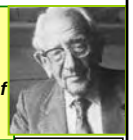
MathResources Inc.

October 1st 2008

What's New, What's Possible, What's Coming ...

Jonathan Borwein, FRSC www.cs.dal.ca/~jborwein
Canada Research Chair in Collaborative Technology, Dalhousie
Visiting Professor Laureate, University of Newcastle

"intuition comes to us much earlier and with much less outside influence than formal arguments which we cannot really understand unless we have reached a relatively high level of logical experience and sophistication."



George Polya
1887-1985

RMIT UNIVERSITY

THE UNIVERSITY OF NEWCASTLE AUSTRALIA

Revised 25/09/2008

Abstract of Presentation

I will describe and illustrate my experiences over the past two-and-a-bit decades in using, designing and trying to sell mathematical software

I will do this from the perspective(s) of a researcher, an educator, a consultant, and of a partner in a small but robust business

Outline of Presentation

0. Early Chronology of a Company

I. The Changing Research Landscape

II. New Ways of Doing Mathematics

III. New Ways of Seeing Mathematics

IV. Amazing New Web Services

MathResources: Chronology

1. 1971: I arrive in Oxford. Meet Borowski 'lexicographically'.
2. 1985: Sabbatical in UK/France. We consult for Collins. (And 'stand ready to entertain all invitations',)
3. 1995-89: UK Dictionary (first book set from disk). We keep IP and "electronic and musical" rights. 1991: US Edition. 1993-98: Chinese, Arabic, Italian, Indonesian,...
4. 1990: JMB and Carolyn Watters/Jack Ho begin "MathProbe" - hypertext.
5. 1993: Technology used for Rio Conference. Migration from Pagemaker to Hypercard to SGI to SUN to Windows (to Mac ?) continues.
6. 1994: MRLtd established with Ron Fitzgerald. Letter written to HarperCollins.
7. 1994-95. Investors and regional funding found.
8. 1996: MathResource released (Dec).
9. 1997: MathProbe released (Sept).
10. 1998: the future. Constant marketing, distribution, updates, new products.

Maple inside

1998-2002
- •Dot bubble burst

We learned about
- •Burn rates
- •Naming products
- •Retail software
- •How schools decide
- •Bundling
- •Casio
- •…

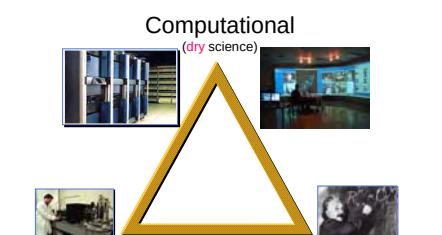
2002-2008
- •$2.5M from Gov't for Interactive School Math
- •Dictionary in Maple
- •Reference books die
- •Morph in part to contractor: MAA, NIST, NSF, IBM…

http://www.mathresources.com/

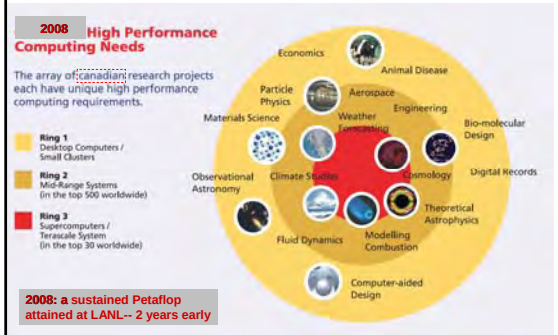
A 1985 Relational Silicon Database

• MacWrite, 3 Apple+'s, a brain dead Lisa, and 5" floppies

I. Changing Research Landscape: a new triangle

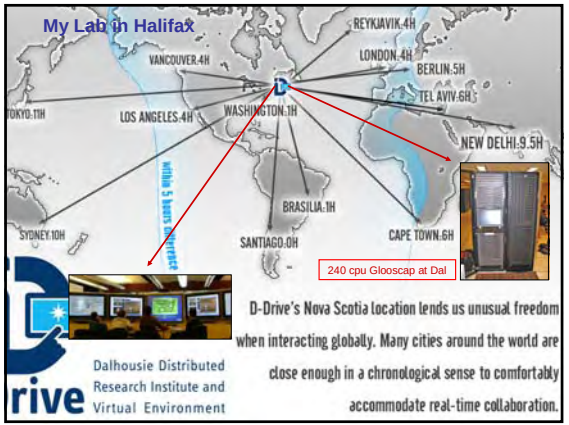


HPC Needs in Canada or Oz



The Changing Computing Landscape

Tera becomes Peta becomes … Bigga



Moore's Law and its Implications

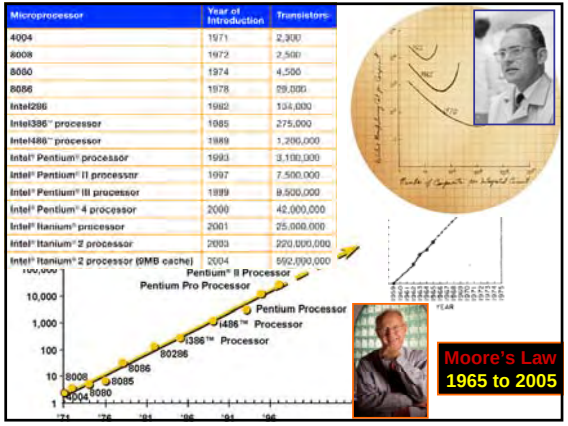
"The complexity for minimum component costs has increased at a rate of roughly a factor of two per year ...

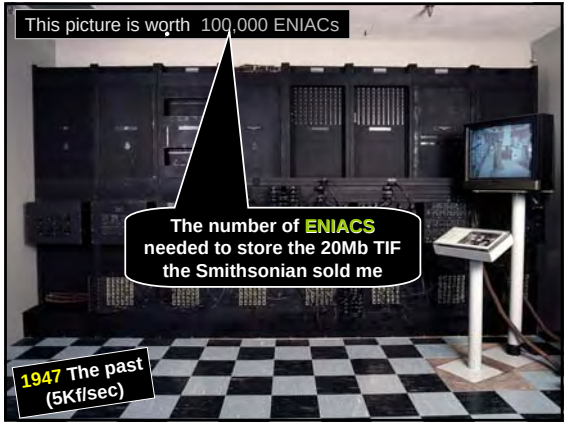
- now taken as "every 18 months to 2 years"

Certainly over the short term this rate can be expected to continue, if not to increase. Over the longer term, the rate of increase is a bit more uncertain, although there is no reason to believe it will not remain nearly constant for at least 10 years. That means by 1975, the number of components per integrated circuit for minimum cost will be 65,000. I believe that such a large circuit can be built on a single wafer.

Gordon Moore (**Intel**) "Cramming more components onto Electronic Circuits", *Electronics Magazine* 19 April 1965

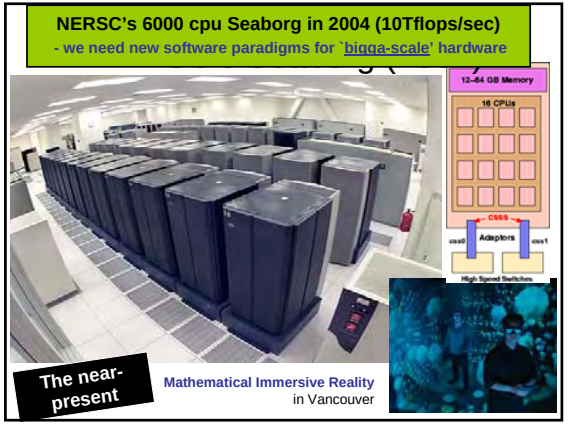
Unprecedented and expected to continue for 10-20 years.





NERSC's 6000 cpu Seaborg in 2004 (10Tflops/sec)

- we need new software paradigms for 'bigga-scale' hardware



IBM BlueGene/L at LANL

System
(64 cabinets, 64x32x32)

IBM Computer Achieves Petaflop Performance
6/9/2008

A National Nuclear Security Administration (NNSA) supercomputer has achieved an operational rate of 1,000 trillion calculations per second, or 1 petaflop, making the Roadrunner -- which the NNSA commissioned IBM Corp. to build in 2006 for around $130 million -- the world's fastest computer, the agency announced today.

2.8/5.6 GF/s
4 MB

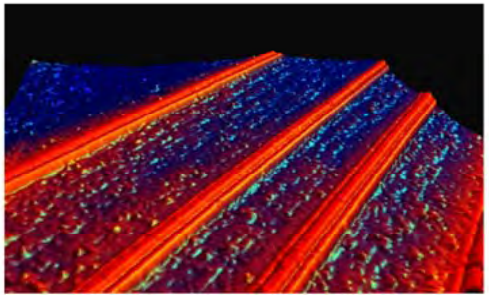
0.5 GB DDR

2^{17} cpu's: Oct 2007 ran Linpack benchmark at over **596 Tflop /sec**
(5 x Canada or 8 x Oz)

The future 2005-2010

Things we can't model here include:

Self assembling wires 2nm apart (HP Labs)



The Changing Computing Landscape — Simulation by Keuckes-Williams

"It says it's sick of doing things like inventories and payrolls, and it wants to make some breakthroughs in astrophysics."

II. New Ways of Doing Math

- and **related subjects**: Computer Science, Statistics, Engineering, all Sciences, *every* other subject …. for learning or for research
  - Experimentally on the Computer
  - Visual or Haptic or Acoustic Output
  - Simulations and Emersions
  - With Web-services, Databases, Wikis, …
    - Marvelous support tools for the **Classroom**
- also **New Ways** of **Collaborating**

2006 ICM Satellite Meeting Collection

AKPeters, October 2008

"The digital era has dramatically changed the ways that researchers search, produce, publish, and disseminate their scientific work. These processes are still rapidly evolving due to improvements in information science, new achievements in computer science technologies, and initiatives such as DML and open access journals, digitization projects, scientific reference catalogs, and digital repositories.

These changes have prompted many mathematicians to play an active part in the developments of the digital era, and have led mathematicians to promote and discuss new ideas with colleagues from other fields, such as technology developers and publishers. This book is a collection of contributions by key leaders in the field, offering the paradigms and mechanisms for producing, searching, and exploiting scientific and technical scholarship in mathematics in the digital era."

Jon Borwein's Mathematics Portal

The following is a list of useful math tools. The distinction between categories is somewhat arbitrary.

Utilities (General)

1. The On-Line Encyclopedia of Integer Sequences
2. ISC2.0: The Inverse Symbolic Calculator
3. 3D Function Grapher
4. Julia and Mandelbrot Set Explorer
5. The KnotPlot Site

Utilities (Special)

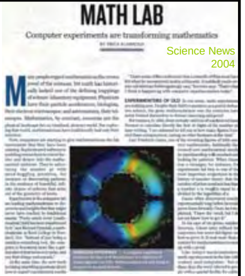
6. EZ Face : Evaluation of Euler Sums and Multiple Zeta Values
7. GraPHedron: Automated and Computer Assisted Conjectures in Graph Theory
8. Embree-Trefethen-Wright Pseudospectra and Eigenproblems
9. Symbolic and Numeric Convex Analysis Tools

Reference

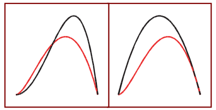
10. NIST Digital Library of Mathematical Functions(X)
11. Experimental Mathematics Website
12. Numbers, Constants, and Computation
13. Numbers: the Competition

Experimental Mathodology

1. Gaining insight and intuition
2. Discovering new relationships
3. Visualizing math principles
4. Testing and especially falsifying conjectures
5. Exploring a possible result to see if it merits formal proof
6. Suggesting approaches for formal proof
7. Computing replacing lengthy hand derivations
8. Confirming analytically derived results



Science News 2004



Comparing $-y^2\ln(y)$ (red) to $y-y^2$ and y^2-y^4

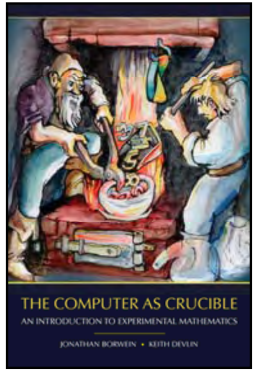
The Computer as Crucible

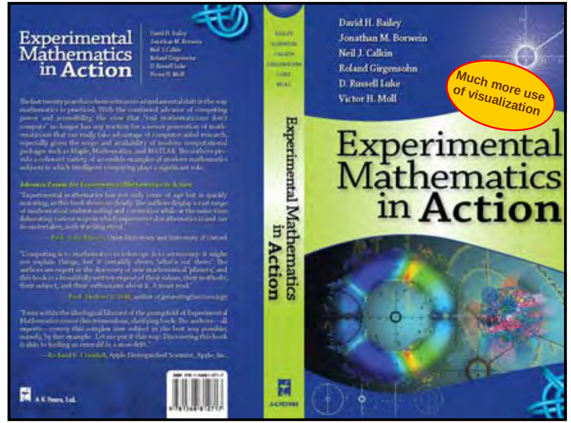
An Introduction to Experimental Mathematics

Jonathan Borwein
Keith Devlin

with illustrations by Karl H. Hofmann

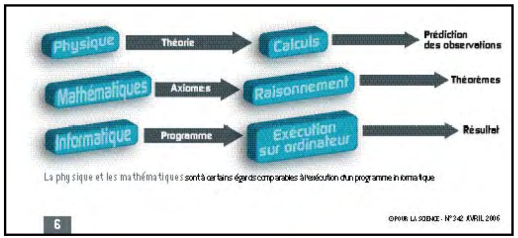
"The Crucible"
AKPeters November 2008





Math + Physics = Computing ?

- En français

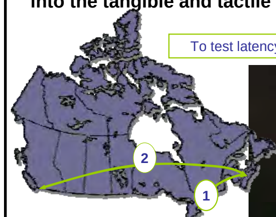


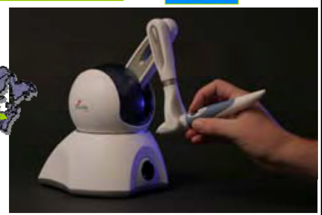
Haptics and Light Paths

D-DRIVE Doug a haptic mascot

Haptic Devices extend the world of I/O into the tangible and tactile

To test latency issues …

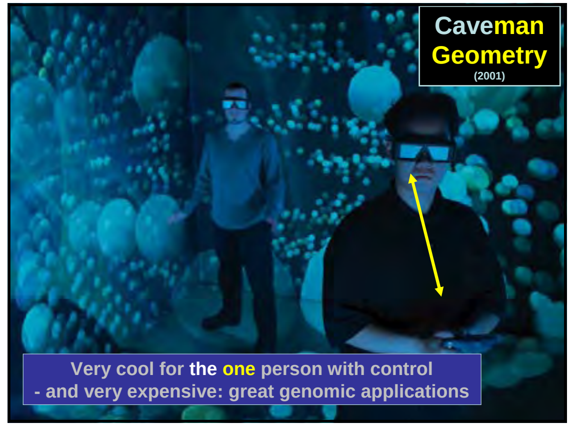




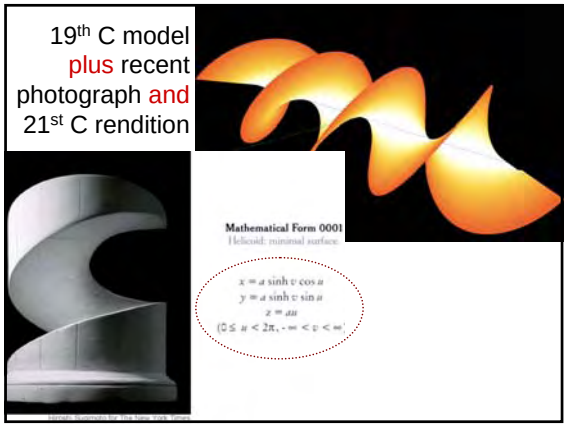
Links multiple devices so two or more users may interact at a distance (**BC/NS Demo** April 06)

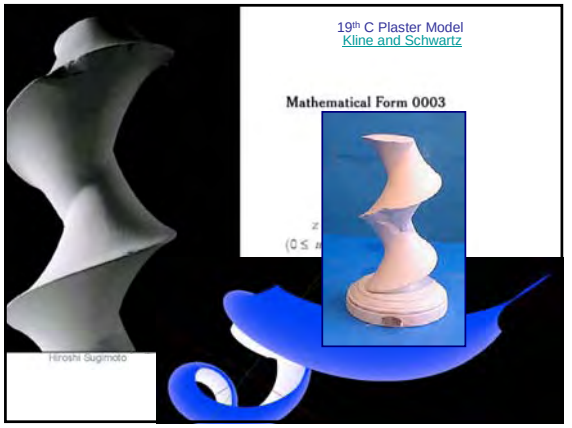
Sensable's **Phantom Omni**

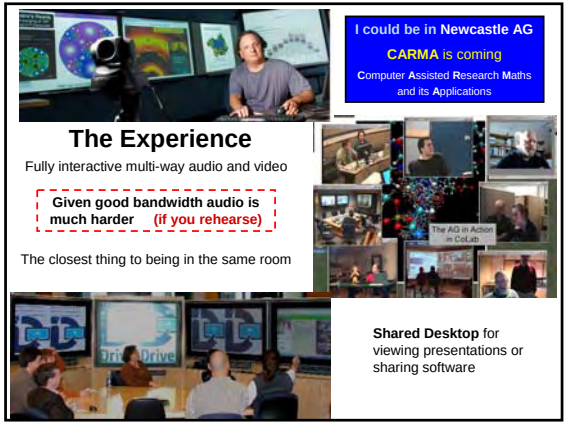
- in Museums, **Aware Homes**, elsewhere
- Kinesiology, Surgery, Music, Art …

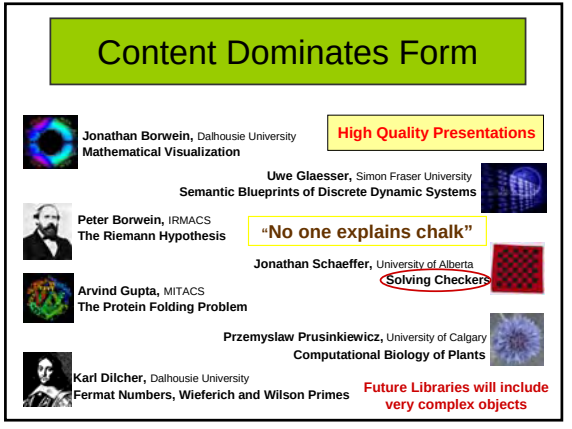


19th C model plus recent photograph and 21st C rendition









III. New Ways of Seeing Math

- **The Colour Calculator**
  - numbers as pictures
- **The Inverse Calculator**
  - numbers go in and symbols come out
- **The Top Ten Numbers Website**

- All at http://ddrive.cs.dal.ca/~isc/portal

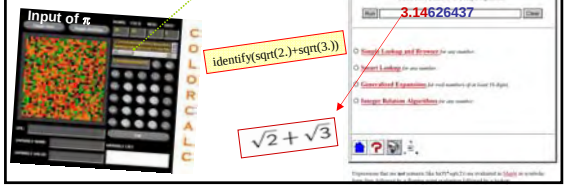
A Colour and an Inverse Calculator (1995 & 2007)

Aesthetic base for middle-school maths (Nathalie Sinclair)

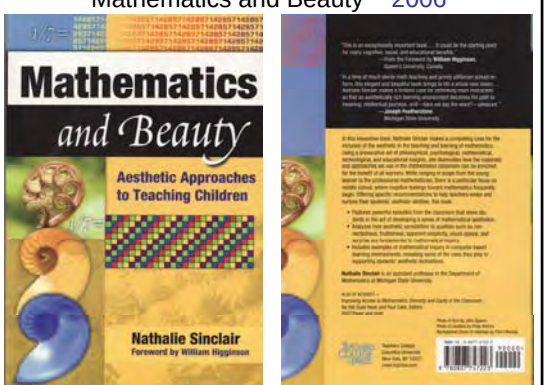
Inverse Symbolic Computation

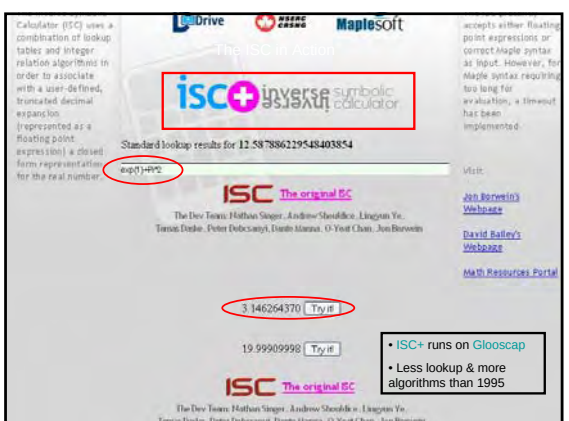
Inferring mathematical structure from numerical data

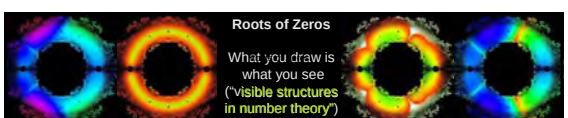
- Mixes *large table lookup*, integer relation methods and intelligent preprocessing – needs ***micro-parallelism***
- It faces the "curse of exponentiality"
- Implemented as **identify** in Maple 9.5



Mathematics and Beauty 2006







Striking fractal patterns formed by plotting complex zeros for all polynomials in powers of x with coefficients 1 and -1 to degree 18

Coloration is by sensitivity of polynomials to slight variation around the values of the zeros. **The color scale represents a normalized sensitivity** to the range of values; red is insensitive to violet which is strongly sensitive.

- All zeros are pictured (at **3600 dpi**)
- Figure 1b is colored by their local density
- Figure 1d shows sensitivity relative to the x^9 term
- **The white and orange striations are not understood**

A wide variety of patterns and features become visible, leading researchers to totally unexpected mathematical results

"The idea that we could make biology mathematical, I think, perhaps is not working, but what is happening, strangely enough, is that maybe mathematics will become biological!" Greg Chaitin, Interview, 2000.

The TIFF on VARIOUS SCALES

Pictures are more democratic but they come from formulae

When is a Movie an Interactive Proof?

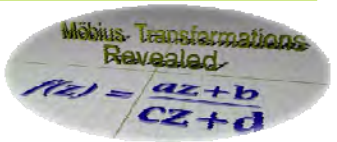
The Perko Pair 10_{161} and 10_{162}

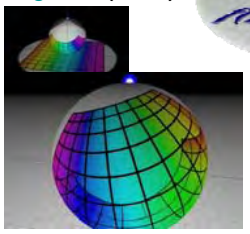
are two adjacent 10-crossing knots (1900)

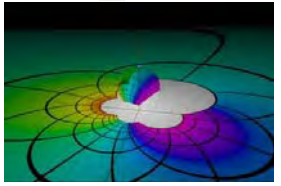
- first shown to be the same by Ken Perko in 1974
- and beautifully made dynamic in KnotPlot (open source-ish)

A Movie that Teaches Beautifully

- Arnold and Rogness (2007)







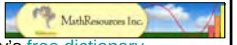
"What it comes down to is our software is too hard and our hardware is too soft."

IV. Amazing New Web Services

- **AT&T** Online Encyclopedia of Sequences
  What is 1,2,3,6,11,23,47,106,235,…?

Supernumerary Rainbow over Newton's birthplace

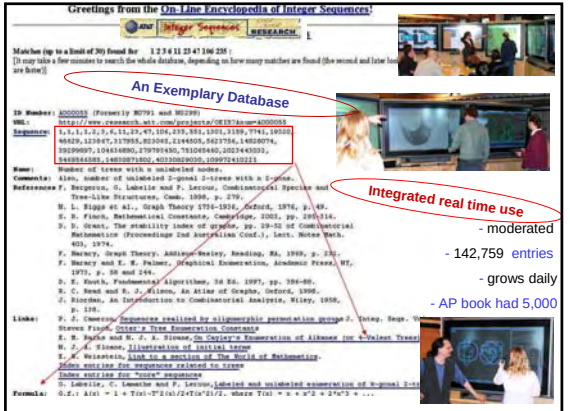
- **NIST** Digital Library of Math Functions
  What is an Airy Function?



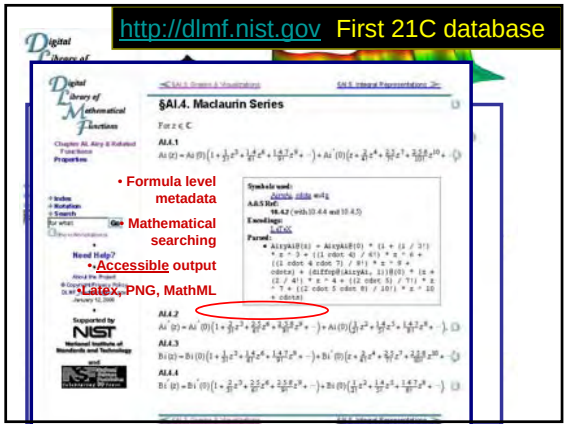
- **MAA** Digital Library with my company's free dictionary
  - also in *Maple* since 9.5

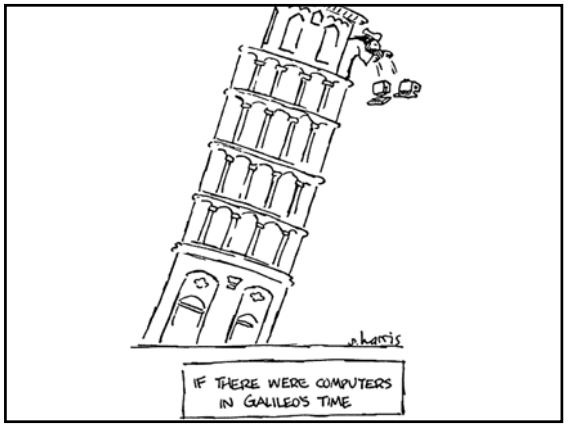
Soon the texts will also do lots of the maths

PlanetMath.org MathDL WolframMathWorld



http://dlmf.nist.gov First 21C database





REFERENCES


Enigma

J.M. Borwein and D.H. Bailey, *Mathematics by Experiment: Plausible Reasoning in the 21st Century*, A.K. Peters, 2nd expanded edition, **2008**
and with
R. Girgensohn, *Experimentation in Mathematics: Computational Paths to Discovery*, A.K. Peters, 2004. [Active CDs 2006]

D.H. Bailey and J.M Borwein, "Experimental Mathematics: Examples, Methods and Implications," *Notices AMW*, **52** No. 5 (2005), 502-514.

J. Borwein, D. Bailey, N. Calkin, R. Girgensohn, R. Luke, and V. Moll, *Experimental Mathematics in Action*, A.K. Peters, 2007.

Jon Borwein and Keith Devlin, *The Computer as Crucible*, A.K. Peters, November, **2008.**

"The object of mathematical rigor is to sanction and legitimize the conquests of intuition, and there was never any other object for it."

• J. Hadamard quoted at length in E. Borel, *Lecons sur la theorie des fonctions*, 1928.