



# Tools and Resources for Mathematics and Science/ Engineering Practices

## Moving from Standards to Practice Conference



25 February 2013

Ed Dickey

College of Education





# Common Core Standards

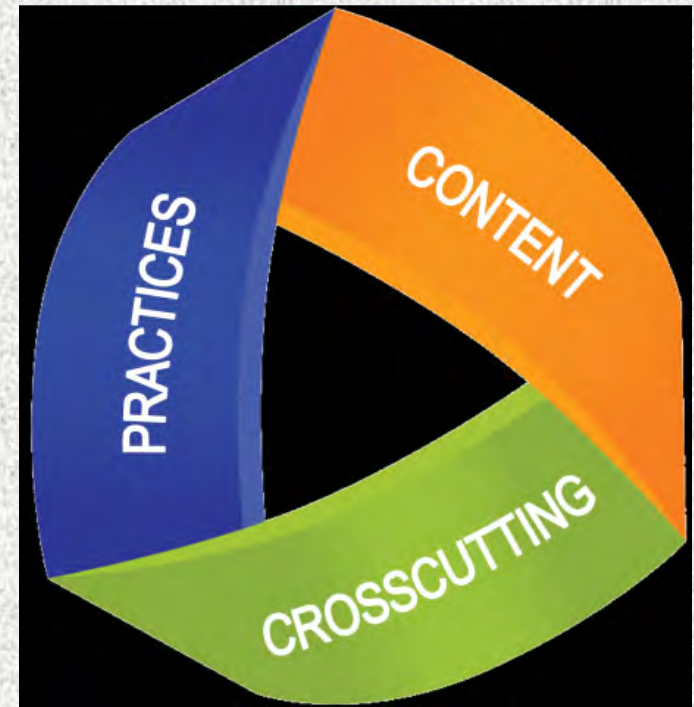
- National standards adopted by 45 states
- Based on most recent research regarding students' learning trajectories related to mathematics content
- Includes detailed description of the way mathematics is learned and used by students (Mathematical Practice)





# Next Generation Science Standards

- Second Draft under review January 2013
- To be complete by March 2013
- NRC, NSTA, AAAS, Achieve
- 26 States (NC, GA, no SC)
- States review/adopt





# CCSSM Mathematical Practices

- Common Core includes a set of Standards for Mathematical Practice that all teachers should develop in their students.
- Similar to NCTM's Mathematical Processes from the *Principles and Standards for School Mathematics*.
- Mathematics Proficiencies from the National Research Council report *Adding It Up*
- Practices **MUST** be assessed



# Mathematical Practices

- Expectations that begin with “understand” are especially good opportunities to connect practices to content.
- “Students who lack understanding of a topic may rely on procedures too heavily.”
- Understanding standards (intersection of content and practice) “are intended to be weighted toward central and generative concepts.. That most merit time, resources, innovative energies, and focus...”



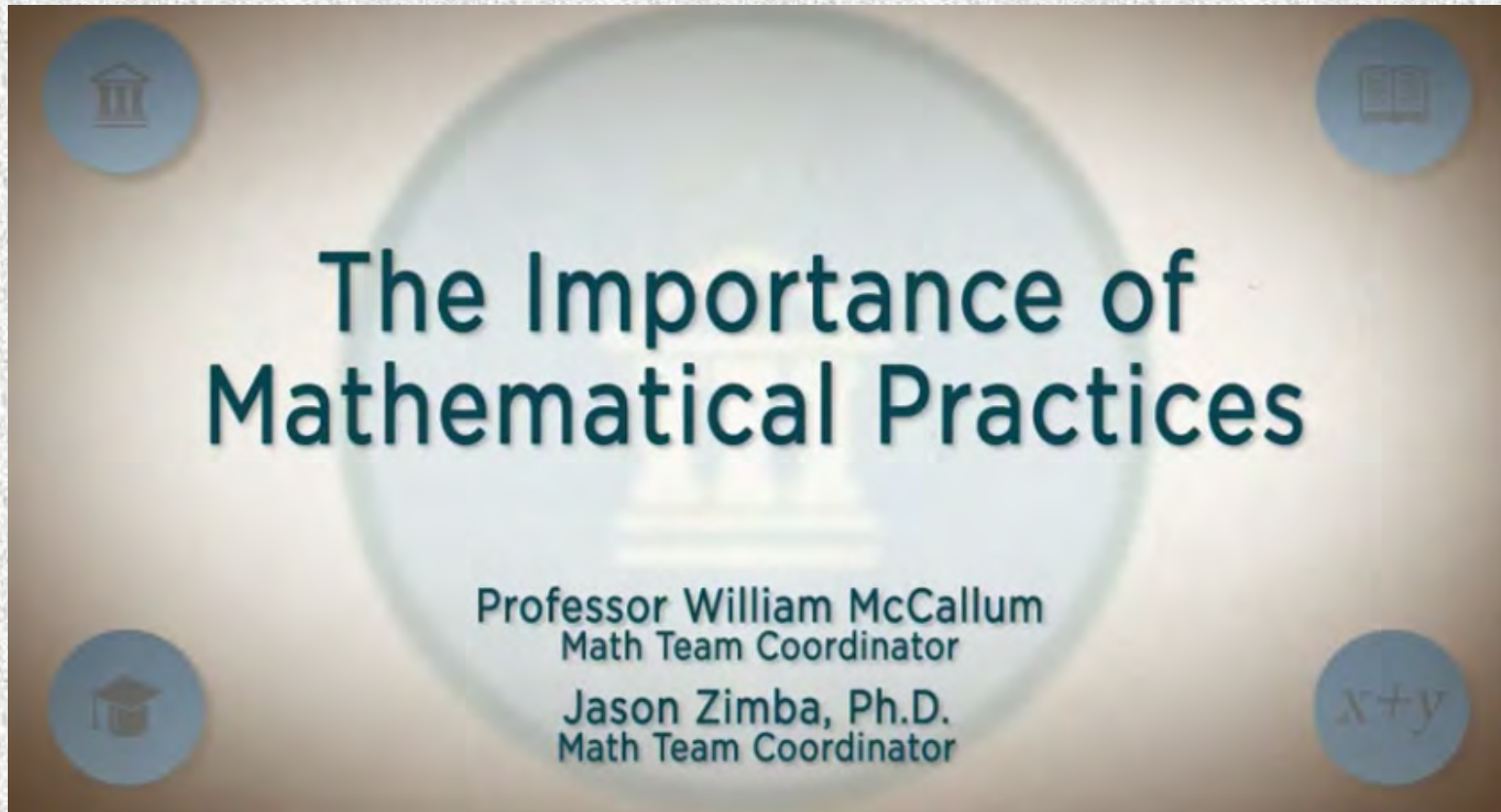
# NGSS Science and Engineering Practices

- “... behaviors that scientists engage in as they investigate and build models and theories about the natural world.
- “... to better explain and extend what is meant by ‘inquiry’ in science and the range of cognitive, social, and physical practices that it requires.
- ... behaviors that engineers engage in as they apply science and mathematics to design solutions to problems.”



# Importance of Mathematical Practices

- <https://www.youtube.com/watch?v=m1rxkW8ucAI>





## 8 CCSSM Mathematical Practices

1. Make sense of problems and persevere in solving them.
2. Reason abstractly and quantitatively.
3. Construct viable arguments and critique the reasoning of others.
4. Model with mathematics.





## 8 CCSSM Mathematical Practices

5. Use appropriate tools strategically.
6. Attend to precision.
7. Look for and make use of structure.
8. Look for and express regularity in repeated reasoning.



# 8 Science and Engineering Practices

1. Asking Questions (for science and Defining Problems (for engineering)
2. Developing and Using Models
3. Planning and Carrying Out Investigations
4. Analyzing and Interpreting Data



## 8 Science and Engineering Practices

5. Using Mathematical and Computational Thinking
6. Constructing Explanations (for science and Designing Solutions (for engineering)
7. Engaging in Argument from Evidence
8. Obtaining, Evaluating, and Communicating Information



# Graphic Organizer

*Overarching habits of mind of a productive mathematical thinker*

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*Reasoning and Explaining*

*Modeling and using tools*

*Seeing structure and generalizing*



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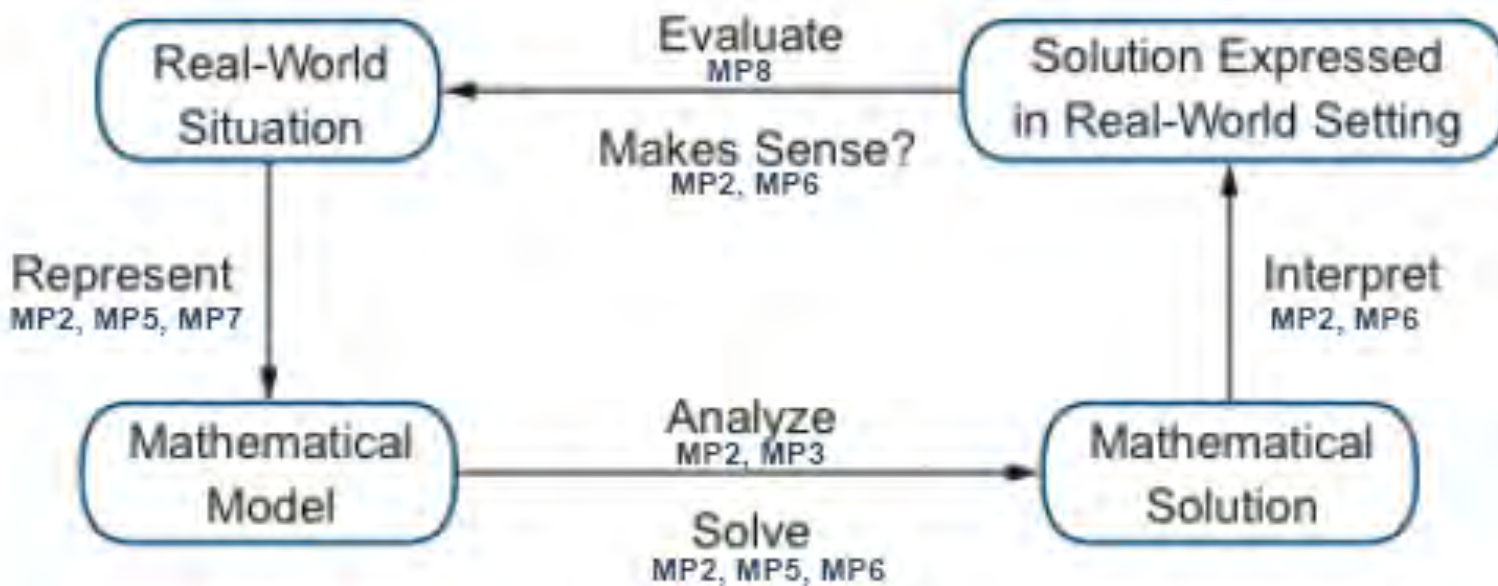
*Investigations and Communicating*



# Mathematical Modeling

## Process of Mathematical Modeling

Connecting Mathematical Practices (MP) and Content Standards (CS)  
MP1 and MP4 are the focal practices of the entire process.



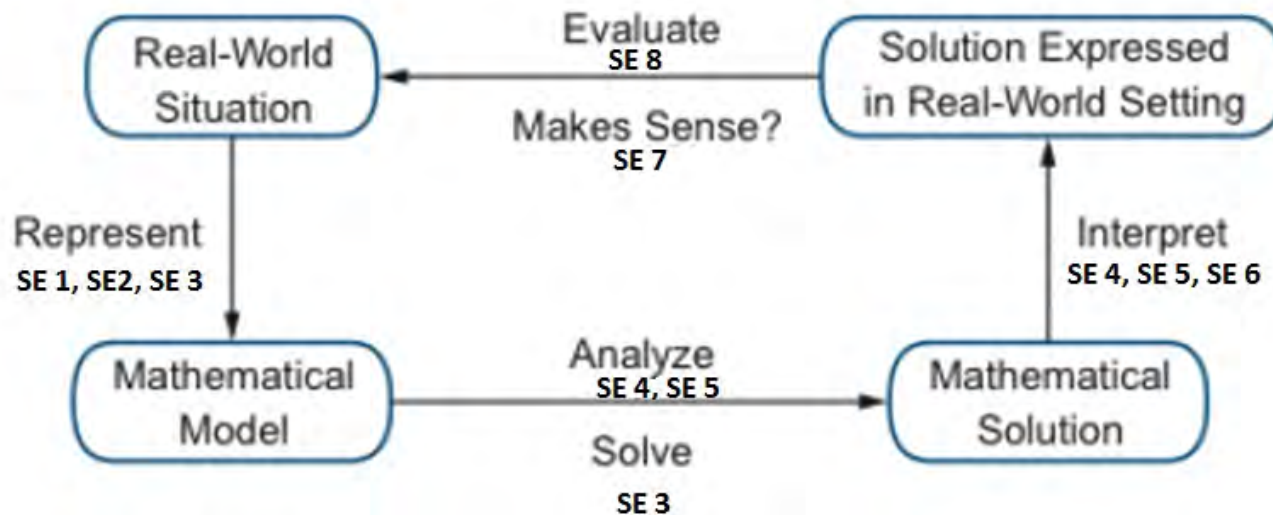
- Dr. Christian Hirsch, Western Michigan Univ.



# Science and Engineering Practices

## Process of Mathematical Modeling

Connecting Science and Engineering Practices to the focal process of modeling.





## CAUTIONS from Bill McCallum

- Not intended as free floating proficiencies observed independently of content
  - Blended with content and groups of practices
- Not uniformly applied over all work students do
  - But all practices should be addressed within a school year or high school course
- Must be integrated with content
  - A balanced diet





## Plan for this Session

- View a video OR review Common Core tools that I have selected
- Discuss, decide, and share ideas for how the video might be used to address Standards for Practice (math or science/engineering).
- All videos and tools freely available on web and can be captured for use in classrooms (even behind school firewall).



# Kylie Minogue

- Come Into My World
- <http://www.youtube.com/watch?v=ErU5hKT2KM8>



THANKS  
to David Masunga  
for bringing this  
video to my  
attention



# Music Video: What Practices?

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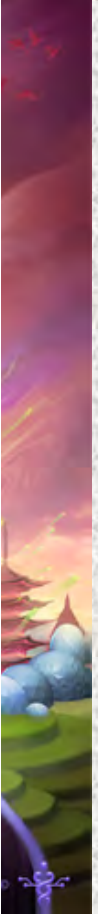
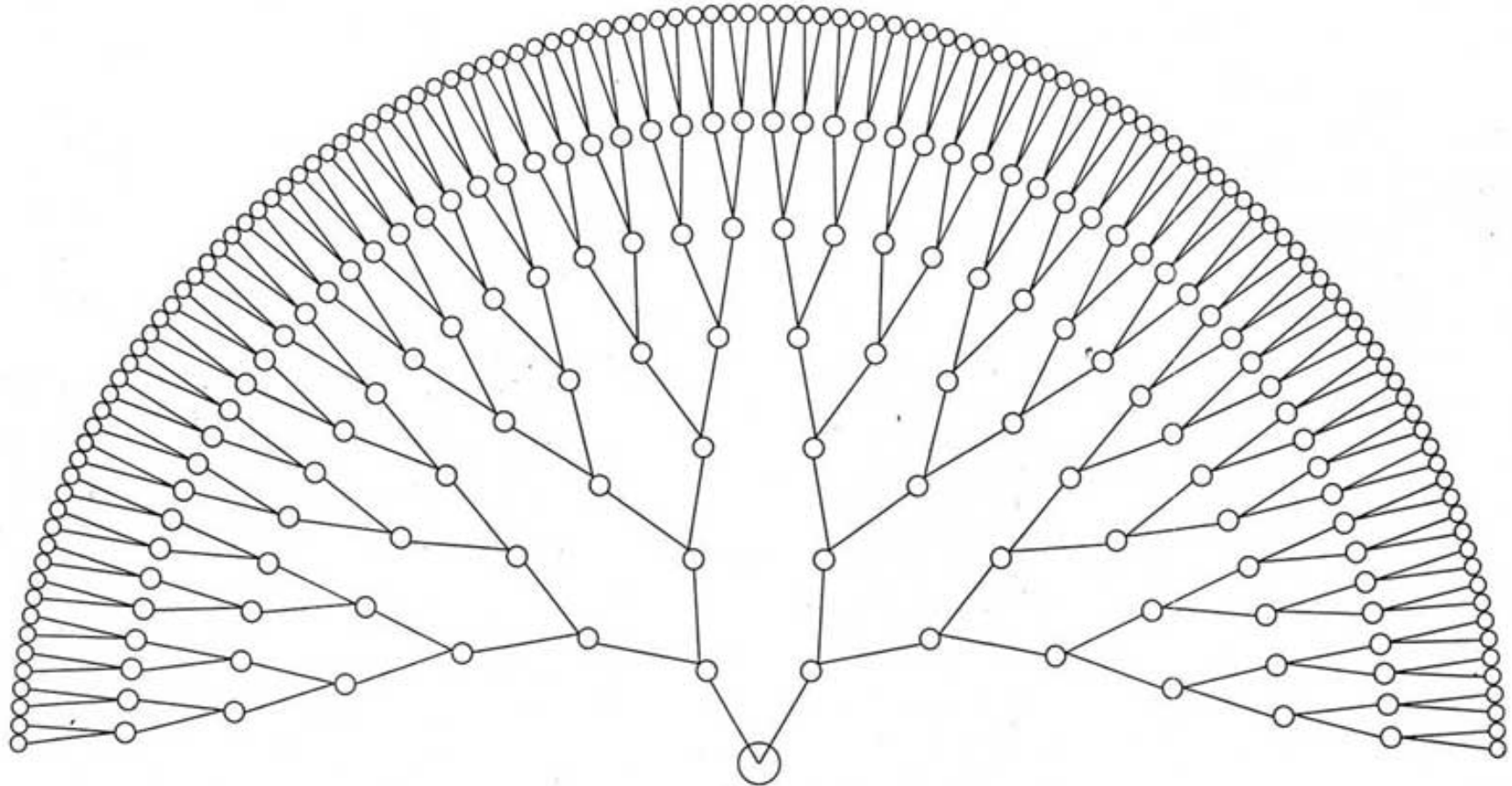
*Modeling and Mathematics*

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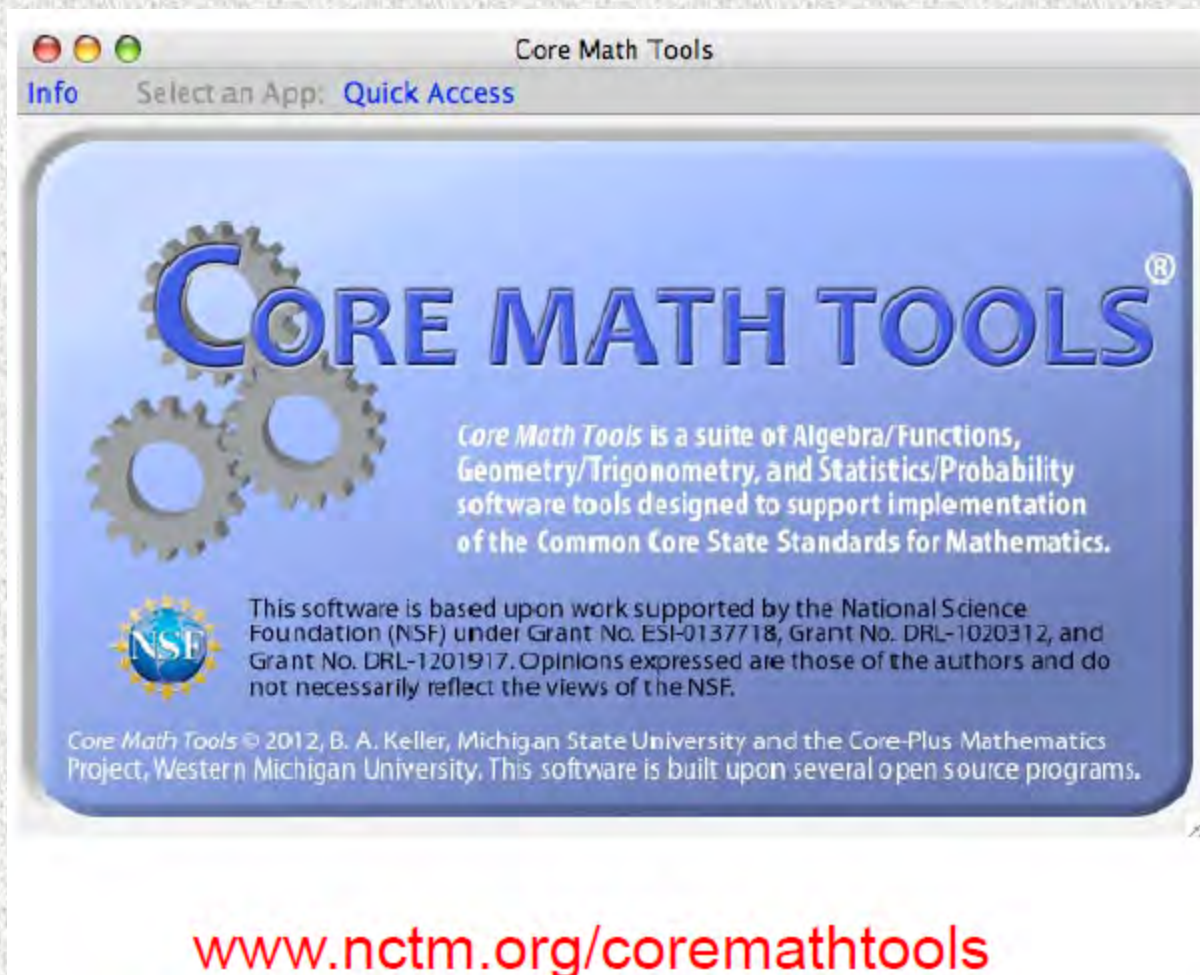


# Recursion & Self-Repeating Patterns





# Core Math Tools




The image shows a screenshot of a computer window titled "Core Math Tools". The window has a standard macOS-style title bar with red, yellow, and green window control buttons. Below the title bar is a menu bar with "Info" and "Select an App: Quick Access". The main content area has a blue background with the text "CORE MATH TOOLS" in large, blue, 3D-style letters. To the left of the text are three interlocking gears. Below the main title, there is a paragraph of text describing the software as a suite of Algebra/Functions, Geometry/Trigonometry, and Statistics/Probability software tools designed to support implementation of the Common Core State Standards for Mathematics. Below this is the NSF logo and a paragraph of text stating that the software is based upon work supported by the National Science Foundation (NSF) under Grant No. ESI-0137718, Grant No. DRL-1020312, and Grant No. DRL-1201917. At the bottom, there is a copyright notice for 2012, B. A. Keller, Michigan State University and the Core-Plus Mathematics Project, Western Michigan University.

Core Math Tools

Info Select an App: Quick Access

## CORE MATH TOOLS<sup>®</sup>

Core Math Tools is a suite of Algebra/Functions, Geometry/Trigonometry, and Statistics/Probability software tools designed to support implementation of the Common Core State Standards for Mathematics.

 This software is based upon work supported by the National Science Foundation (NSF) under Grant No. ESI-0137718, Grant No. DRL-1020312, and Grant No. DRL-1201917. Opinions expressed are those of the authors and do not necessarily reflect the views of the NSF.

Core Math Tools © 2012, B. A. Keller, Michigan State University and the Core-Plus Mathematics Project, Western Michigan University. This software is built upon several open source programs.

[www.nctm.org/coremathtools](http://www.nctm.org/coremathtools)



# Core Math Tools

- *Core Math Tools* is accompanied by user support and resources at a CMT portal within the NCTM website.
- *Core Math Tools* is designed for use with *any* CCSSM-oriented high school textbook series.
- *Core Math Tools* is a promising resource for mathematics teacher preparation programs.



# Core Math Tools

Core Math Tools

Info Select an App: Quick Access

Algebra & Functions	Geometry & Trigonometry	Statistics & Probability
<b>CAS</b> <p>Produce tables and graphs of functions, manipulate symbolic expressions, and solve equations and inequalities.</p>	<b>Synthetic</b> <p>Construct, measure, manipulate, transform, and animate geometric figures.</p>	<b>Data Analysis</b> <p>Graphically display and analyze univariate and bivariate data.</p>
<b>Spreadsheet</b> <p>Use familiar spreadsheet functions, insert class data or data from other sources, and employ data transformations.</p>	<b>Coordinate</b> <p>Construct, measure, manipulate, transform, and animate geometric figures in a coordinate plane.</p>	<b>Simulation</b> <p>Create and run simulations of probabilistic situations.</p>
<b>General Purpose Tools</b> CAS, Spreadsheet, Interactive Geometry, Data Analysis and Simulation	<b>Custom Apps</b> → Focused exploration of specific topics such as triangle congruence conditions, sampling distributions, and linear programming.	<b>Advanced Apps</b> → Tools for exploring post-CCSSM topics including vertex-edge graphs, contour diagrams, difference quotients, and cryptography.

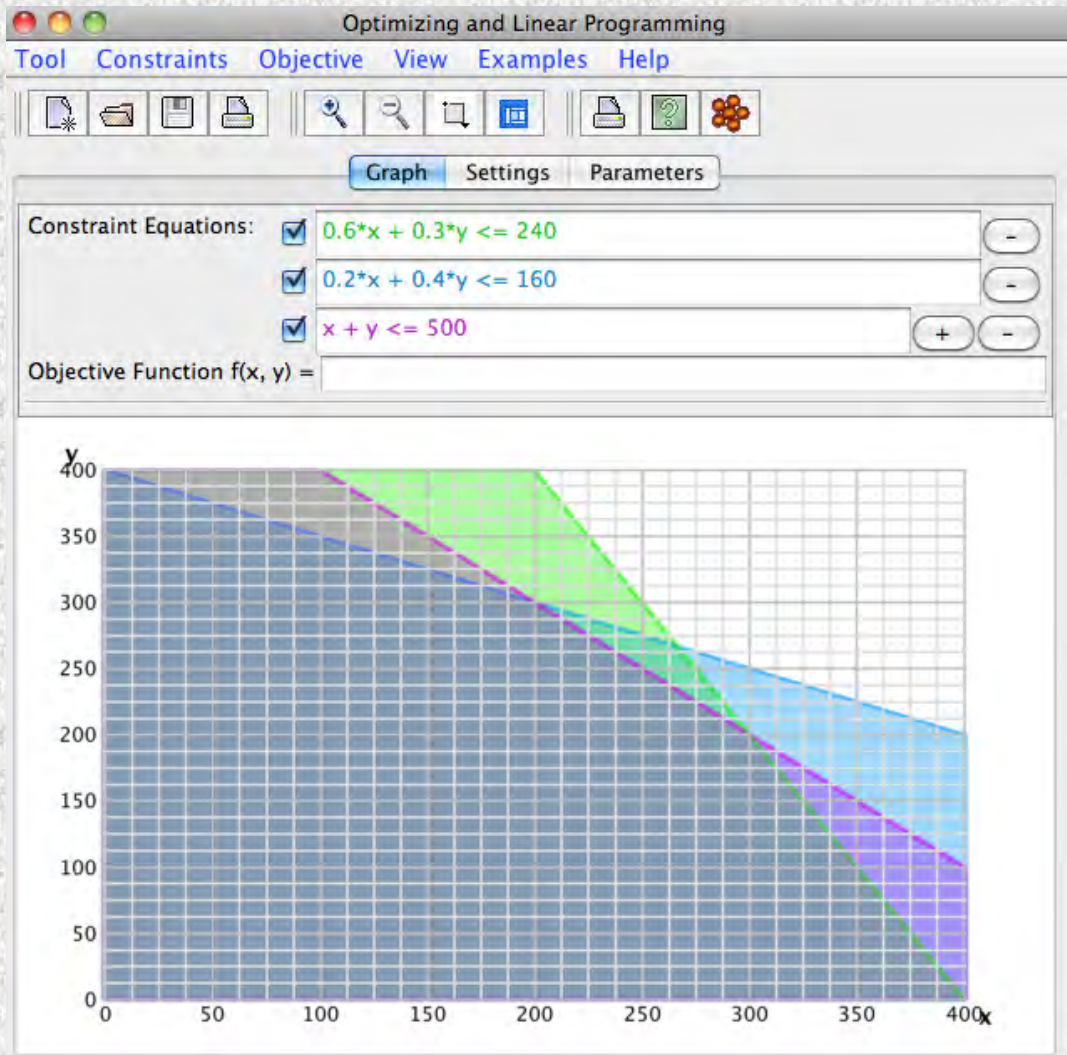
## General Purpose Tools





# Algebra Tools

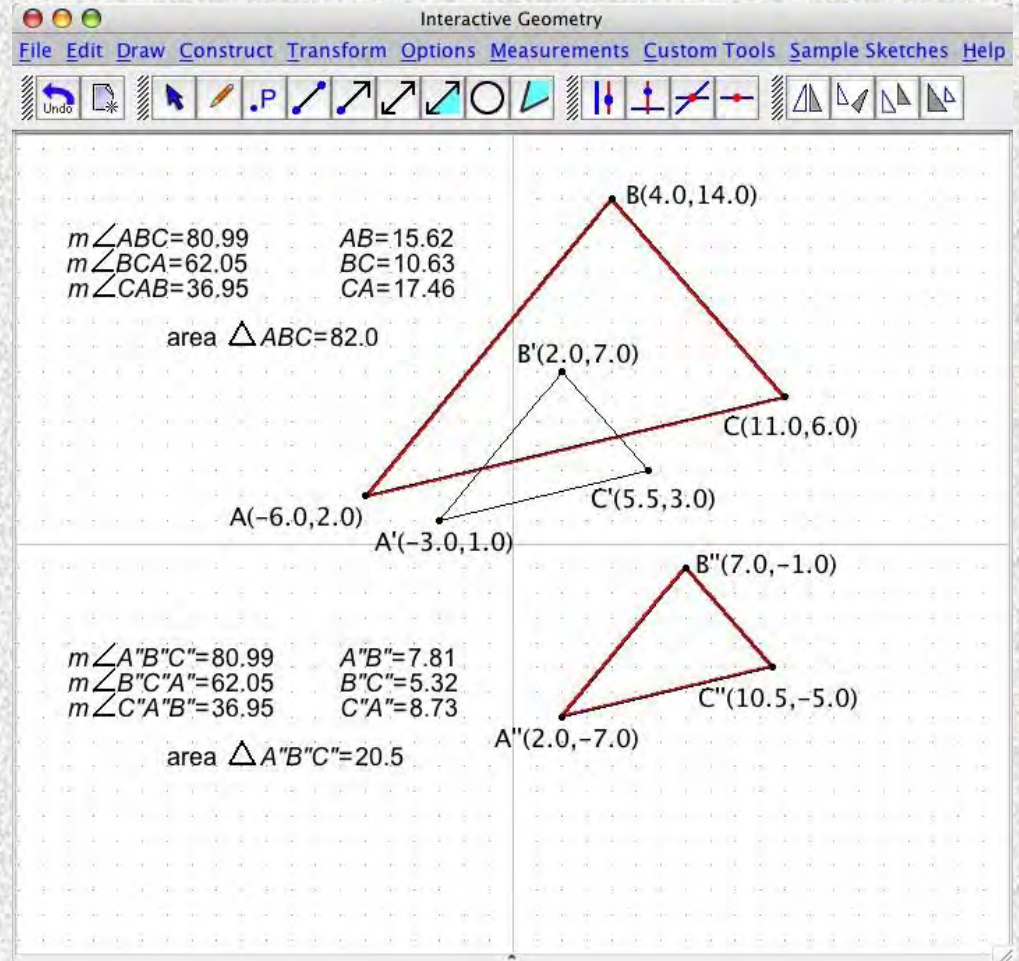
- electronic spreadsheet and a computer algebra system (CAS) that produces tables and graphs of functions, manipulates algebraic expressions, and solves equations and inequalities; and modeling.





# Geometry Tools

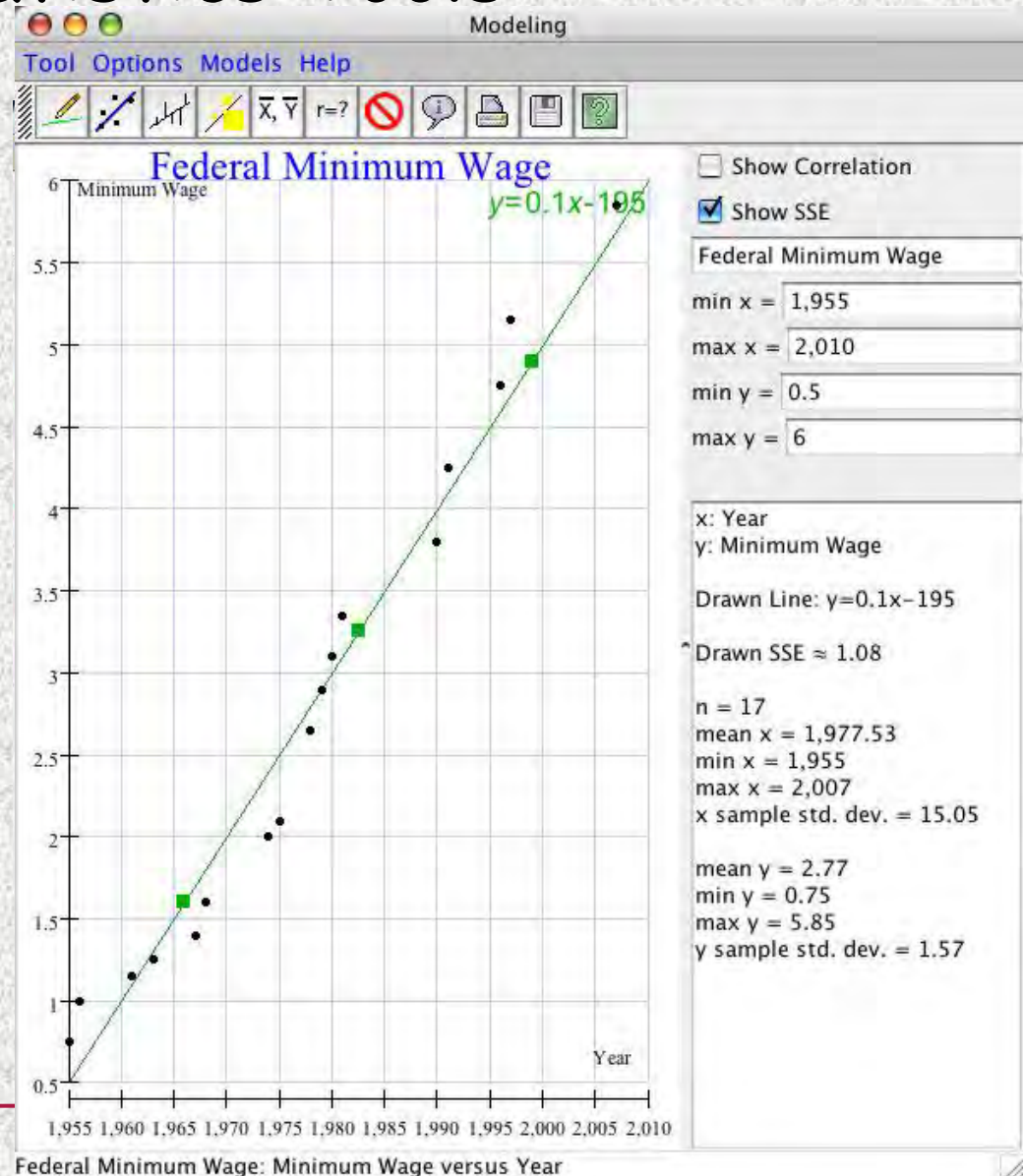
- interactive drawing tool for constructing, measuring, manipulating, and transforming geometric figures in both a coordinate and coordinate-free environment, a simple object-oriented programming language for creating animations





# Statistics Tools

- for graphic display and analysis of univariate and bivariate data, simulation of probabilistic situations and mathematical modeling of quantitative relationships. Spreadsheets allow easy insert of class data or data available from other sources. CMT includes pre-loaded data sets for developing key statistical ideas.





# Custom Apps

Core Math Tools

Info Select an App: Quick Access

### Discrete Mathematics Apps

**Vertex-Edge Graphs**

**Control Charts**

**Ranked-Choice Voting**

**Weighted Voting**

**Codes and Cryptography**

### Continuous Mathematics Apps

**Contour Diagrams**

General Purpose Tools → Custom Apps → Advanced Apps

General Purpose Tools: CAS, Spreadsheet, Interactive Geometry, Data Analysis and Simulation

Custom Apps: Focused exploration of specific topics such as triangle congruence conditions, sampling distributions, and linear programming

Advanced Apps: Tools for exploring post-CCSSM topics including vertex-edge graphs, contour diagrams, difference quotients, and cryptography



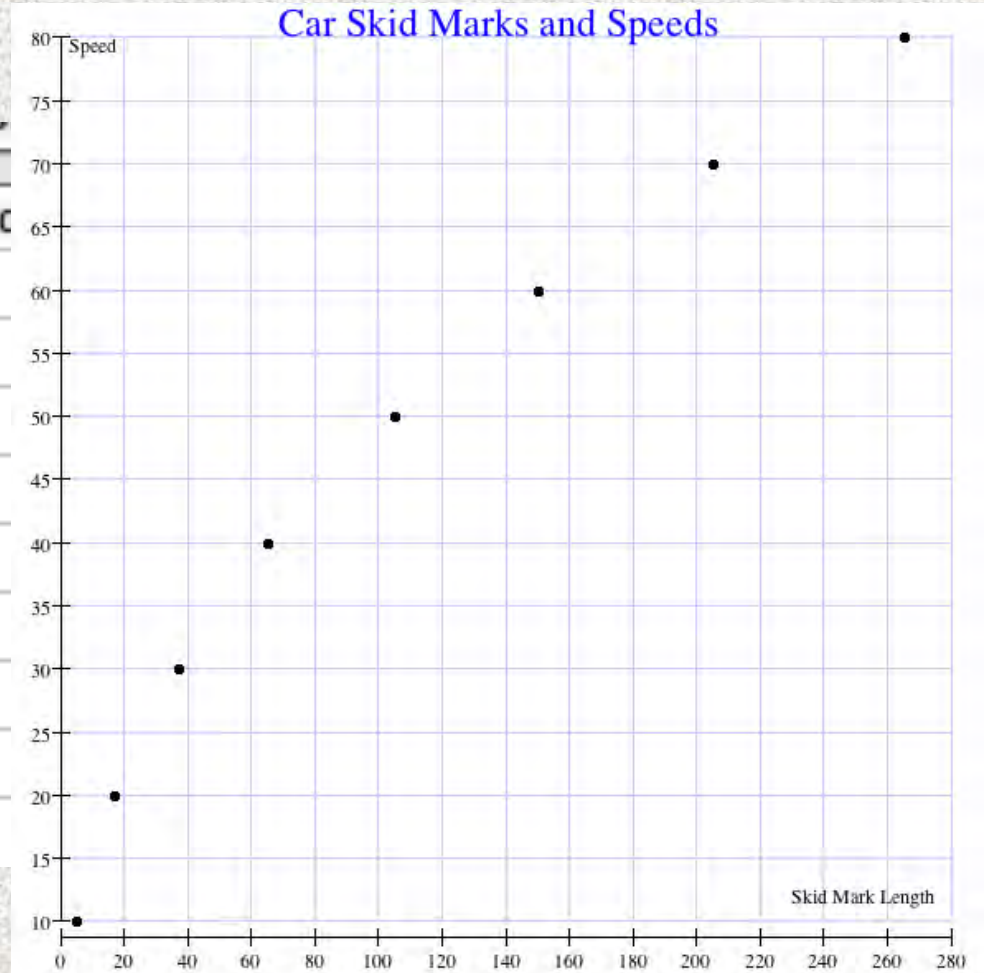
# Car Skid Marks and Speeds

- When police investigate the scene of an automobile accident, they look for skid marks and use the length of those marks to estimate the speed at which the car was traveling. The results of experiments with a test car, giving skid mark length (in feet) and speed (in miles per hour), are shown in the next slide.



# Skid Marks Vs. Speed

	Skid Mark Length	Speed
1	5	10
2	17	20
3	37	30
4	65	40
5	105	50
6	150	60
7	205	70
8	265	80





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# UPS and Girth

- Brian Regan Improv Comedy
- <http://www.youtube.com/watch?v=89frRi8GgGA>



THANKS  
to Tim Kanold for  
bringing this video to  
my attention!



# UPS and Girth

[http://www.ups.com/content/us/en/resources/ship/packaging/weight\\_size.html?srch\\_pos=3&srch\\_phr=girth](http://www.ups.com/content/us/en/resources/ship/packaging/weight_size.html?srch_pos=3&srch_phr=girth)

## How To Measure Your Package Size

To measure ground packages use the following formula:

Length + 2x Width + 2x Height

### Step 1. Determining Length

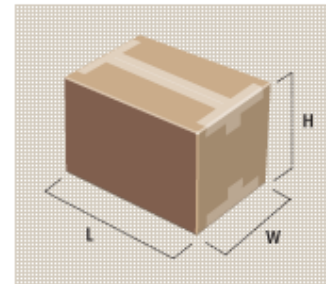
- Measure the longest side of the package, rounding to the nearest inch. This is your length.

### Step 2. Determining Girth (2x Width + 2x Height)

- Measure the width of the package, rounding to the nearest inch. Multiply this number by 2.
- Measure the height of the package, rounding to the nearest inch. Multiply this number by 2.
- Add these two numbers together. This is your girth.

Step 3. Add the length and the girth together. This is your package measurement.

Step 4. Weigh the package to obtain its actual weight.





# Carry-on Luggage and Girth

Airline	No. of Bags Allowed	Maximum Allowable Dimensions	Max Weight
<a href="#">Air Tran carry-on info</a>	1/passenger	55 linear inches (L+W+H)	-
<a href="#">American Airlines carry-on info</a>	1/passenger	45 linear inches (L+W+H)	40 lbs.
<a href="#">America West carry-on info</a>	1/passenger	51 linear inches (L+W+H)	-
<a href="#">Continental carry-on info</a>	1/passenger	51 linear inches (L+W+H)	40 lbs.
<a href="#">Delta Airlines carry-on info</a>	1/passenger	22" x 14" x 9"	40 lbs.
<a href="#">Northwest Airlines carry-on info</a>	1/passenger	22" x 14" x 9"	40 lbs.
<a href="#">Southwest Airlines carry-on info</a>	1/passenger	24" x 16" x 10"	-
<a href="#">Spirit Airlines carry-on info</a>	1/passenger	22" x 13" x 10"	40 lbs.
<a href="#">United Airlines carry-on info</a>	1/passenger	22" x 14" x 9"	40 lbs.
<a href="#">US Airways carry-on info</a>	1/passenger	24" x 16" x 10"	40 lbs.



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# Wolfram Alpha

factor  $2x^5 - 19x^4 + 58x^3 - 67x^2 + 56x - 48$  - Wolfram|Alpha - Windows Internet Explorer

http://www.wolframalpha.com/input/?i=factor+2x%5E5+...-19x...

File Edit View Favorites Tools Help

factor  $2x^5 - 19x^4 + 58x^3 - 67x^2 + 56x - 48$  ...

**WolframAlpha** computational knowledge engine

factor  $2x^5 - 19x^4 + 58x^3 - 67x^2 + 56x - 48$

Input interpretation:

factor  $2x^5 - 19x^4 + 58x^3 - 67x^2 + 56x - 48$

Result:

$(x - 4)^2 (2x - 3)(x^2 + 1)$

Plots:

(x from 0 to 5)

(x from -60 to 60)

Factorizations over finite fields: [More](#)

GF(2)  $x^2 (x + 1)^2$

Computed by **Wolfram Mathematica** Download as: [PDF](#) [Live Mathematics](#)



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# Growing Hair

- The Big Bang Theory: Hair Me Out

<http://www.youtube.com/watch?v=iQ3CyK1osY8>





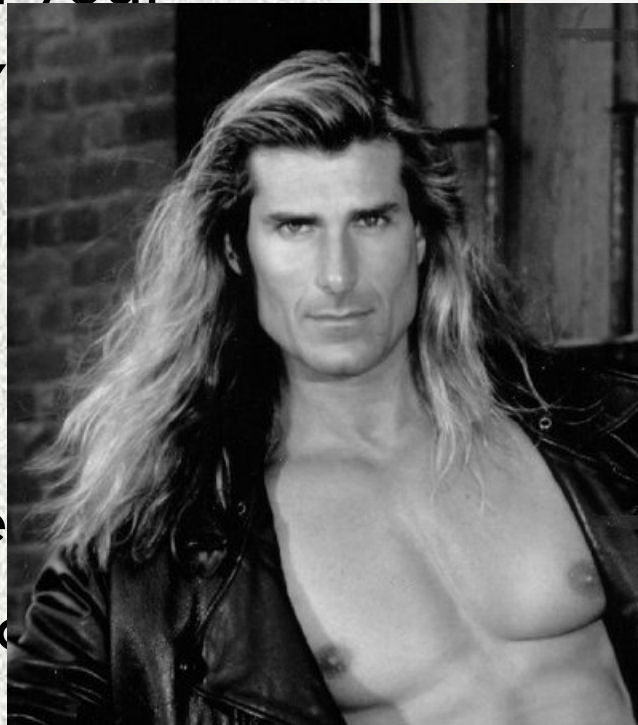
## Growing Hair

- Sheldon: “... my hair is growing at 4.6 yoctometers per femtosecond...”
- What does that mean?
- Is it accurate?
- Can you re-phrase the growth rate?
- ... in centimeter per second, per nanosecond, or other units



# Grow Hair: Useful info

- Hair grows at approximately 15 cm per year
- Seconds in year
- Or 31,557,600



seconds in a year

31,557,600 results (0.18 seconds)

$10^{-24}$	1 yoctosecond
------------	---------------

$10^{-6}$	1 micrometre ( $\mu\text{m}$ )
-----------	--------------------------------

$10^{-5}$	10 $\mu\text{m}$
-----------	------------------

$10^{-4}$	100 $\mu\text{m}$
-----------	-------------------

$10^{-24}$	1 yoctometre (ym)	3.15576	second
------------	-------------------	---------	--------

$10^{-3}$	1 millimetre (mm)
-----------	-------------------

$10^{-21}$	1 zeptometre (zm)
------------	-------------------

$10^{-2}$	1 centimetre (cm)
-----------	-------------------

$10^{-18}$	1 attometre (am)
------------	------------------

$10^{-1}$	1 decimetre (dm)
-----------	------------------

- 1 yoctometre
- 1 femtasecond

$10^0$	1 metre
--------	---------



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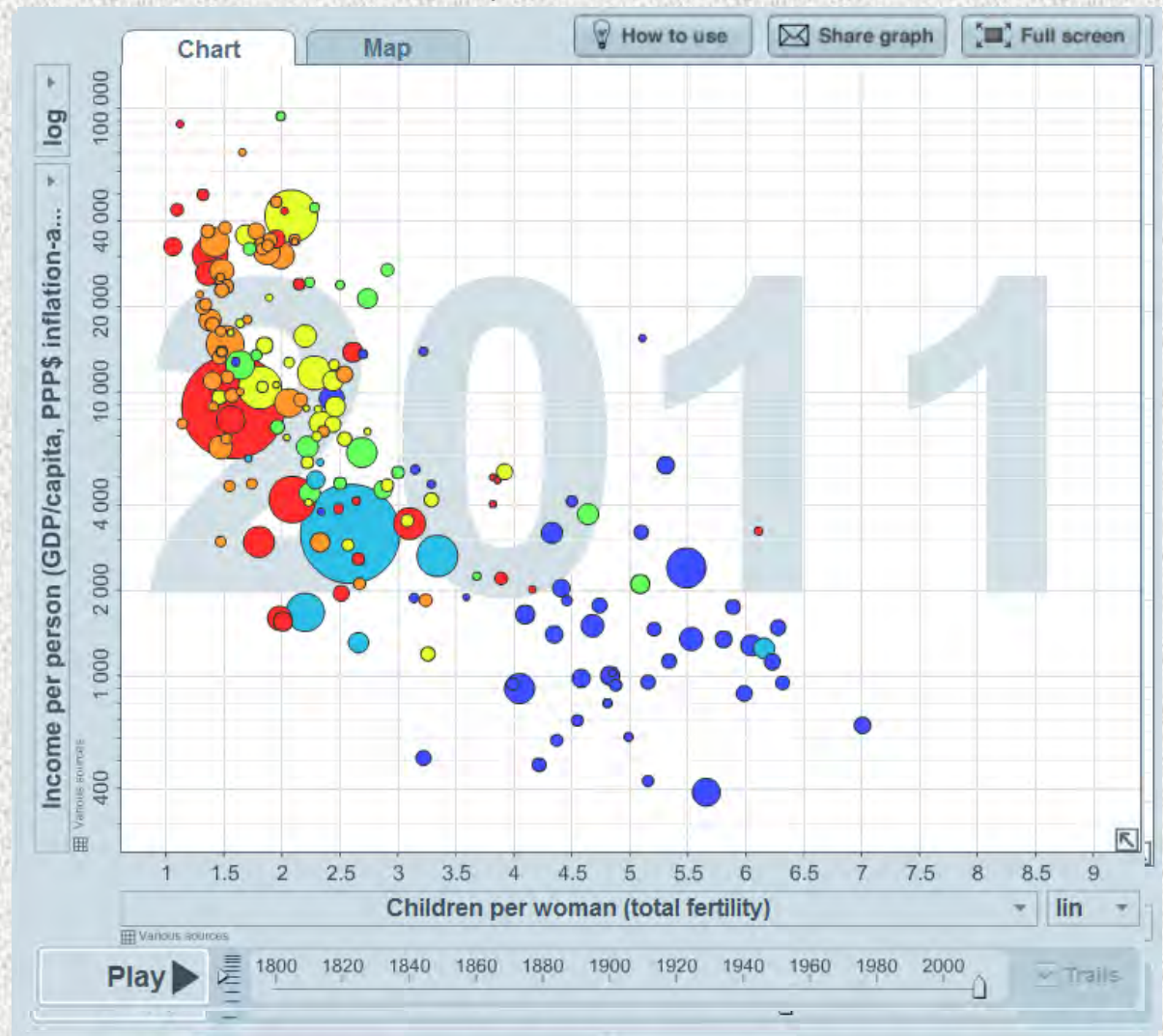
# Visual Data Analysis





# Some Examples

- Children per Woman vs. Income per person





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# Vi Hart

- How to Snakes
- <http://www.youtube.com/watch?v=Gx5D09s5X6U>
- Buy at [Amazon](#)



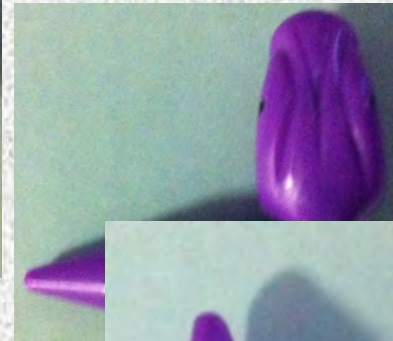


# How Many Possible Snakes?

- Each snake is made of two body parts (S).
- Each snake is made of two body parts (S).



body/tail part b (S).



- smallest (one body part and one





# How Many Possible Snakes?

- Given each snake is “unique” if it is oriented with its body or tail L, R, or S,
- How long must a snake be so that the number of unique snakes equals or surpasses the population of South Carolina? ... the U.S.? ... the world?





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# Population

- South Carolina: 4,679,230 (est. in 2011)
- U.S.: 311,591,917 (est. in 2011)
- World: 7,021,836,029 (est. in 2011)

Real solution:

[Approximate form](#) [Step-by-step solution](#)

$$x = \frac{\log(13) + \log(71) + \log(101) + \log(75323)}{\log(3)}$$

[Examples](#) [Random](#)

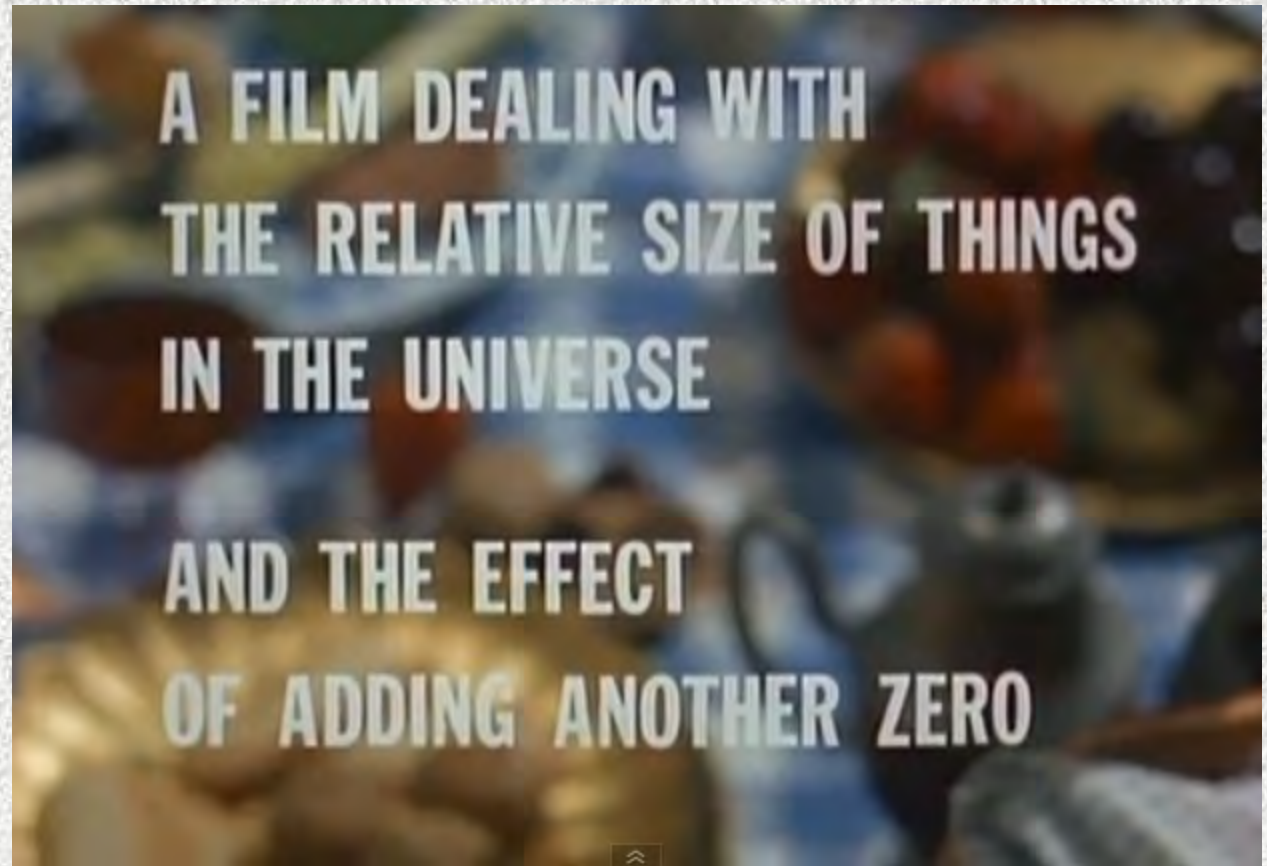
log(x) is the natural logarithm »

- U.S.: 17.8 or 18 snake segments
- World: 20.637 or 21 snake segments



# Powers of Ten

- By Charles and Ray Eames for IBM in 1977







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*Investigations and Communicating*



July 24–26, 2012 | Los Angeles, CA

# Infusing the Classroom with Reasoning & Sense Making

AN INTERACTIVE INSTITUTE FOR GRADES 9–12  
WITH EXTENDED ONLINE PROFESSIONAL DEVELOPMENT

July 28–30, 2011 | Orlando, Florida

# Infusing the Classroom with Reasoning & Sense Making



AN NCTM INTERACTIVE INSTITUTE ON HIGH SCHOOL MATHEMATICS

## 2013 Institutes

**High School Mathematical Practices:**  
August 1-3, Washington, DC

**K-5 Number and Operations Institute**  
July 11-13, New Orleans

**6-8 Algebra Readiness Institute:**  
July 8-10, New Orleans

August 1–3, 2013 | Washington, D.C.



Engaging Students  
in Learning: Mathematical  
Practices & Process Standards

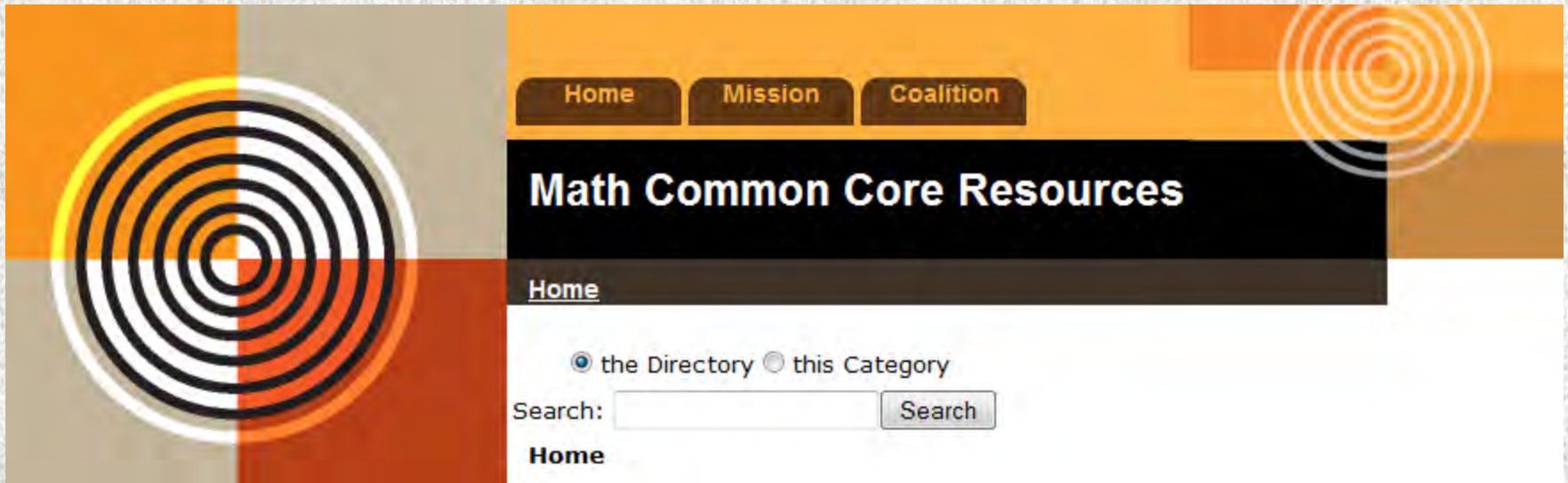
AN NCTM INTERACTIVE INSTITUTE FOR GRADES 9-12





# Math Common Core Resources

- <http://www.nctm.org/standards/mathcommoncore/>





# Web Resources

- Common Core: <http://www.corestandards.org>
- Math Common Core Resources:  
<http://www.nctm.org/standards/mathcommoncore/>
- SBAC: <http://www.k12.wa.us/smarter/>
- South Carolina Common Core:  
[http://ed.sc.gov/agency/pr/standards-and-curriculum/South\\_Carolina\\_Common\\_Core.cfm](http://ed.sc.gov/agency/pr/standards-and-curriculum/South_Carolina_Common_Core.cfm)
- Next Generation Science Standards:  
<http://www.nextgenscience.org/>



# Web Resources

- Core Math Tools: <http://www.nctm.org/coremathtools>
- Wolfram Alpha: <http://www.wolframalpha.com>
- UPS Girth:  
[http://www.ups.com/content/us/en/resources/ship/packaging/weight\\_size.html?srch\\_pos=3&srch\\_phr=girth](http://www.ups.com/content/us/en/resources/ship/packaging/weight_size.html?srch_pos=3&srch_phr=girth)
- Vi Hart Blog: <http://vihart.com>
- Snakes at Amazon:  
<http://www.amazon.com/dp/B003I6USDW?tag=notcot-20>
- Orders of Magnitude  
[http://en.wikipedia.org/wiki/Orders\\_of\\_magnitude\\_%28time%29](http://en.wikipedia.org/wiki/Orders_of_magnitude_%28time%29)  
[http://en.wikipedia.org/wiki/Orders\\_of\\_magnitude\\_%28length%29](http://en.wikipedia.org/wiki/Orders_of_magnitude_%28length%29)



# Videos

- The Importance of Mathematical Practices:  
<https://www.youtube.com/watch?v=m1rxkW8ucAI>
- Kylie Minogue – Come Into My World:  
<http://www.youtube.com/watch?v=ErU5hKT2KMs>
- UPS and Girth: <http://www.youtube.com/watch?v=89frRi8GgGA>
- The Big Bang Theory:  
<http://www.youtube.com/watch?v=iQ3CyK1osY8>
- How to Snakes by Vi Hart:  
<http://www.youtube.com/watch?v=Gx5D09s5X6U>
- Powers of Ten: <http://www.powersof10.com/film>



Thank you...

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[www.ite.sc.edu/dickey.html](http://www.ite.sc.edu/dickey.html)