM by dcernst

Save | Save & quit | Discard & quit

File... | Action | Data... | sage | Typeset | Print | Worksheet | Edit | Text | Undo | Share | Publish

```
f=(x+1)^2
integral(f,x)
```

evaluate

$$\frac{1}{3}x^3 + x^2 + x$$

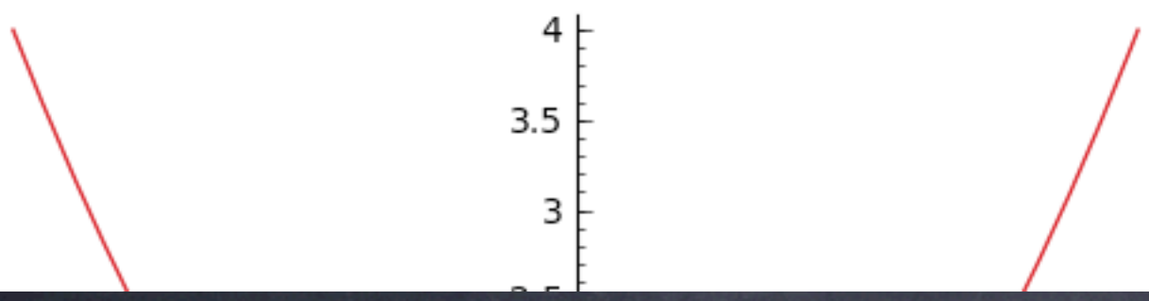
```
f.expand()
```

$$x^2 + 2x + 1$$

```
f.is_zero()
```

False

```
plot(f,(-2,2),color='red')
```



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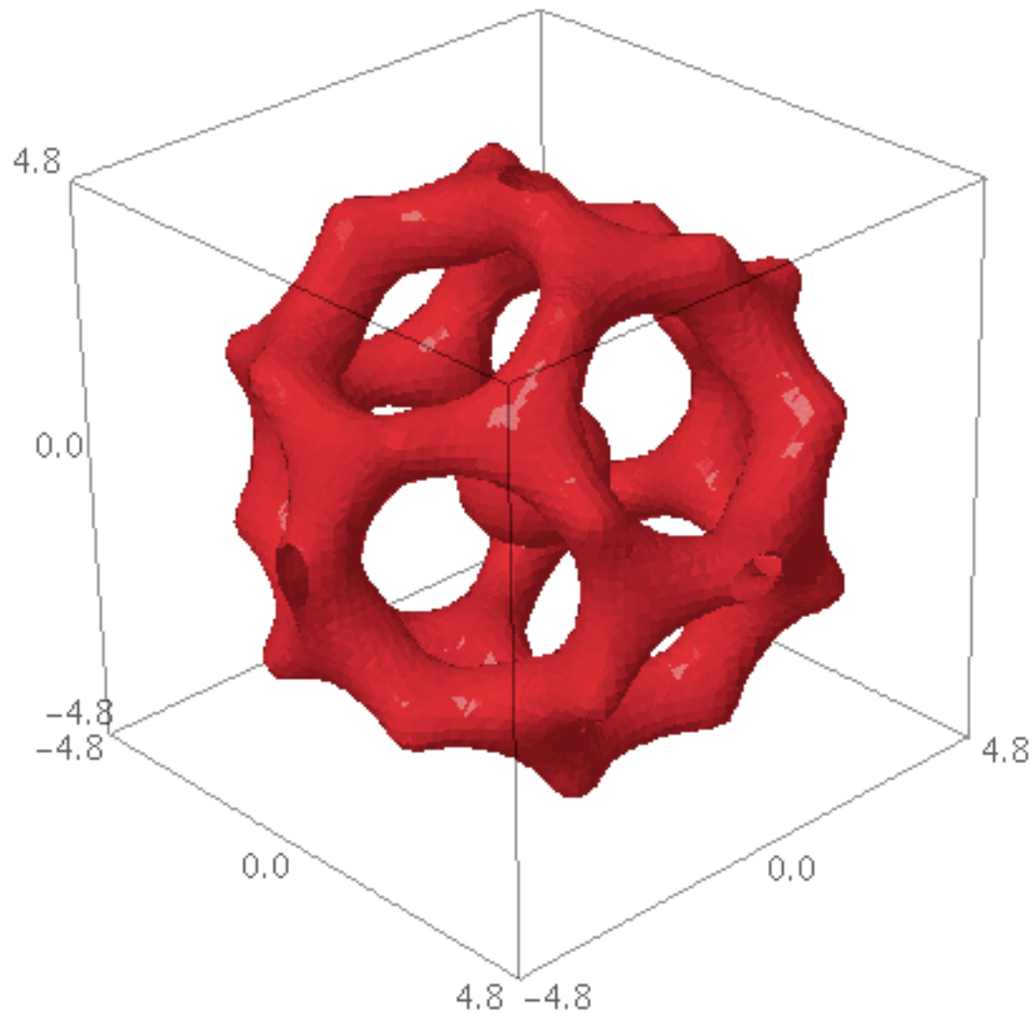
```
var('x,y,z'); T = golden_ratio
p = 2 - (cos(x + T*y) + cos(x - T*y) + cos(y + T*z) + cos(y - T*z) + cos(z - T*x) + cos(z +
T*x)); r = 4.78
implicit_plot3d(p, (x, -r, r), (y, -r, r), (z, -r, r), plot_points=50, color='red')
```



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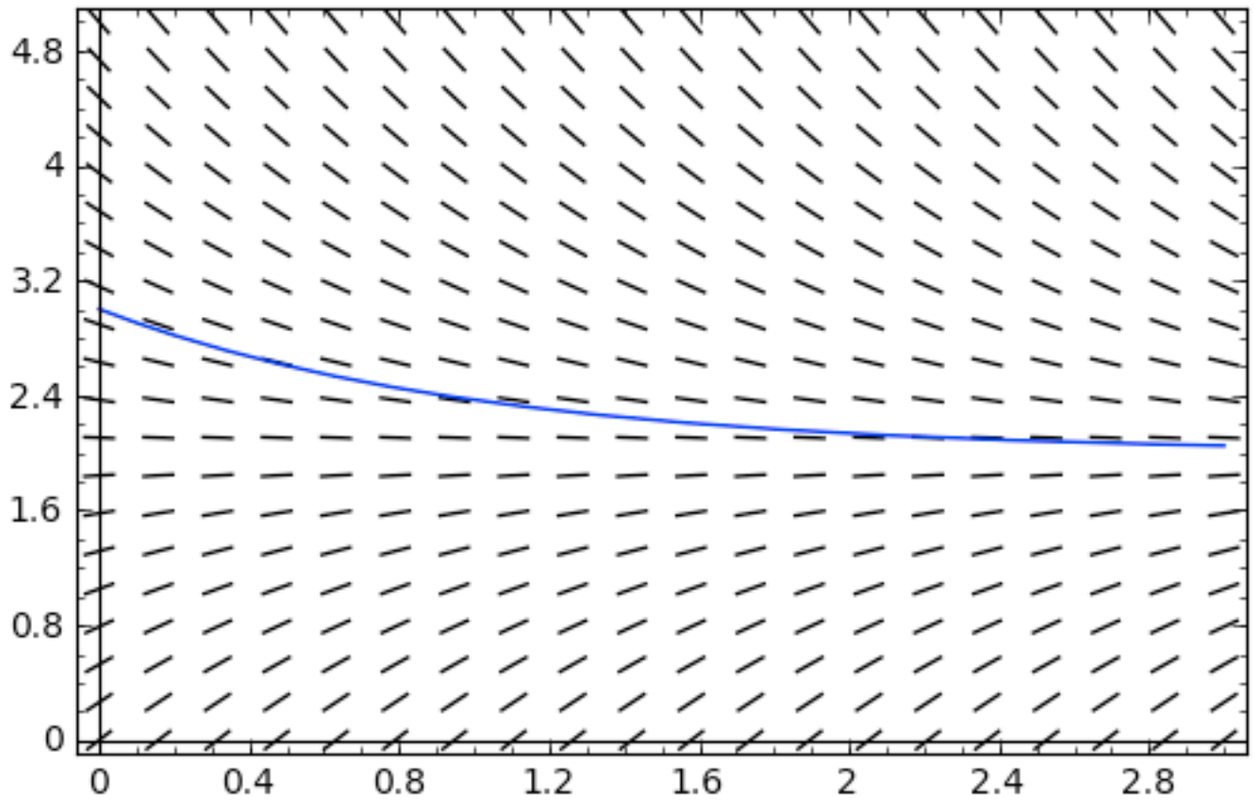
```
h = desolve(de, y, ics=[0,3]); h
```

```
(2*e^x + 1)*e^(-x)
```

And of course we have already noted that we can plot all this with a slope field.

```
var('y') # Needed so we can plot
Plot1=plot_slope_field(2-y,(x,0,3),(y,0,5))
Plot2=plot(h,x,0,3)
Plot1+Plot2
```



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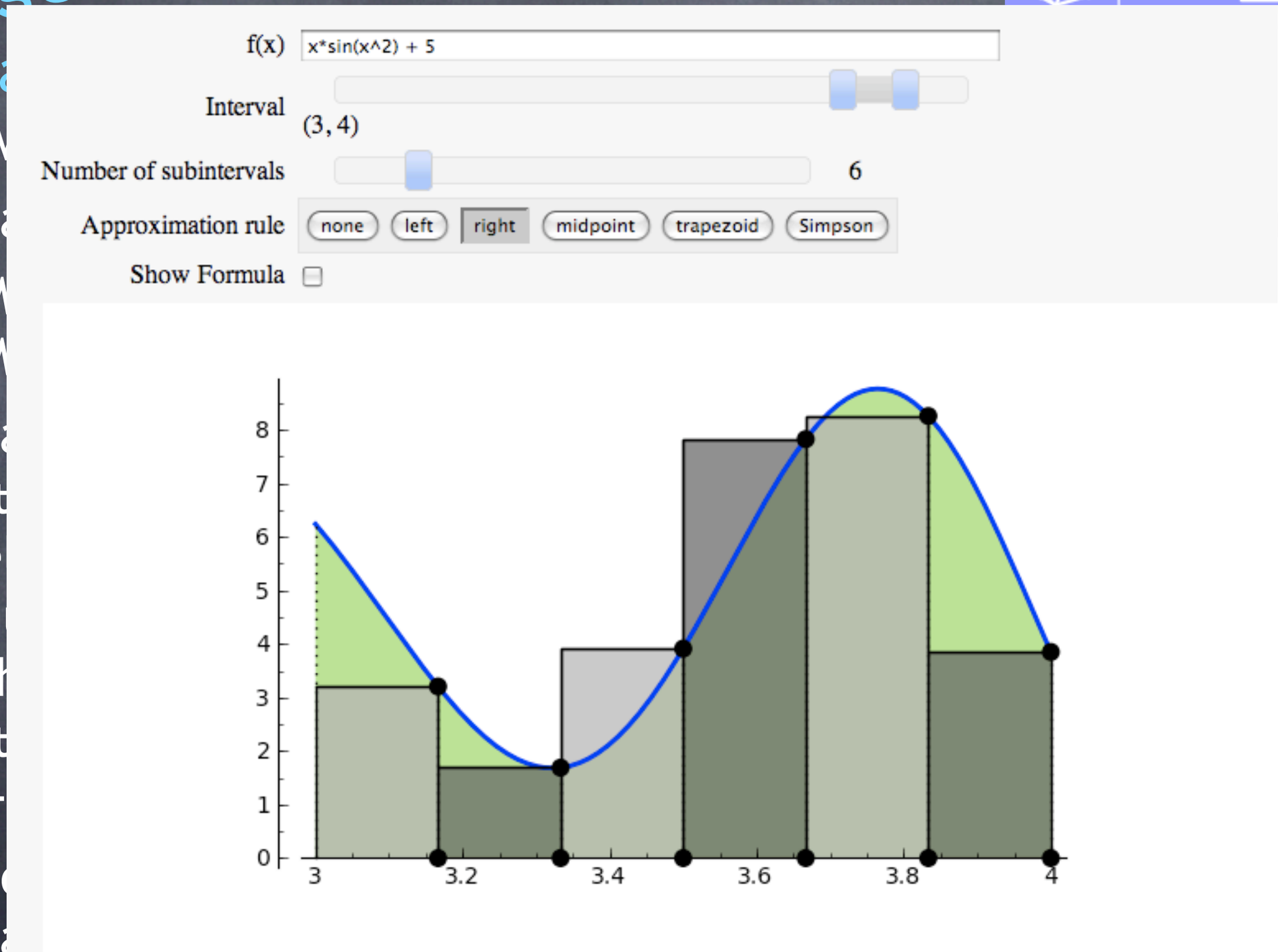

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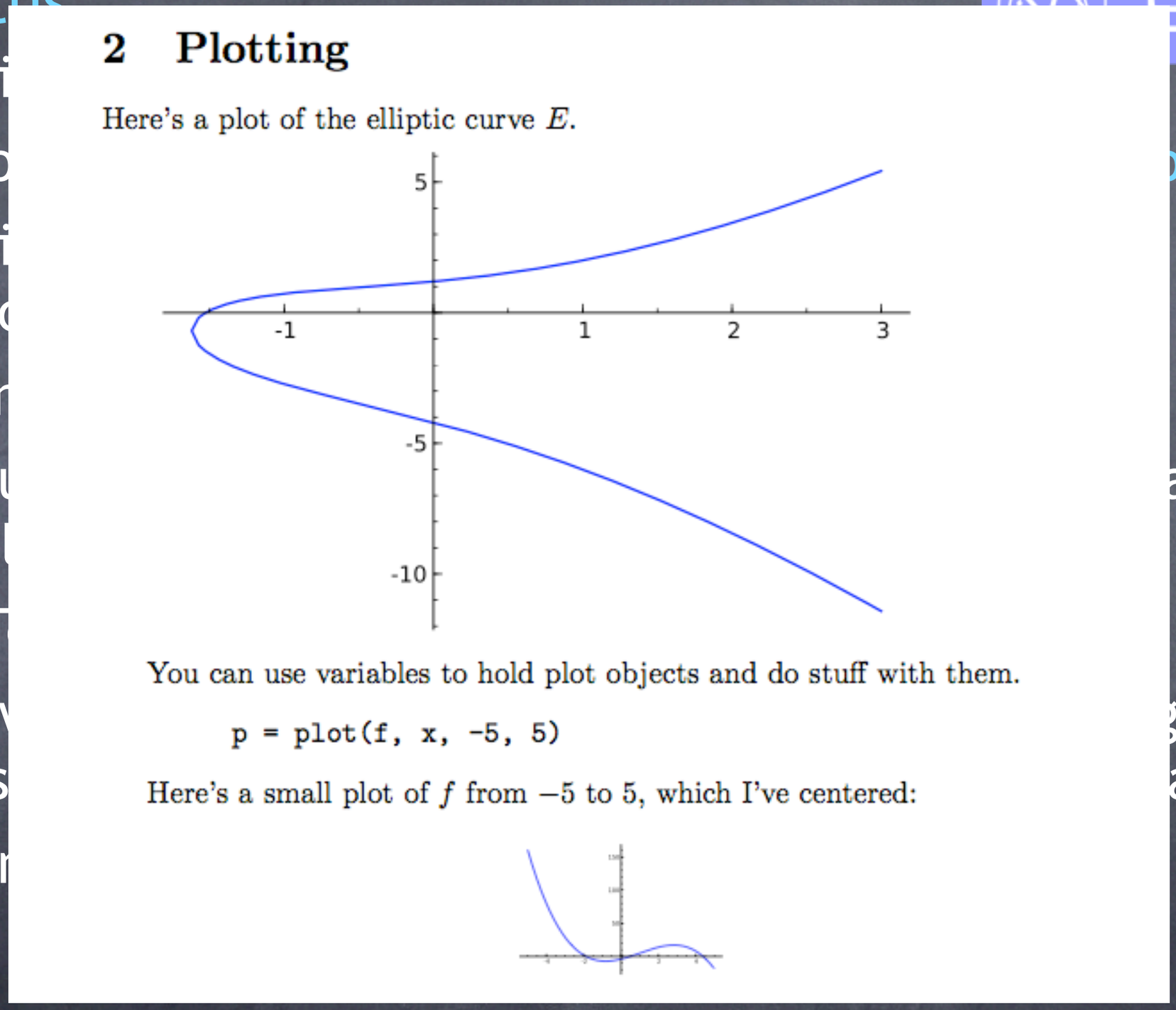

2 Plotting

Here's a plot of the elliptic curve E.

You can use variables to hold plot objects and do stuff with them.

```
p = plot(f, x, -5, 5)
```

Here's a small plot of f from -5 to 5, which I've centered:

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Consider the following algebra centering on polynomial multiplication,

$$\begin{aligned}(1-x)(1+x+x^2+x^3+\cdots+x^n) &= 1+x+x^2+x^3+\cdots+x^n \\ &\quad -(x+x^2+x^3+\cdots+x^n+x^{n+1}) \\ &= 1+(x-x)+(x^2-x^2)+\cdots+(x^n-x^n)-x^{n+1} \\ &= 1-x^{n+1} \\ &\approx 1\end{aligned}$$

The approximation in the last step is valid if x^{n+1} is small, which will be the case if $-1 < x < 1$ and n is large. Keep those conditions in mind as we continue.

If we assume $x \neq 1$ and divide both sides of the above by $1-x$ we obtain

$$\frac{1}{1-x} \approx 1+x+x^2+x^3+\cdots+x^n \qquad (1)$$

This will be the basis of all but one of our approximations. In the demonstration below notice the following:

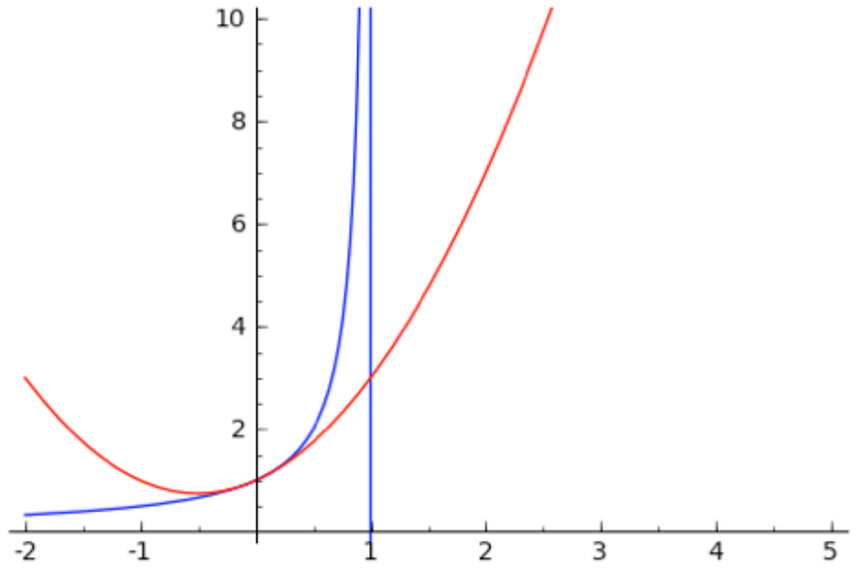
- The approximation gets better as the degree, n, increases.
- No matter how large the degree is, the approximation appears limited to $-1 < x < 1$.
- For even versus odd degrees, the left end of the approximating polynomial approaches $\pm\infty$.
- The degree 1 approximation is just the tangent line at the point $(0, 1)$.

```
%hide
```

Degree 2

Function: $\frac{-1}{x-1}$

Approximation: x^2+x+1



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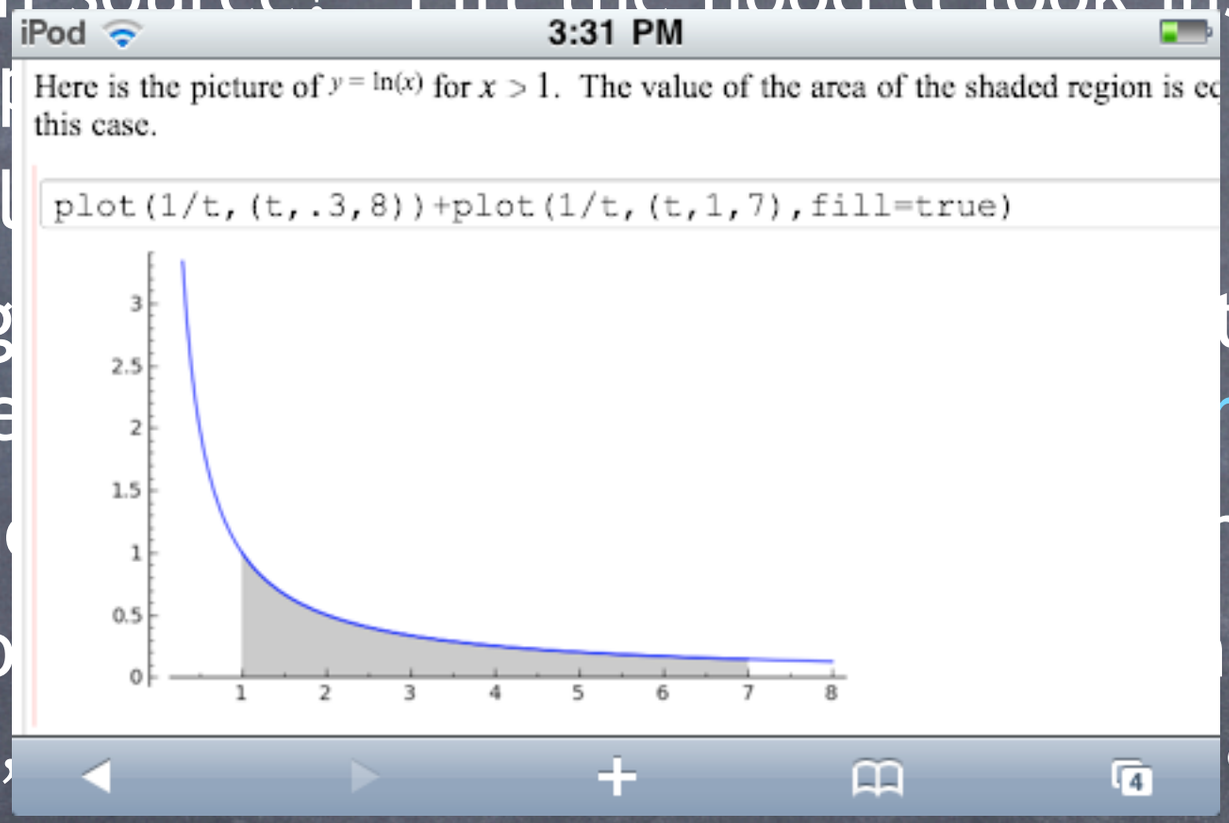

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Weaknesses

- sagenb.org can be slow during high traffic.

Wolfram|Alpha

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- Computational knowledge engine: it generates output by doing computations from its own internal knowledge base.

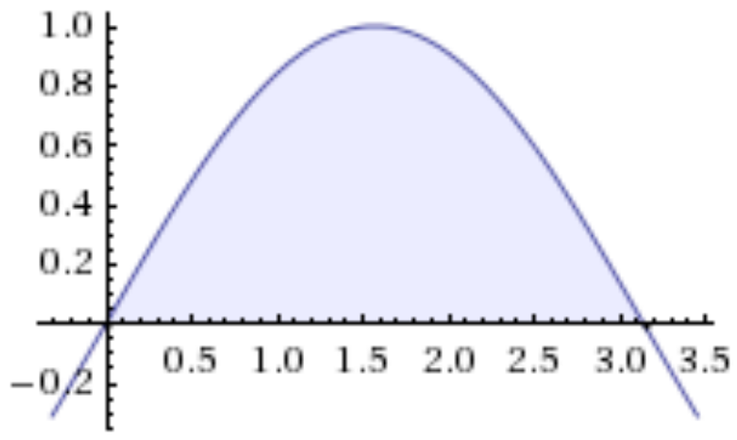
WolframAlpha™ computational... knowledge engine

integral of sin(x) from x=0 to x=pi

Definite integral:

$$\int_0^{\pi} \sin(x)\,dx = 2$$

Visual representation of the integral:



Computed by: Wolfram *Mathematica*

Download as: PDF | Live *Mathematica*

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WolframAlpha computational... knowledge engine

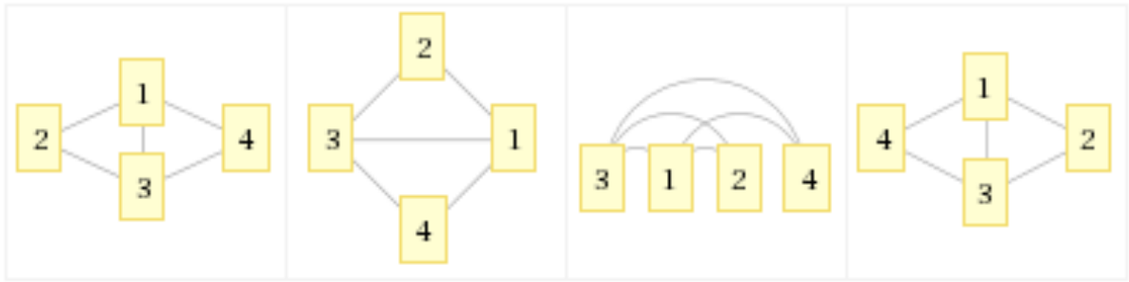
1->2, 2->3, 3->1, 3->4, 4->1

Assuming "1->2" is a mathematical object | Use as referring to substitution system instead

Input: *Mathematica* form

$\{1 \to 2, 2 \to 3, 3 \to 1, 3 \to 4, 4 \to 1\}$

Images: Single image



Combinatorial properties:

vertex count	4
edge count	5

Vertex degrees:

2 (2 vertices) | 3 (2 vertices)

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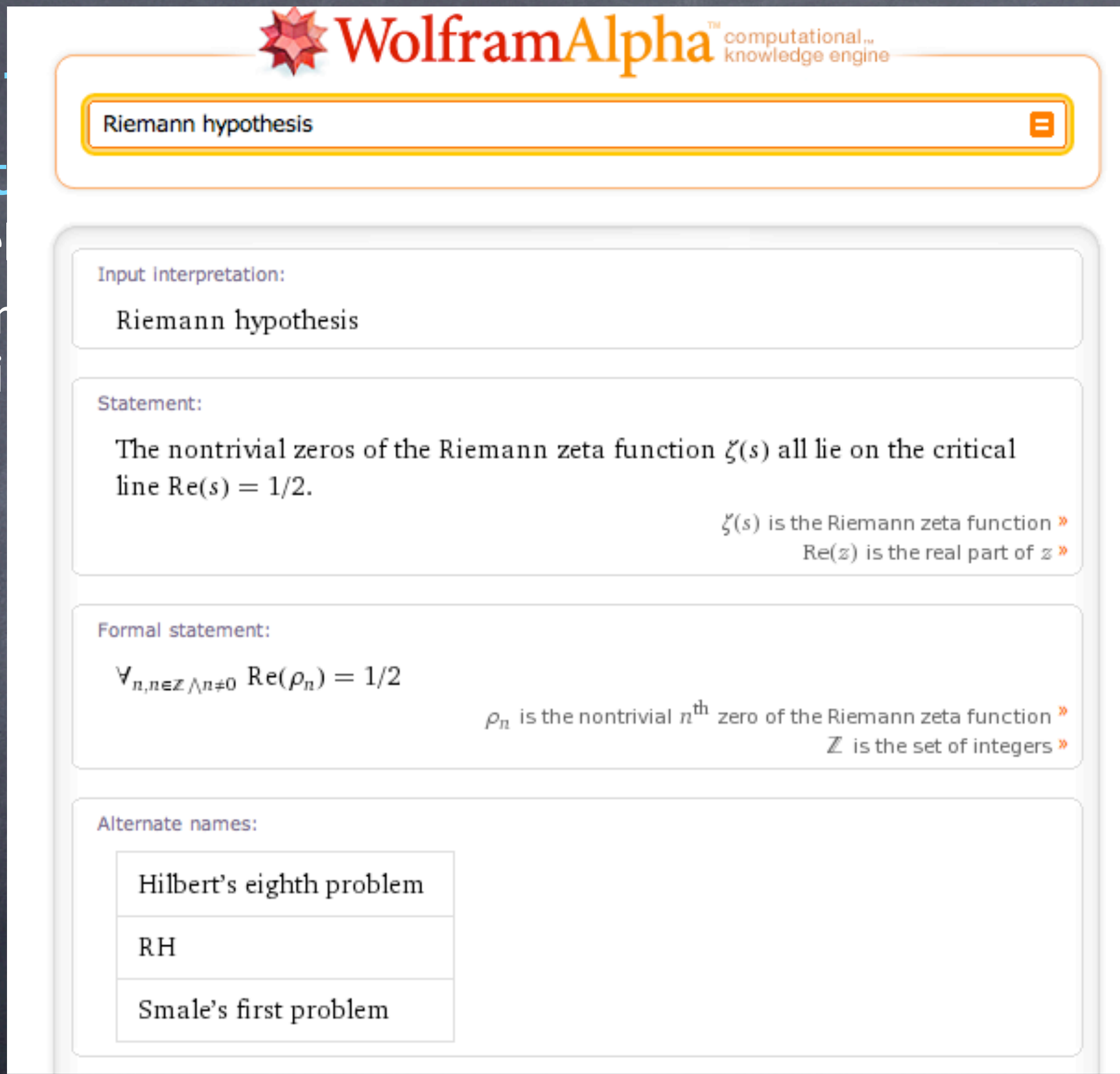

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- Widgets available.

Wolfram|Alpha

What is it?

- Web page: http://www.wolframalpha.com
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Strengths

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- iDevices app ($1.99 each).

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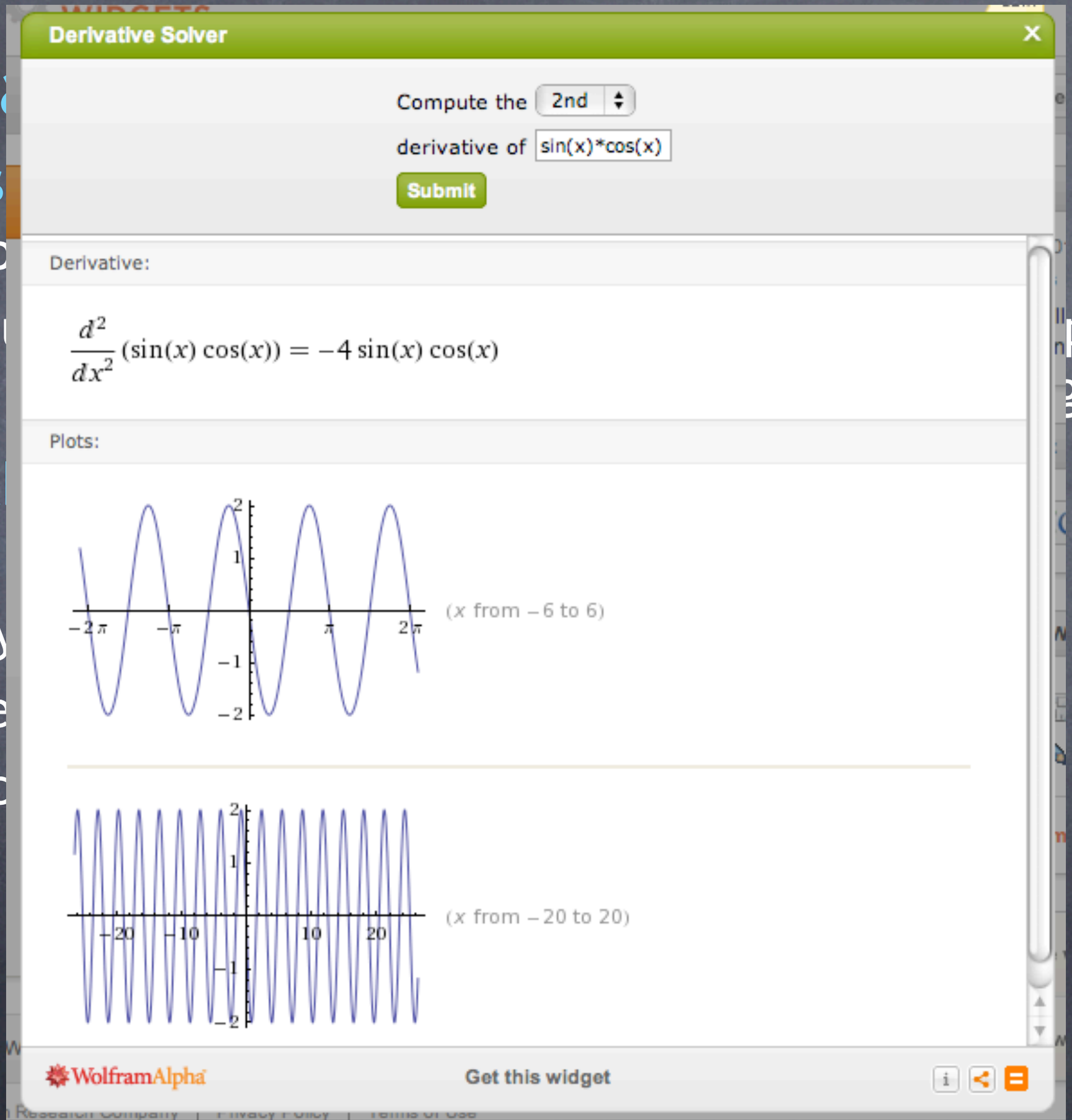

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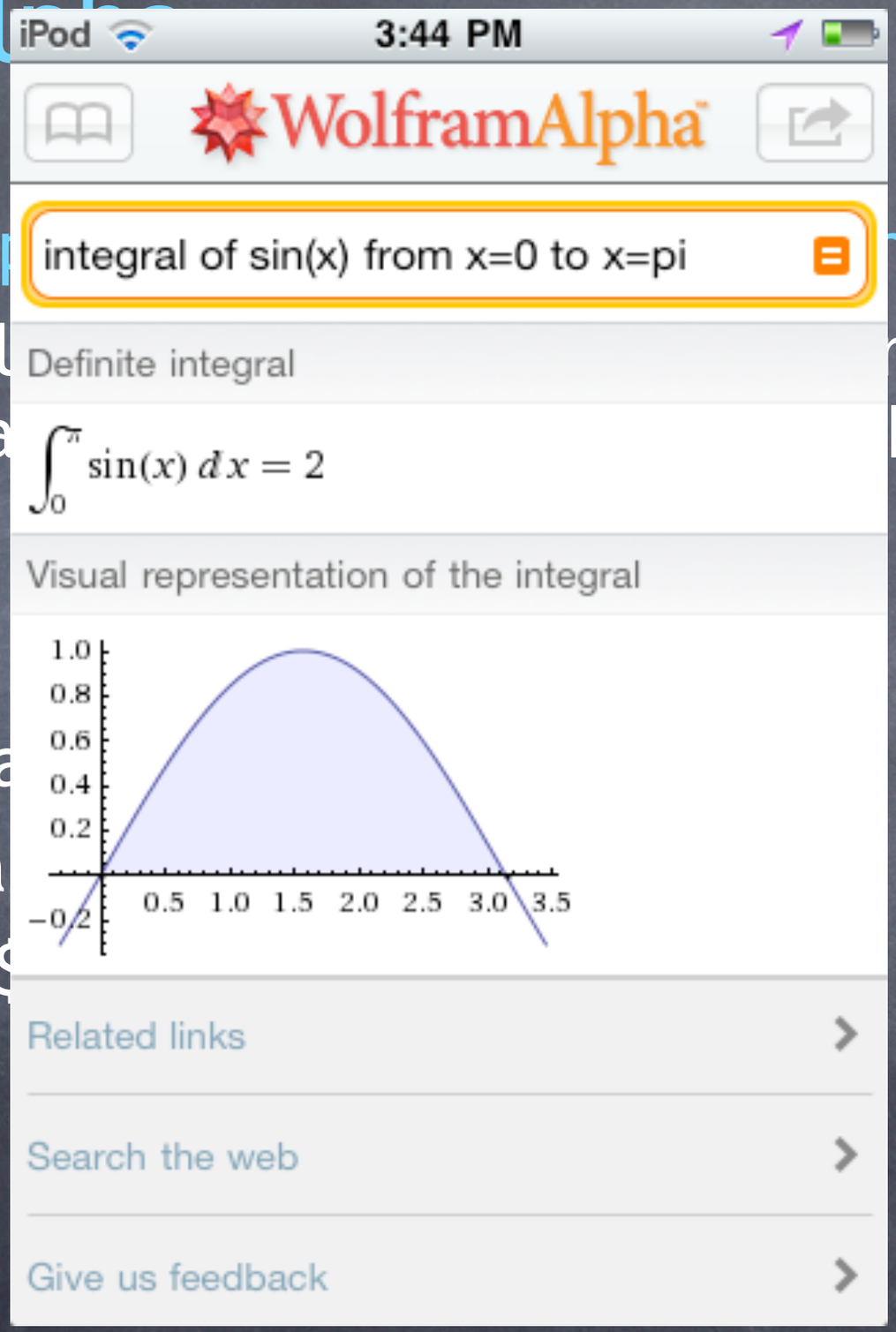

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- Closed-source! How does it work?
- I can’t add new features.

Lurch

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- Open-sou
- Word pro eps of your work in r

$$\frac{d}{dx}(\sin x^2)$$

$$= \quad (\cos x^2)\frac{d}{dx}x^2 \qquad \text{valid}$$

$$= \quad (\cos x^2)\cdot 2x \qquad \text{valid}$$

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$$\int xe^x\,dx$$

$$= \left(\int x\,dx\right)\left(\int e^x\,dx\right)$$ invalid

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LurchLite File Edit Format Tools Help

Paragraph

Example boolean algebra proofs

This document shows the boolean algebra library. The user uses menus to insert equational proofs, and chooses reasons that they feel justify the individual equalities within the proof. Green text means a reason Lurch has validated, and red text means a reason Lurch finds invalid.

Boolean Algebra proof:

	x ∧ (y ∧ z)'	
=	x ∧ (z ∧ y)'	Commutativity of ^, X ^ Y = Y ^ X
=	x ∧ (z' ∨ y')	Associativity of ^, (X ^ Y) ^ Z = X ^ (Y ^ Z)
=	x	(no reason given)

Editing expression

Operator	Expression	Reason
=	x ^ (z' v y')	Associativity of ^, (X ^ Y) ^ Z = X ^ (Y ^ Z)

OK Cancel

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LurchLite

File Edit Format Tools Help

Paragraph

Using Lurch for elementary geometry

This simple example uses the line-numbered proofs math topic, which keeps line numbers in the reasons column in sync as you insert/delete/move lines. It also does automatic TeXing of things in the statements column.

1	Assume $\triangle ABC$ is isosceles.	
2	Then $\angle CAB \cong \angle ACB$.	Definition of isosceles triangle, line 1
3	And $\overline{AB} \cong \overline{CB}$.	Definition of isosceles triangle, line 1
4		

- Protect/Unprotect Document

Scripting

- Insert new script after cursor
- Hide/Show all code

Line-numbered proofs

- Insert new proof
- Delete current proof
- Increase line indent
- Decrease line indent
- Insert new line
- Delete current line
- Move line up
- Move line down

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Work in classical propositional logic #2

This classical propositional library is modeled after the system taught by P.D. Magnus in his textbook "forallx," which you can view and download for free online. To get started, click "Add new work section," and then choose either "Add proof premise" or "Start new subproof."

You enter formulas using the following syntax:

To write this:	Type this:
propositional variable	**A** (or **B** or **C**, etc.)
negation	**-A**
conjunction	**A & B**
disjunction	
conditional	
biconditional	

Combine expressions using parentheses wh

Section 1, work:

1	**P**	
2	**Q**	
3	**P & Q**	&I 1,2

Document
- Add new work section
- Remove current work section
- Next work section
- Previous work section
- Next work line
- Previous work line

Proof utilities
- Add proof premise
- Start new subproof
- Insert a goal
- Delete line above insertion marker
- Turn current work into a

ent work into a
t Rule
le
ion
roduction rule
duction rule
n introduction rule
onal introduction rule
tional introduction
on
nination rule
nation rule A
- Or elimination rule B

Invoke function And elimination rule

3	**P & Q**		
	P	&E 3	All premises for this rule are available in the proof already.
	Q	&E 3	

	Parameter	Value
1	A	P
2	B	Q

Apply Rule | Cancel

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What is

- Web p
- Open-
- Word

of your work

File Tools Help

New Document - Derivatives

1. Comment:

This library allows you to guide Lurch Lite through taking derivatives of basic calculus expressions. To try it out, click "Start new problem." After your problem is in place, use the Tools menu or the links on the right to perform each step in the derivative process.

2. New Problem:

$$\frac{d}{dx} \sin (1 + 2 \cdot x)$$

$= \cos (1 + 2 \cdot x) \cdot \frac{d}{dx} (1 + 2 \cdot x)$	Derivative of sine
$= \cos (1 + 2 \cdot x) \cdot (\frac{d}{dx} 1 + \frac{d}{dx} (2 \cdot x))$	Derivative of a sum
$= \cos (1 + 2 \cdot x) \cdot (0 + \frac{d}{dx} (2 \cdot x))$	Derivative of a constant
$= \cos (1 + 2 \cdot x) \cdot (0 + 2 \cdot \frac{dx}{dx})$	Derivative of an expression with a constant coefficient
$= \cos (1 + 2 \cdot x) \cdot (0 + 2 \cdot 1)$	Differentials cancel
$= 2 \cdot \cos (1 + 2 \cdot x)$	Basic simplification

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Circle-Dot

Goal: make the sequence shown.

Thm B:	•••	
(0)	O•	by Axiom A
(1)	•O	by Axiom B
(2)	•	by Rule 1: (1),(0)

Rule 2 : *Inputs*

•	matches line (2)
V	this does not match any line above

Rule 2 : *Output*

••V	this is the conclusion

Expression Editor

Enter the value of W

- O: Enter a Circle
- .: Enter a Dot
- U: Undo (backspace)
- V: Edit V instead
- C: Cancel
- H: Help

Quit

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Weaknesses

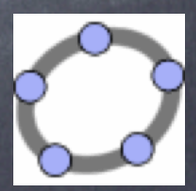
- Early stages of development.
- Not a lot of built-in topics (yet!).

Honorable Mentions

Wikis

- Easy creation & editing of any number of interlinked web pages via a web browser, mathematical typesetting, collaborative authoring, history of modifications, revision control, message boards & forums.
  - Wikidot: http://wikidot.com (free ed hosting)
  - MoinMoin: http://moinmo.in
  - DokuWiki: http://dokuwiki.org (no database required)

GeoGebra



- Free & multi-platform dynamic mathematics software for all levels of education that joins geometry, algebra, tables, graphing, statistics & calculus in easy-to-use package.

Honorable Mentions

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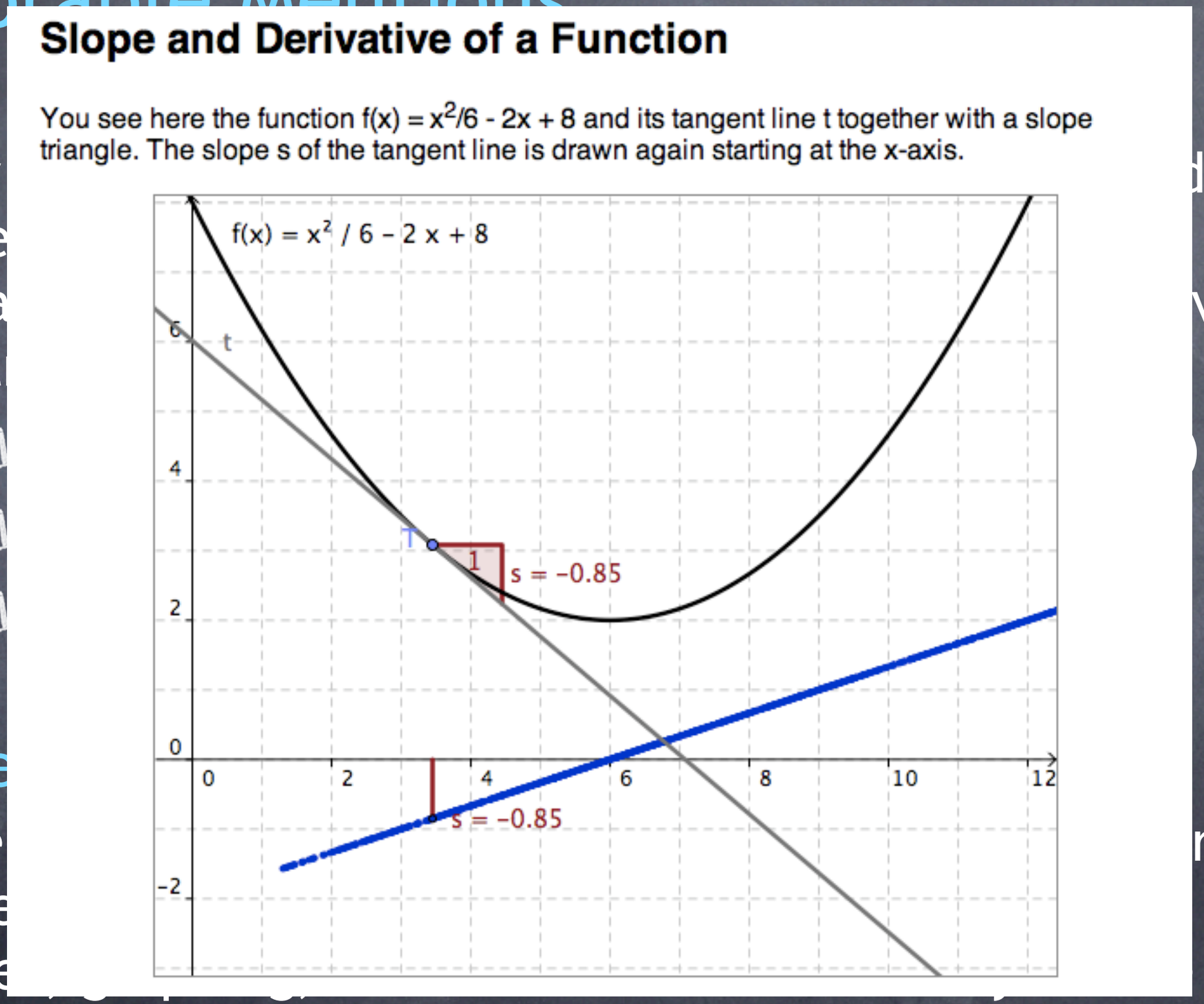

Collaborative LaTeX

- LaTeX Labs: http://docs.latexlab.org
  - open source implementation of a web based LaTeX editor for Google Docs.
- ScribTeX: http://www.scribtex.com
  - Pricing: Free → Premium ($9.99/month)
  - Works on iDevices.
- Others: SpartanTeX, MonkeyTeX, Verbosus,...

Livescribe

- A paper-based computing platform that includes a smartpen, dot paper, & software applications.
- Record & playback, save & search, send & share via pencast or PDF.

Closing Remarks/Questions

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Philosophical Questions

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- How does your institution value that, if at all?