

Benefits and Risks of Media and Technology in the Classroom

Oliver Knill, Harvard University

ICTCM Feb 15-18, 2007, Boston

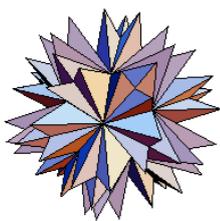
Choice

In our information age, a teacher faces a plethora of teaching possibilities, especially in the realm of media and technology.

```

In[45]= Needs["Graphics`Polyhedra`"]
Show[Stellate[Stellate[Polyhedron[Icosahedron]]],
      Boxed -> False, Axes -> False, AspectRatio -> 1];

```



```

Integrate[Sin[x]^10, x]

```

$$\frac{63x}{256} - \frac{105}{512} \sin[2x] + \frac{15}{256} \sin[4x] - \frac{15 \sin[6x]}{1024} + \frac{5 \sin[8x]}{2048} - \frac{\sin[10x]}{5120}$$

```

In[47]= ParametricPlot3D[{Cos[u] Sin[3 v / 2], Sin[u] Cos[v], Cos[u]},
      {u, 0, 2 Pi}, {v, 0, 2 Pi}, PlotPoints -> 40, Boxed -> False,
      Axes -> False]

```



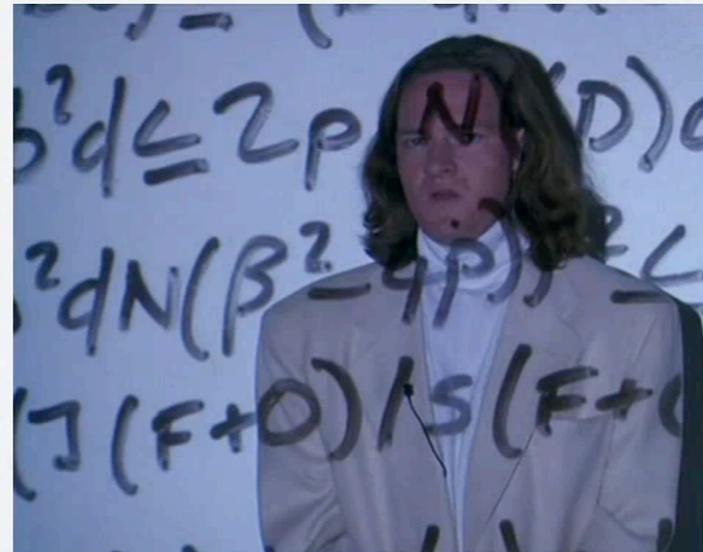

Mathematics Math21a
 Spring 2003
 Oliver Knill
 Email: math21a@math.harvard.edu

Multivariable Calculus

Some T/F question for the Final

Notes: This page is for training purpose only. No scores will be recorded. Some of the questions are randomized each time you access the page. Especially, the "True" or "False" can be on either side. When finished click on the "grade button" below.

1)	The line integral of the constant vector field $F=(2,3,2)$ along the straight line connecting the point $(0,0)$ with the point $(1,0)$ is	<input type="radio"/> 3	<input type="radio"/> 2
2)	The line integral of the vector field $F(x,y,z)=(x,y,z)$ vanishes along any closed curve	<input type="radio"/> False	<input type="radio"/> True
3)	A figure 8 curve can not occur as a level curve of a function $f(x,y)$	<input type="radio"/> False	<input type="radio"/> True
4)	The triple integral of $x^2+y^2+z^2$ over the region enclosed by the sphere $x^2+y^2+z^2=1$ is $4/5 \pi$.	<input type="radio"/> True	<input type="radio"/> False
5)	If F is a vector field in the plane which has the property that the line integral of F along any closed curve is zero, then $\text{curl}(F)=0_x - 0_y = 0$ everywhere in the plane.	<input type="radio"/> False	<input type="radio"/> True
	If F is a vector field in space and the surface integral of F is zero along any	<input type="radio"/>	<input type="radio"/>

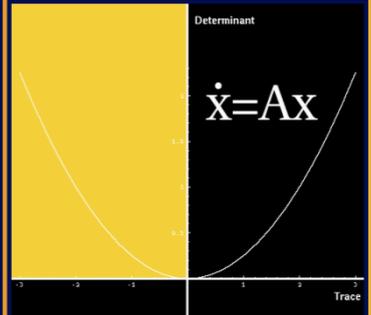


MATH
21B
 Mathematics Math21b Spring 2007
 Linear Algebra and Differential Equations
NEWS
 Course Head: [Oliver Knill](mailto:knill@math.harvard.edu)
 Office: SciCtr 434
 Email: knill@math.harvard.edu

[NEW](#) [SYLLABUS](#) [CALENDAR](#) [SECTION](#) [HOMEWORK](#) [EXAM](#) [EXHIBIT](#) [HANDOUT](#) [LAB](#) [FAQ](#) [LINKS](#)

In the homework of wsection 2.1, Problems 24-30 means all 7 parts. It is actually one problem, with different versions.

- [About the Droste Effect.](#)



Choice

The paradox of choice amplifies traditional dilemmas a curriculum has, also without technology. This happens on many levels, here are four:

I

PEDAGOGICAL LEVEL

II

PRESENTATION LEVEL

III

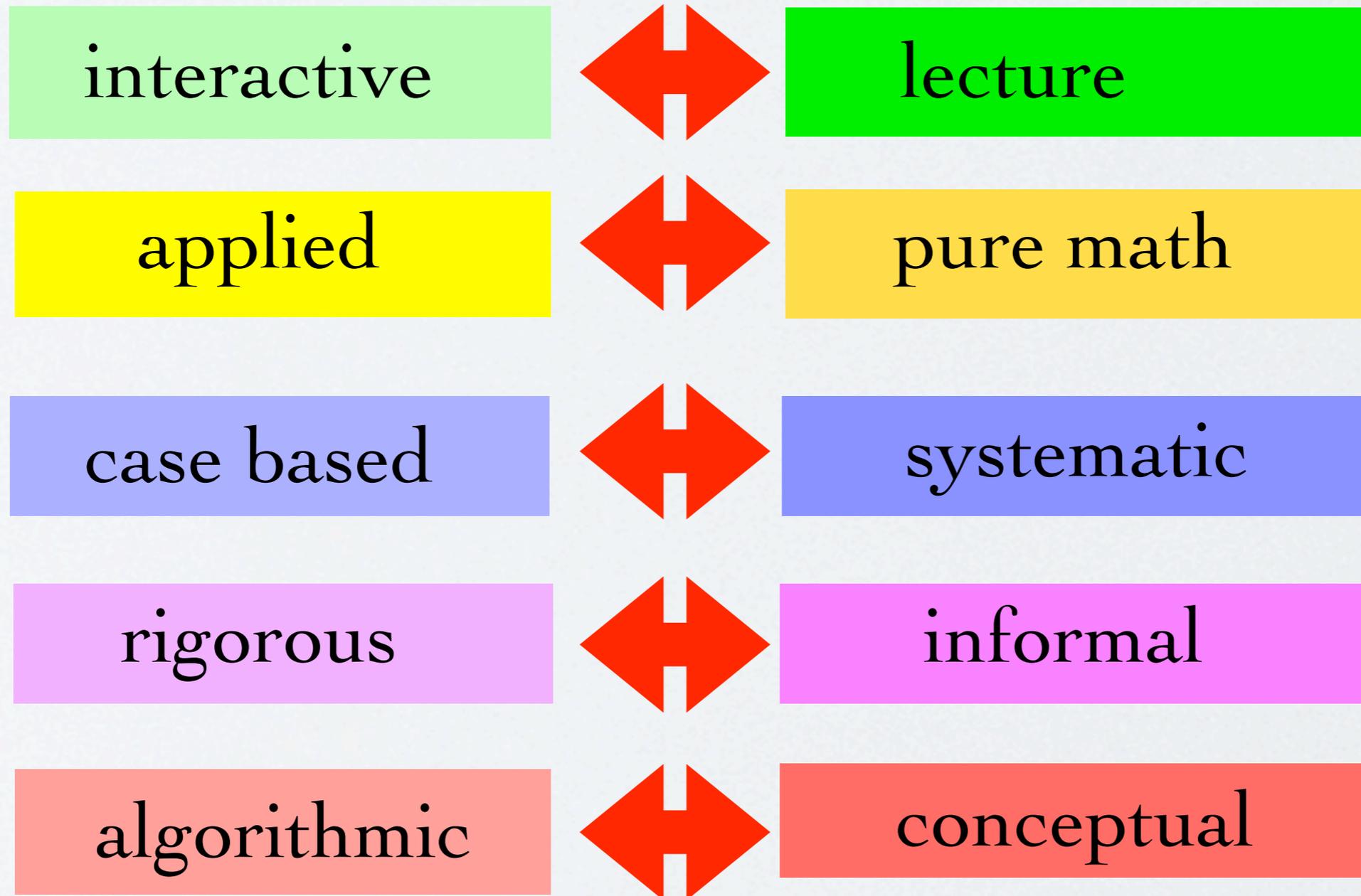
OBJECTIVE LEVEL

IV

TOOL LEVEL

I) Pedagogical Level

Example parameters:



II) Presentation level

increasing level of difficulty

Discovery or inquiry based

Discussion or debate

Workshop or lab

Interactive lecture

Blackboard lecture

Powerpoint presentation

III) Objective Level

Visual
Geometric

Formal
Algebraic

Artistic
Entertaining

Social
Collaborative

Numerical
Algorithmic

Application
Practical

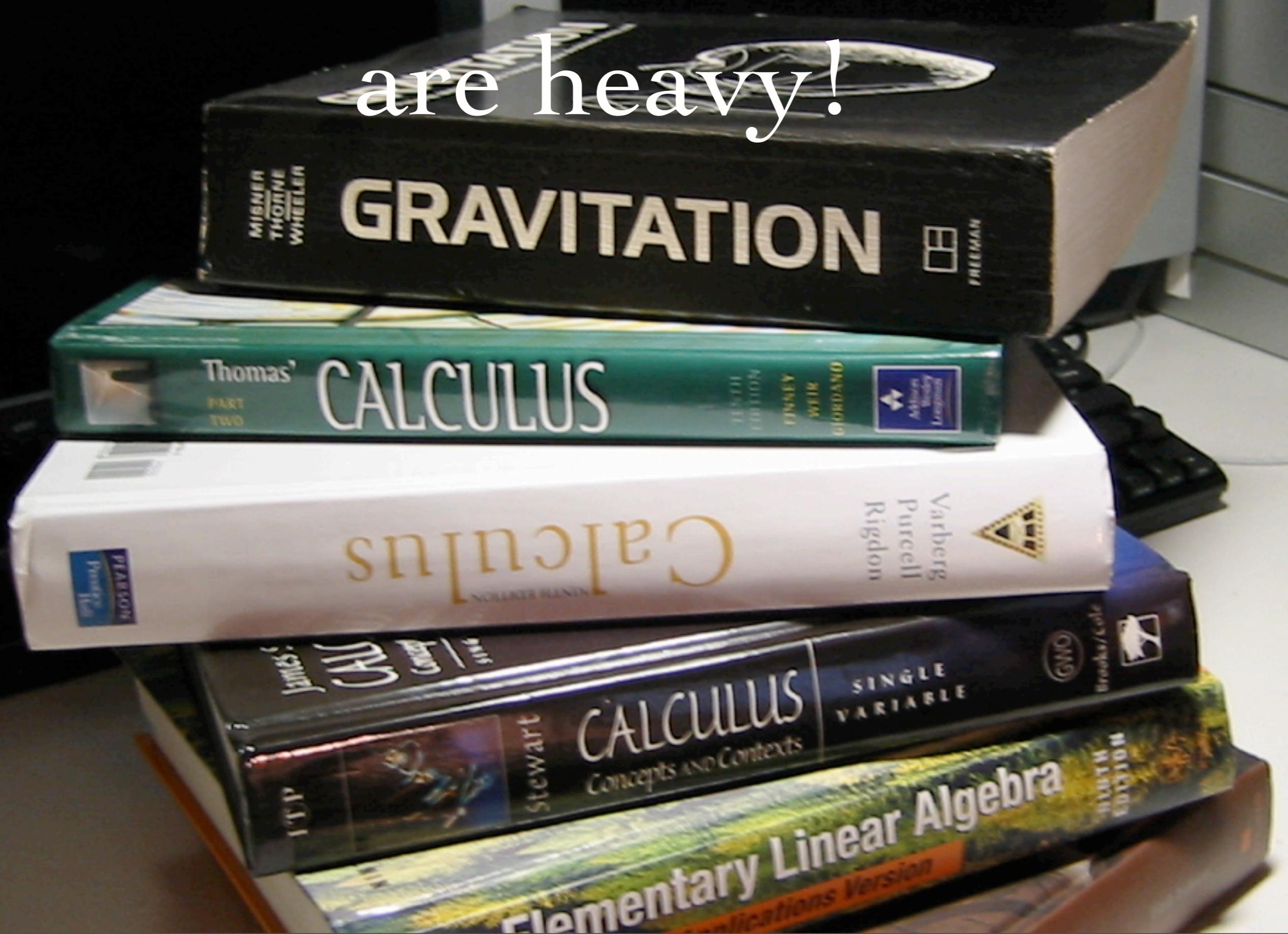
Humour
Fun

Historical
Cultural

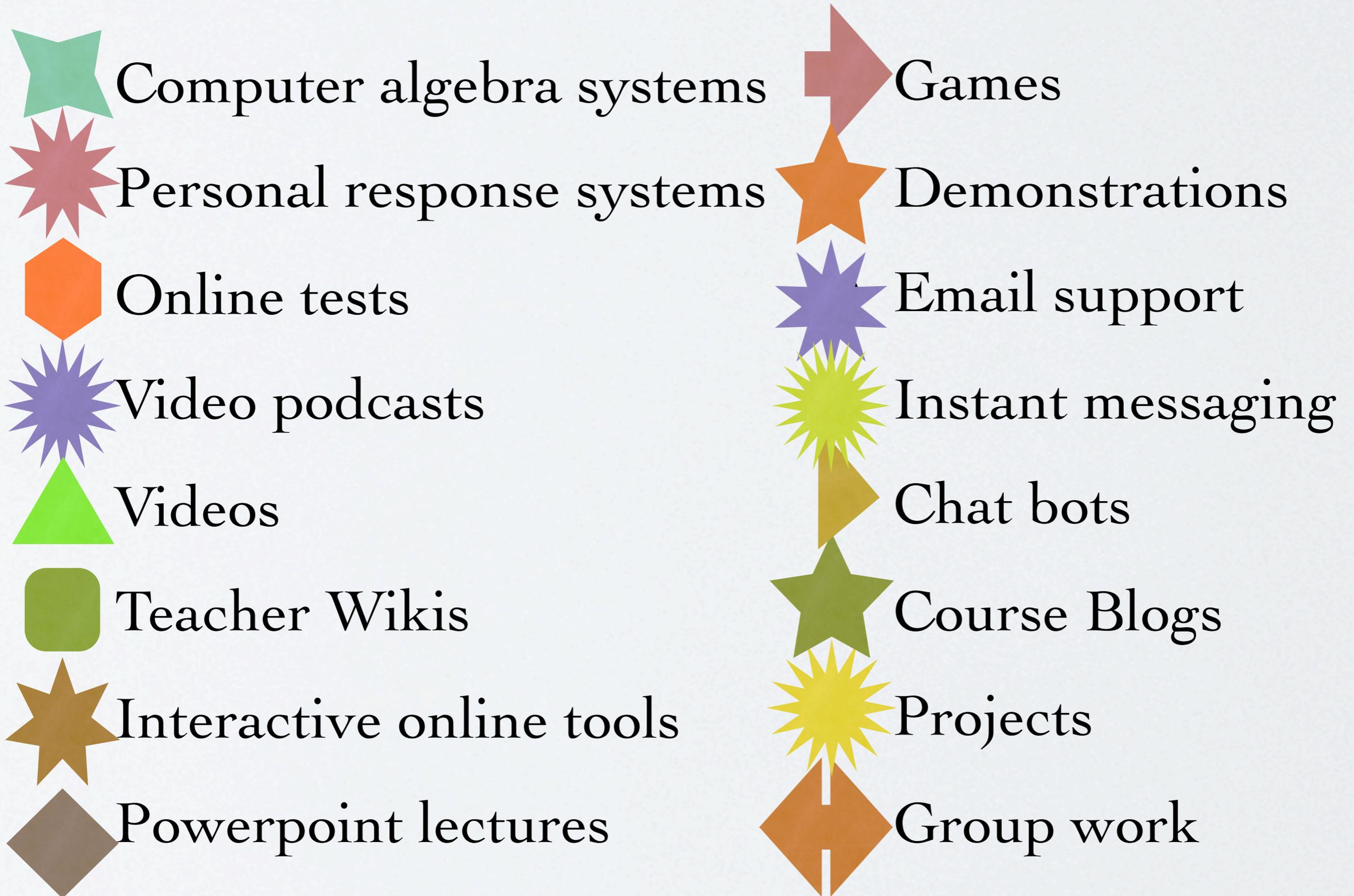
Challenge
Discovery

Inquiry
Exploratory

No wonder, textbooks
are heavy!



IV) Tool Level



Revolutions:

many of you have
witnessed



calculator revolution



CAS, email, digital
photography, VHS

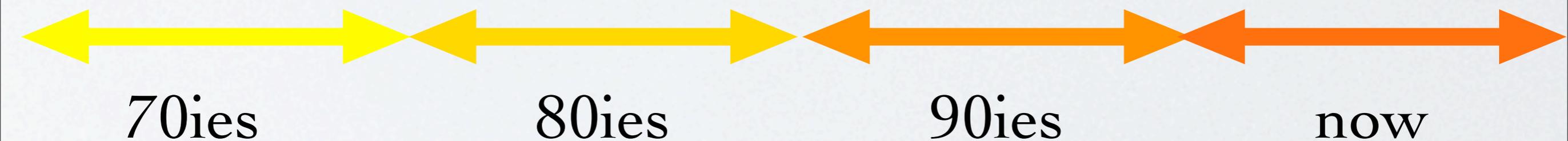
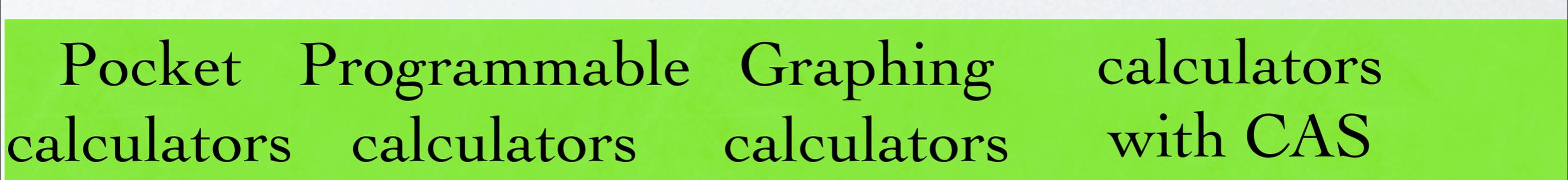
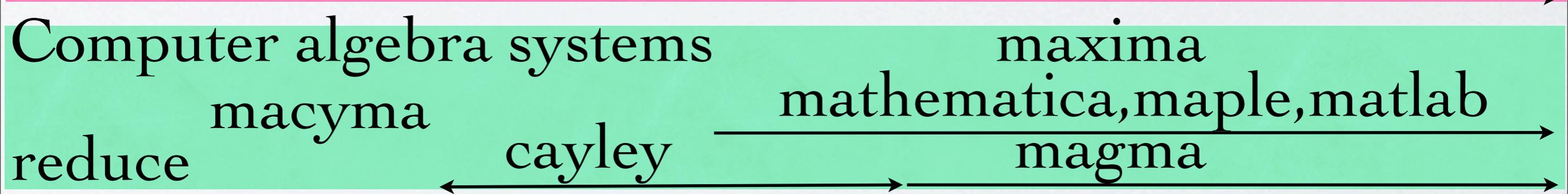
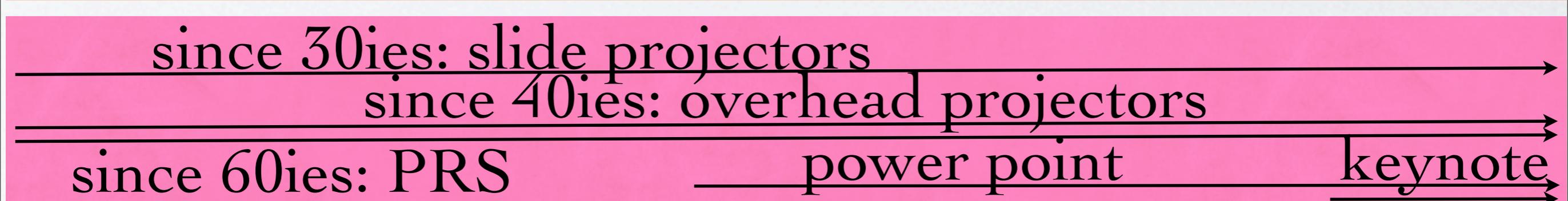
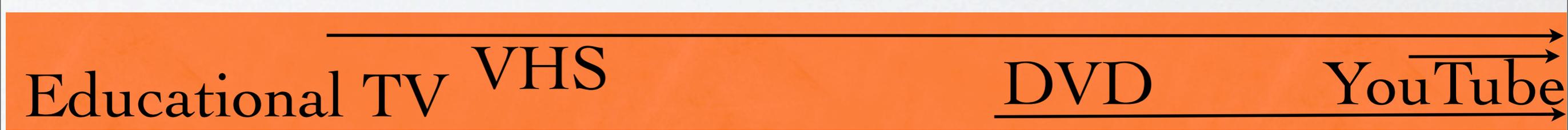


WWW revolution, DVD
games, online applications



Web II, Wiki, blog, Media
video revolution

Some Timelines

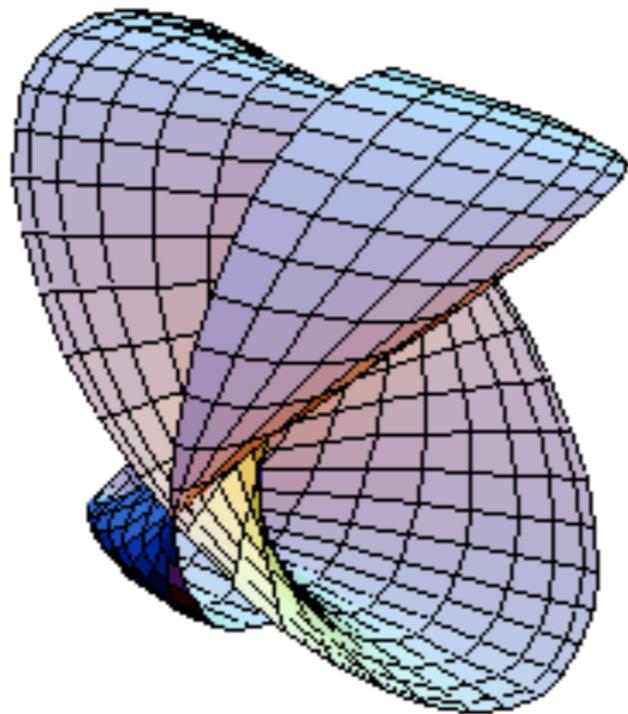


Computer Algebra Systems

```
Integrate[Sin[x]^10, x]
```

$$\frac{63x}{256} - \frac{105}{512} \sin[2x] + \frac{15}{256} \sin[4x] - \frac{15 \sin[6x]}{1024} + \frac{5 \sin[8x]}{2048} - \frac{\sin[10x]}{5120}$$

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  Axes -> False]
```



Example: Mathematica

Online Quizzes



Spring 2003

Mathematics Math21a Spring 2003

Oliver Knill

Email: math21a@math.harvard.edu

Multivariable Calculus

Some T/F question for the Final

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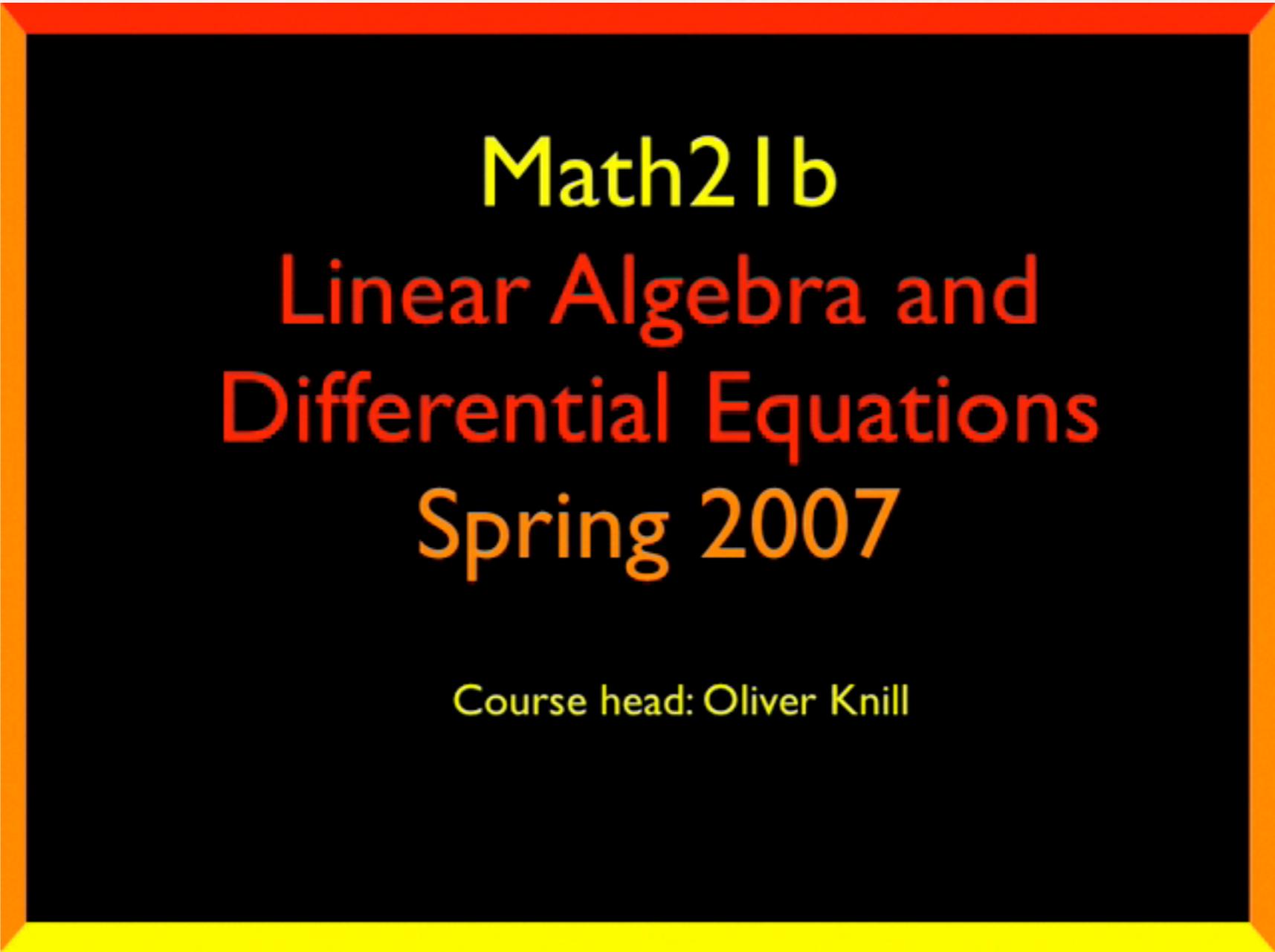
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Personal Response Systems



Source: From *Questions to Concepts, Interactive Teaching in Physics* Featuring Eric Mazur, DVD by Derek Bok Center

Video Podcasts



Math21b
Linear Algebra and
Differential Equations
Spring 2007

Course head: Oliver Knill

Chat bots



Sofia Math Chat Robot

[home](#) [team](#) [guidelines](#) [faq](#) [links](#) [sofia](#) [download](#)

Project information:

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[Harvard University](#)

[Department of Mathematics](#)

One Oxford Street

Cambridge, MA 02138, USA

Tel: (617) 495 5549

Email: knill@math.harvard.edu

Say what you know, do what you must, come what may.

-- Sonya Kovalevsky

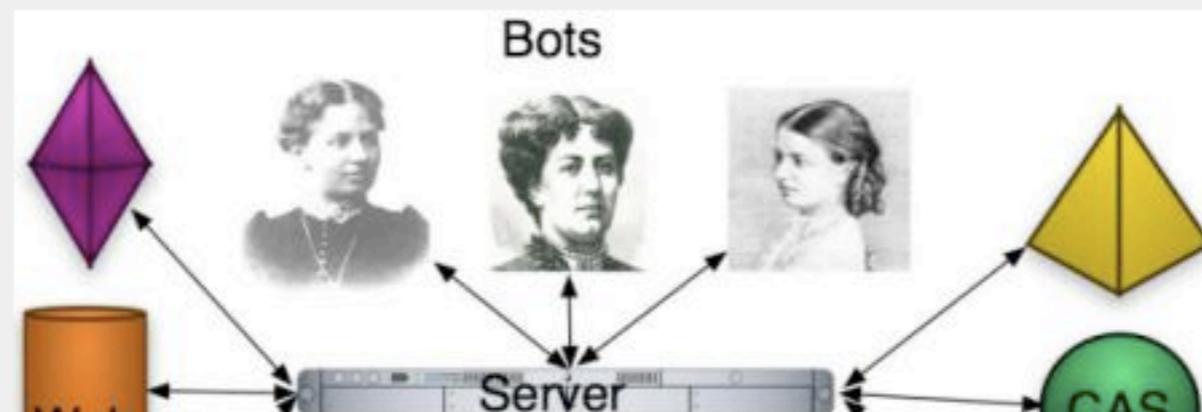
Status

Spring 2004: besides catching up with background AI information (like some Lisp language study) and continuing to feed the memory of Sofia, our first goal in the spring is to solve a notorious "**context problem**" which bothered us already at the end of the Fall semester. When people talk about mathematics, there is always a background context, which makes it clear, what object one is talking about and on which level the communication takes place. The discussion partners do have common knowledge, common pictures in their mind and do not need to be too clear in their statements. For example, the definition of an "isomorphism" can occur in different contexts. A talk about "maxima and minima" can be done on different levels. Mentioning "compact sets" in a first year calculus class for example would not particularly enhance the lesson. People usually adapt automatically to the context. Not doing so can result in communication or teaching disasters. Adapting the level of understanding and gauging the already known knowledge is maybe the most common challenge a teacher has to face in class. To overcome the context problem, we are reorganizing the "brain" of Sofia, build a context filter, as well as an additional channel to communicate the context. All this will be invisible for the user who talks to Sofia: the context evolves with the already experienced conversation. As longer the chat goes, as better Sofia will be able to gauge context and level of sophistication in the answers.

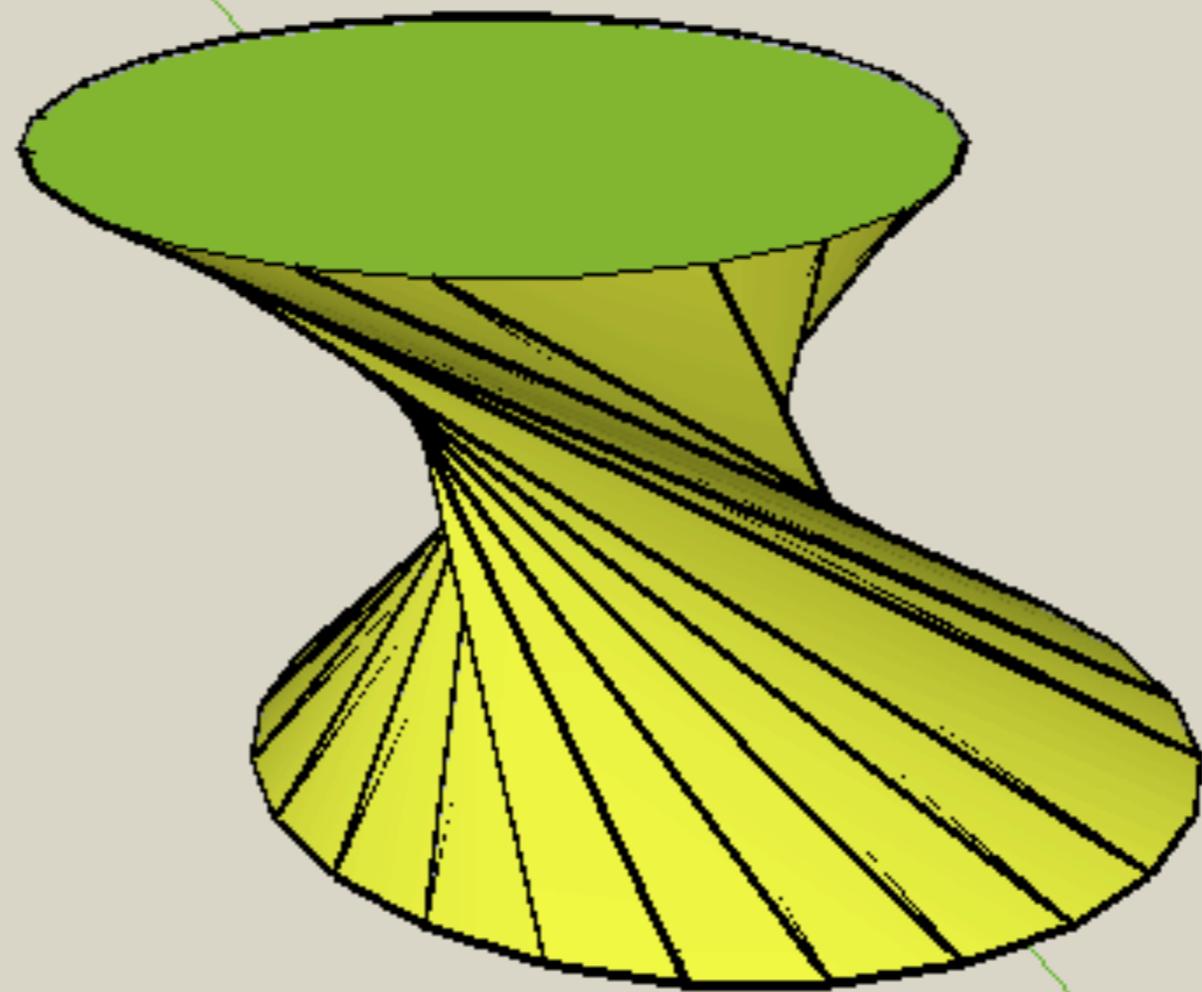
Fall 2003: besides feeding the brain of Sofia, some technological problems were solved:

- setting up the server with a CVS collaboration environment and making everybody comfortable with the platform.
- building a wrapper which forms a link between users, bots and computer algebra systems (CAS). Advantages of an additional layer between the bots and the user:
 - can add interfaces with CAS
 - bots are behind firewall
 - can have a whole "classroom of bots"
 - we can add other interaction tools.
 - can manage additional information, for example through cookies.
- we worked on interfaces between the bot-CAS and focussed on the interaction with
 - Mathematica

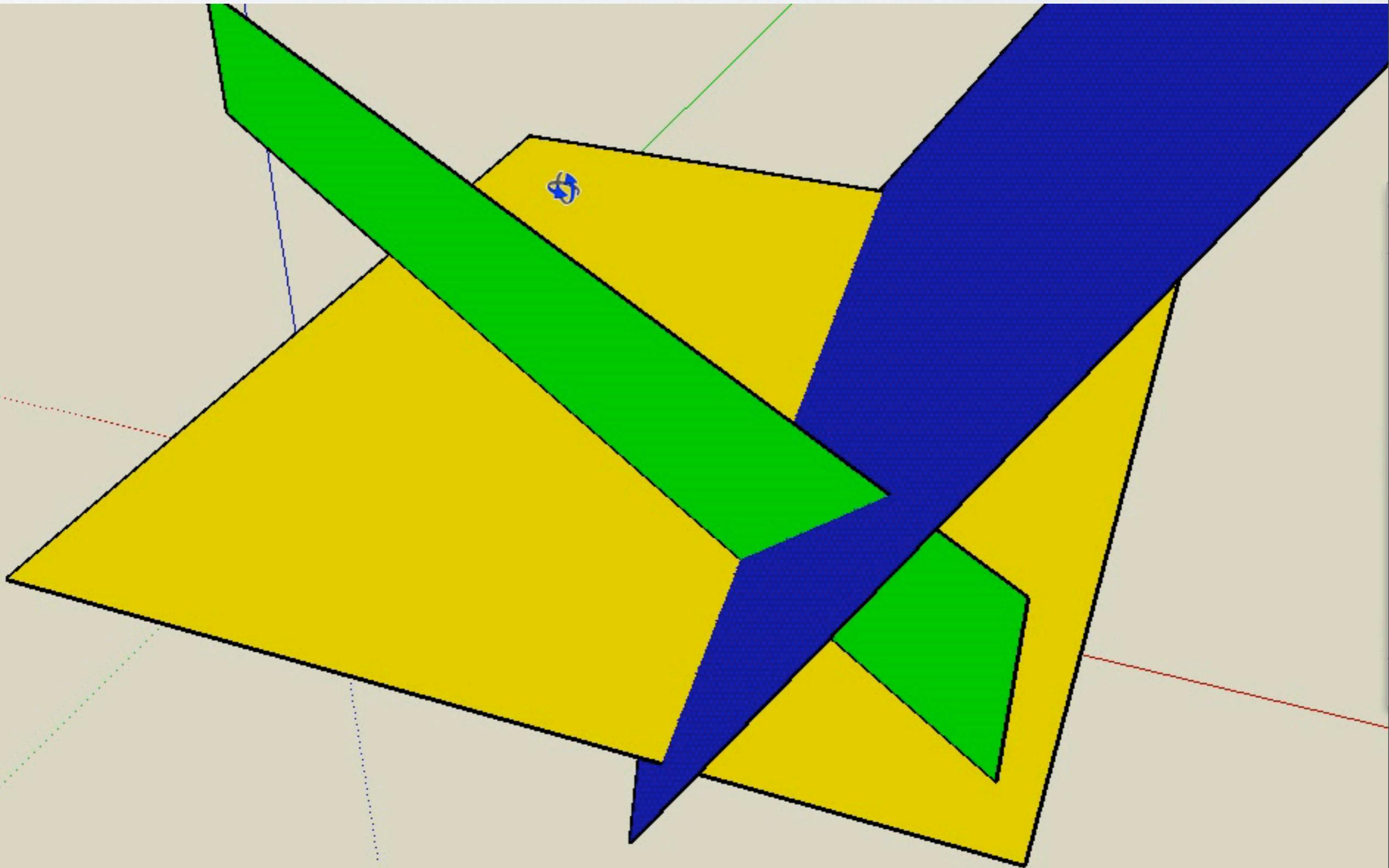
Interactive agents which can chat about mathematics and know mathematics.



3D Software



extremely easy to use



Interactive Demos

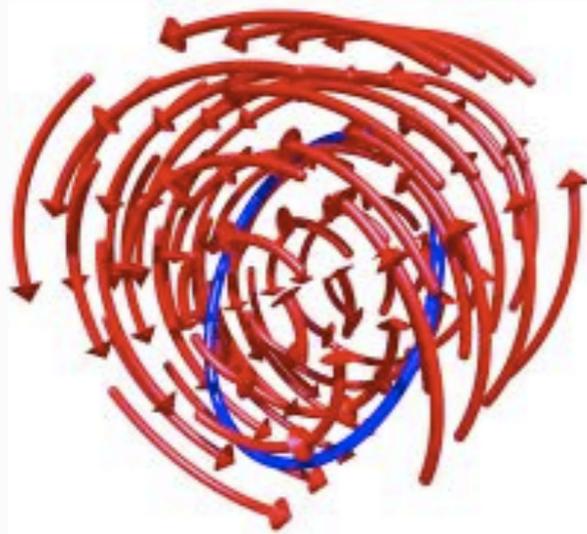
PITF project

Exploring Vectorfields,

Curl and Divergence using Flash

Project leader:

[Oliver Knill](#)
Harvard University
Department of Mathematics
One Oxford Street
Cambridge, MA 02138, USA
Tel: (617) 495 5549
Email: knill@math



home	Earlier versions:	2D fields	2D anim	3D fields	2D curl	2D div	wheel 1	wheel 2	3D curl
Programs:	2D curl/div	3D curl/div	Surface demo	Sound demo	Vector demo	To Do	Download (gzipped tar ball)		



Presidential fellow:
David Drew Mahfouda
mahfouda@fas

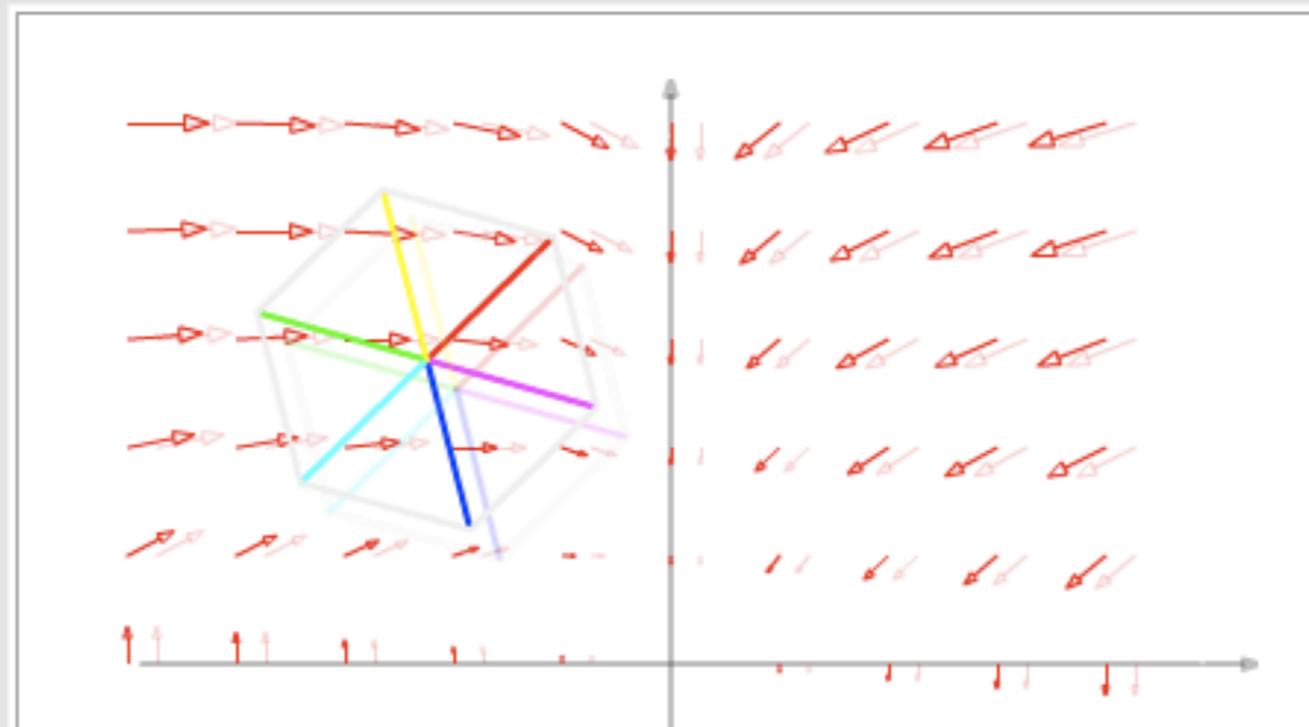
Curl and Divergence in two dimensions

[Direct link to SWF file \(black background\)](#)

Usage: **d key:** switch to divergence, **c key:** switch to curl,

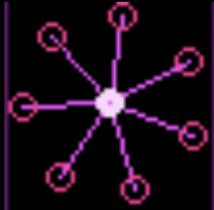
Download: [FLA](#), [Actionscript](#), [SWF](#)

Text: [Proposal](#), [Notations](#)



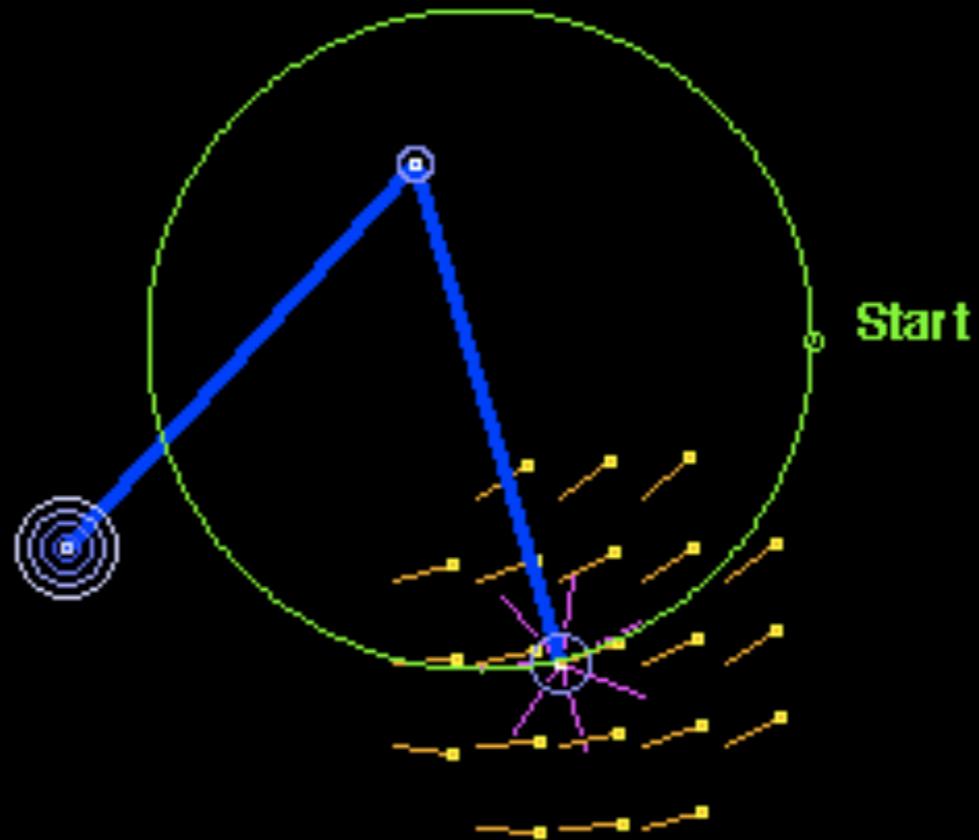
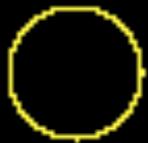
PITF
project
2004

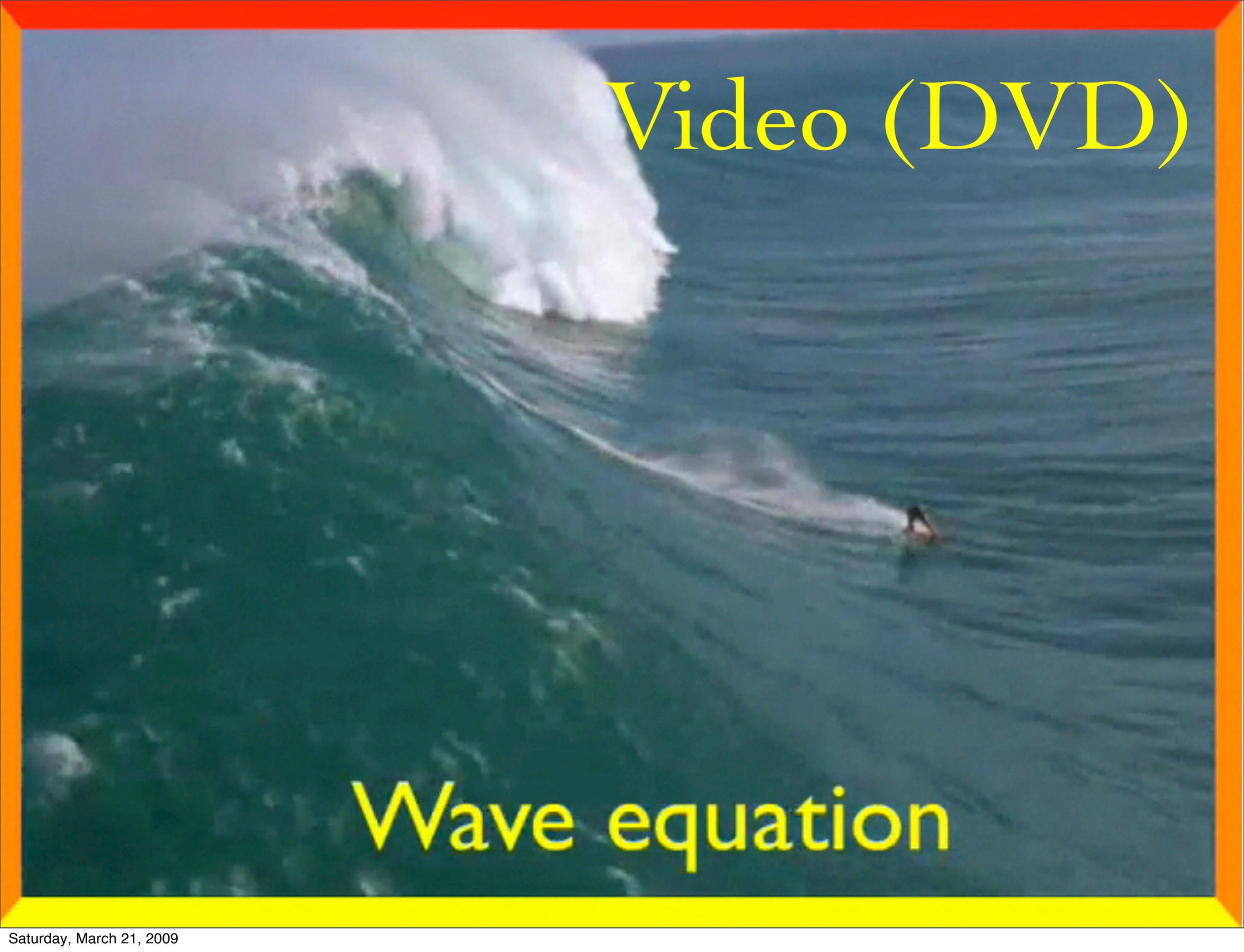
Java example



82

Menu

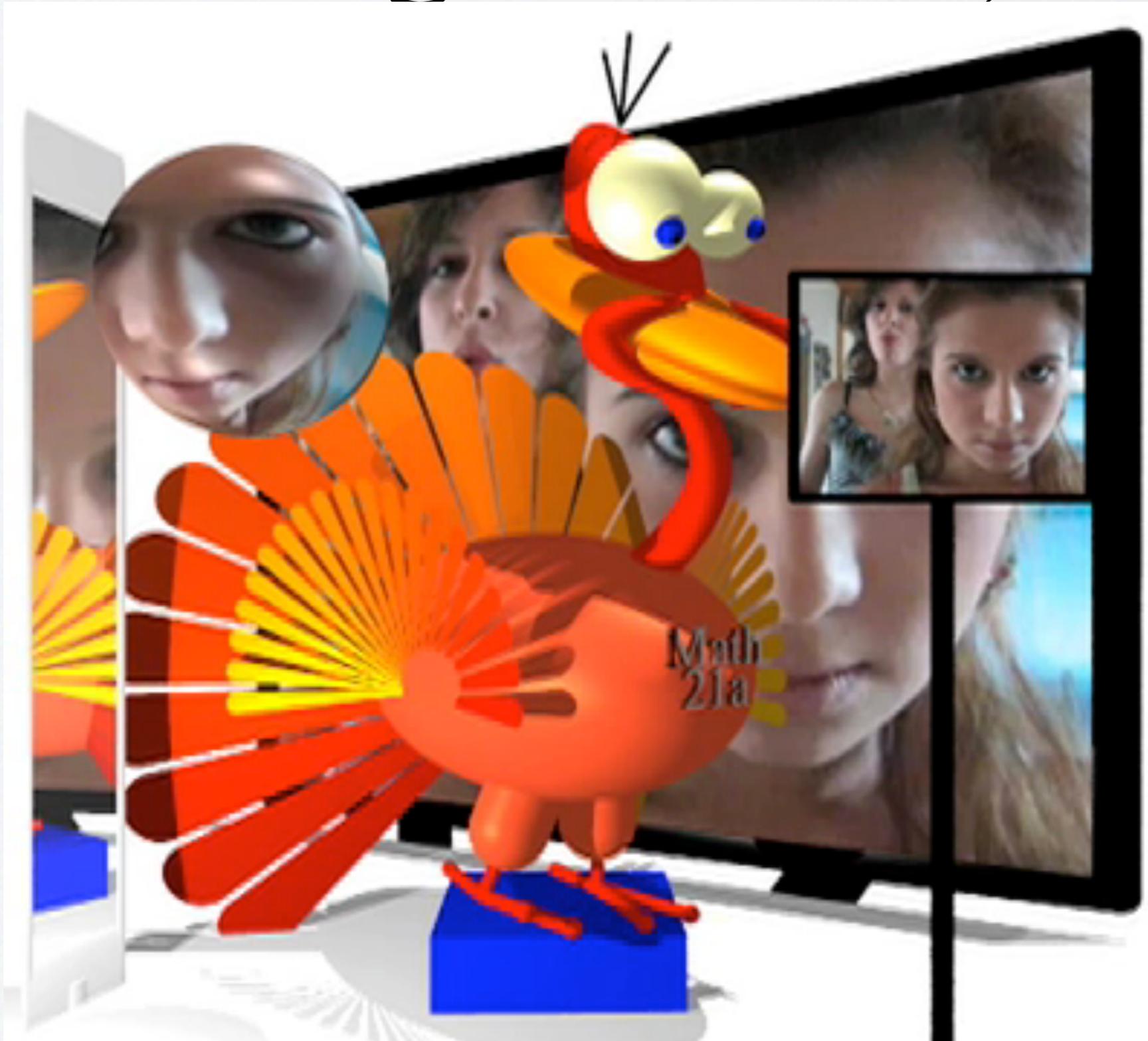


A large, curling ocean wave with a surfer riding the face. The wave is a deep green color, and the crest is white with foam. The surfer is a small figure in the distance, riding the wave's face. The sky is a pale blue.

Video (DVD)

Wave equation

Online Movies (i.e. YouTube, Google Videos)



Education Videos

STANDARD DEVIANTS DVD INTERACTIVE

Conquer Calculus 1

Featuring:

- Instant accessibility to key content areas
- Covers such important topics as exponential functions, asymptotes, and derivatives

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- The Old Schoolhouse Magazine

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Learning Physics

Featuring:

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- Instant accessibility to key content areas
- Helpful resources such as formulas, equations and easy-to-follow examples

Sir Isaac Newton

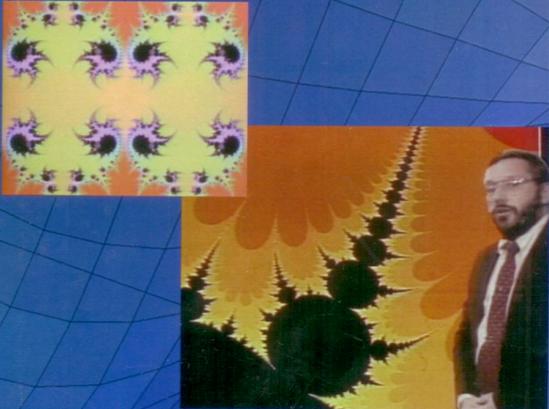
Starring the **STANDARD DEVIANTS**

"Like Sesame Street for adult learners" - The Current

VISUALIZATION IN MATHEMATICS

CHAOS, FRACTALS AND DYNAMICS

ROBERT L. DEVANEY



The Math Video Tutor

Fractions Thru Algebra!
10 Hour Video Course!

$(3/2 + 1/4)^2$

TOPICS COVERED:

- THE NUMBER LINE
- INTEGERS (ADD/SUBTRACT/MULTIPLY/DIVIDE)
- PROPERTIES OF REAL NUMBERS
- FRACTIONS (ADD/SUBTRACT/MULTIPLY/DIVIDE)
- EXPONENTS
- SIMPLIFYING EXPRESSIONS
- SOLVING EQUATIONS
- FACTORS
- SOLVING INEQUALITIES
- POLYNOMIALS (ADD/SUBTRACT/MULTIPLY/DIVIDE)
- MUCH, MUCH MORE!

$Y = X^3 - X + 4$

WHY IS THE MATH VIDEO TUTOR DIFFERENT?
THIS VIDEO SET CONSISTS OF 10 HOURS OF WORKED EXAMPLE PROBLEMS! NO DRY LECTURES!

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The Standard Deviants Academic Team
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THE BELOVED CLASSIC!
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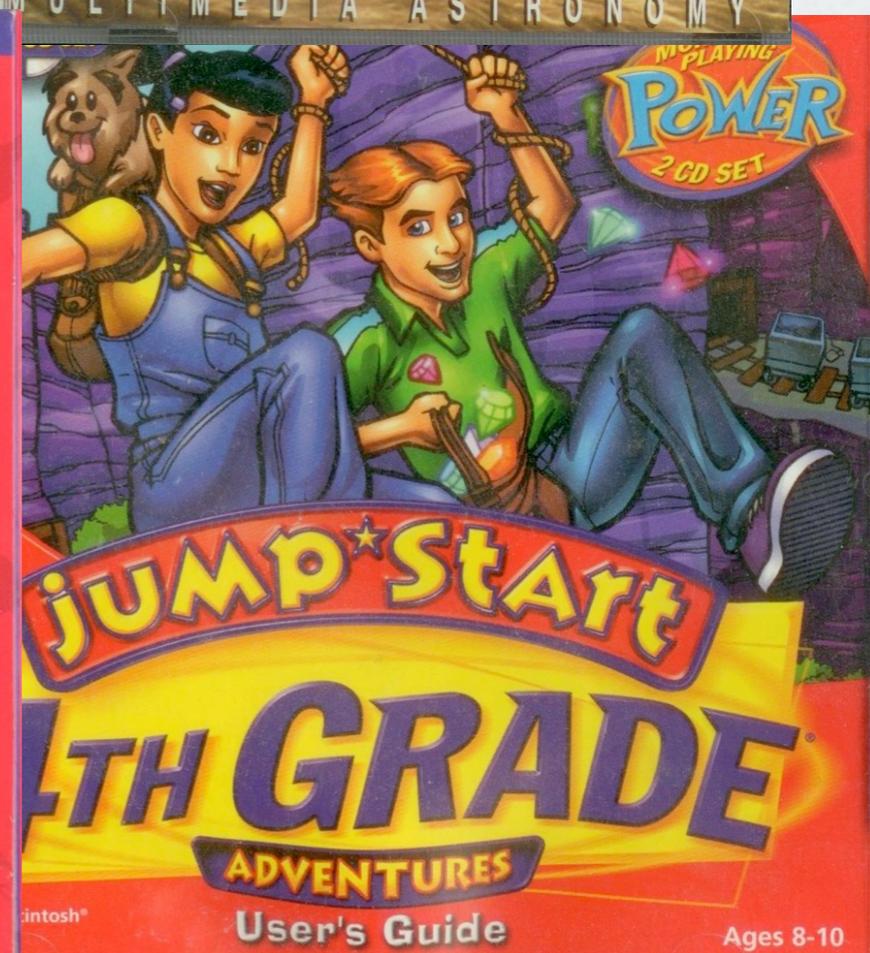
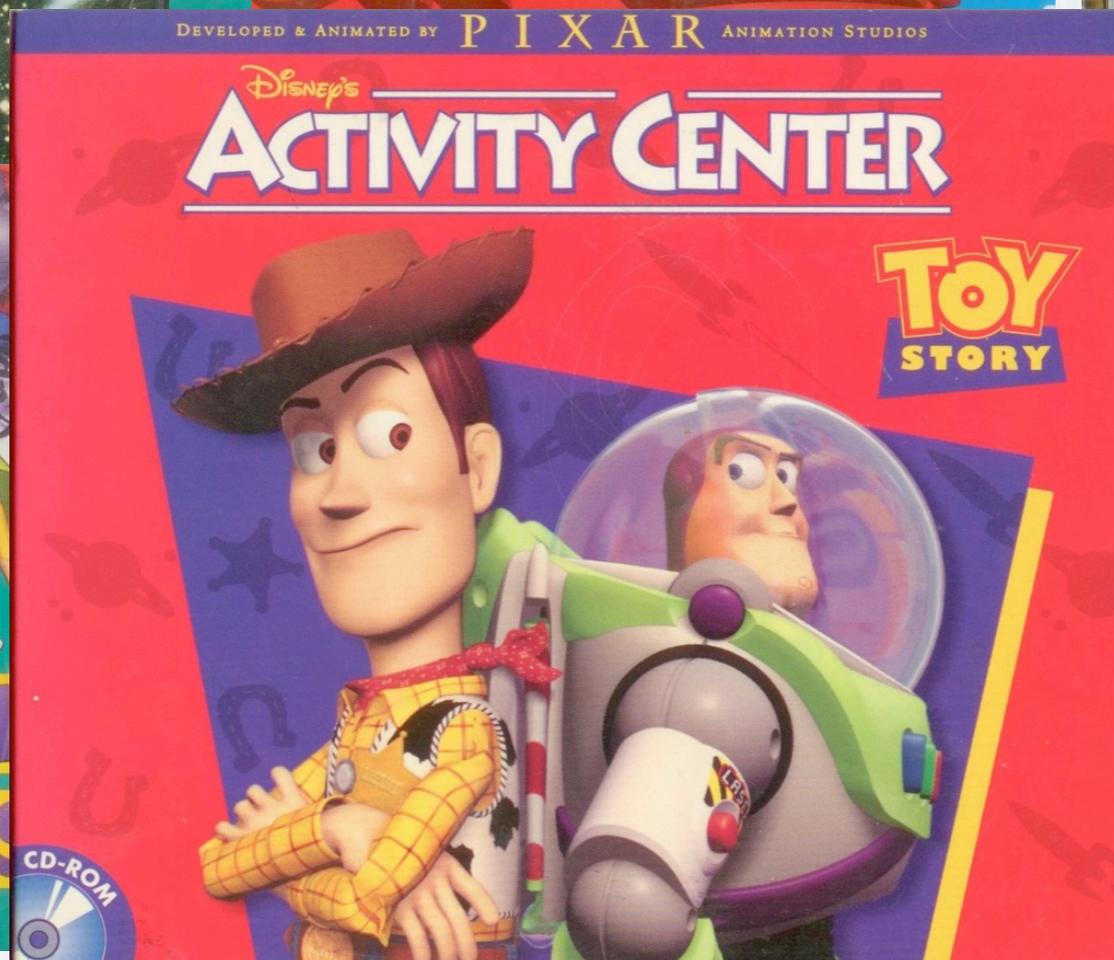
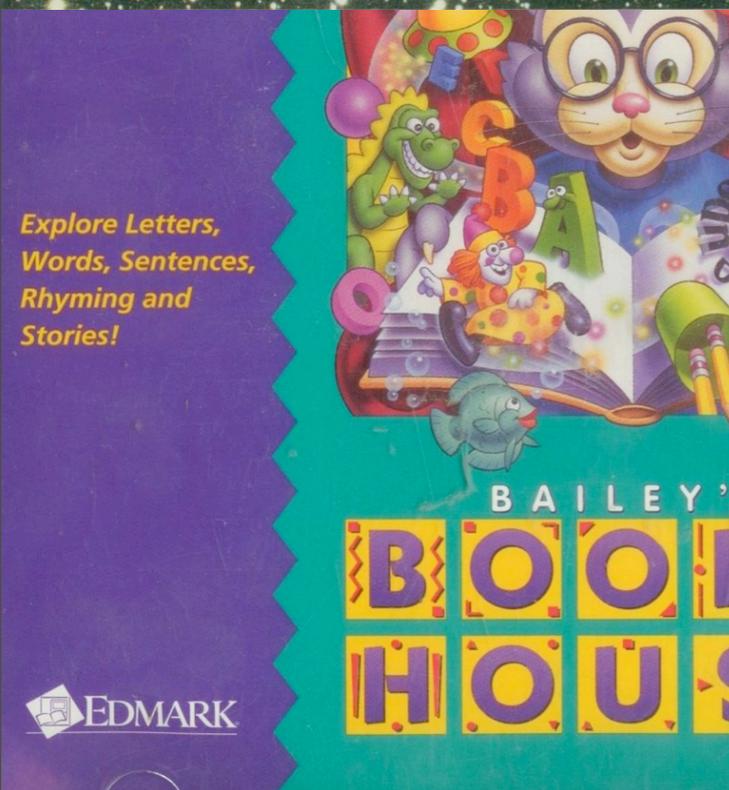
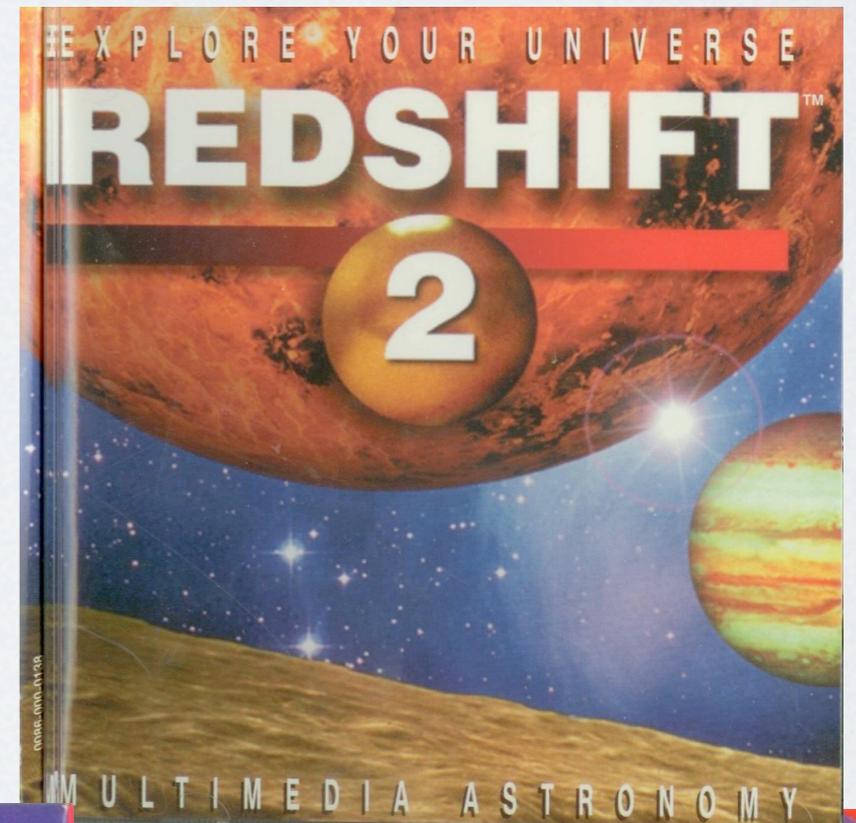
Disney Educational Productions

Education games

UNIVERSE 4.0

William J. Kaufmann III

W. H. Freeman and Company Publishers



Even in Higher Education



Dimension (linear algebra)

Powerpoint Lectures

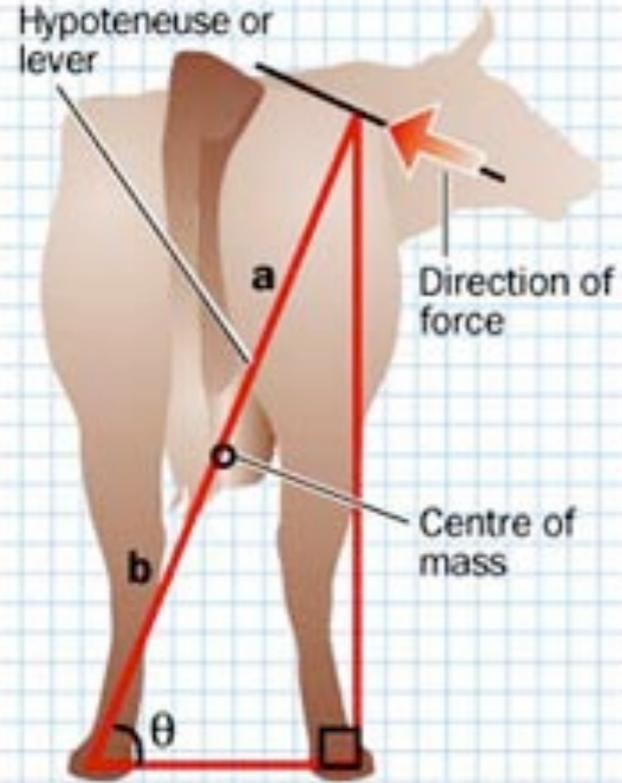
- Bullets and bullets
- No thinking necessary by teacher.
- Despite many pedagogical issues valuable in context with presenting media.



HAPPY TORQUE

Force required to tip a cow

Hypotenuse or
lever



Direction of
force

Centre of
mass

$$\text{Force} = \frac{m g \cos\theta b}{a+b}$$

m is the mass of the cow **682kg**

g is the gravitational force **9.81**

θ is the angle of the lever **66°**

a is the length of lever above
the centre of mass **0.79m**

b is the length of lever below
the centre of mass **0.79m**

$$\frac{682 \times 9.81 \times \cos 66^\circ \times 0.79}{0.79 + 0.79}$$

$$= 1,360\text{n}$$

1,360 newtons of force requires 2.07
people to exert it, if you assume that
each person weighs 67kg and can
push his or her own bodyweight

Cow Tipping problem

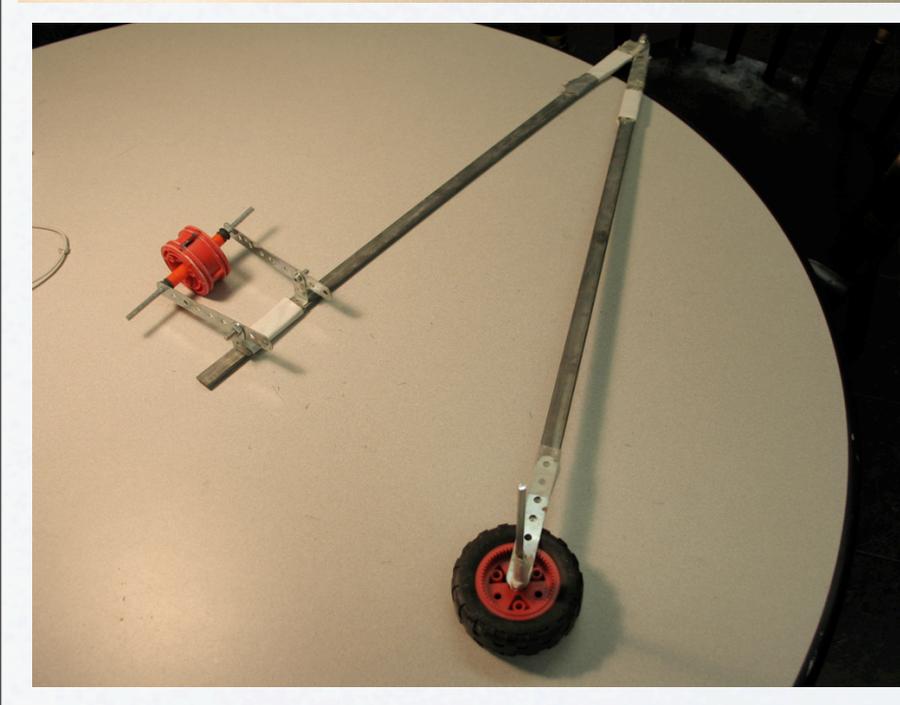
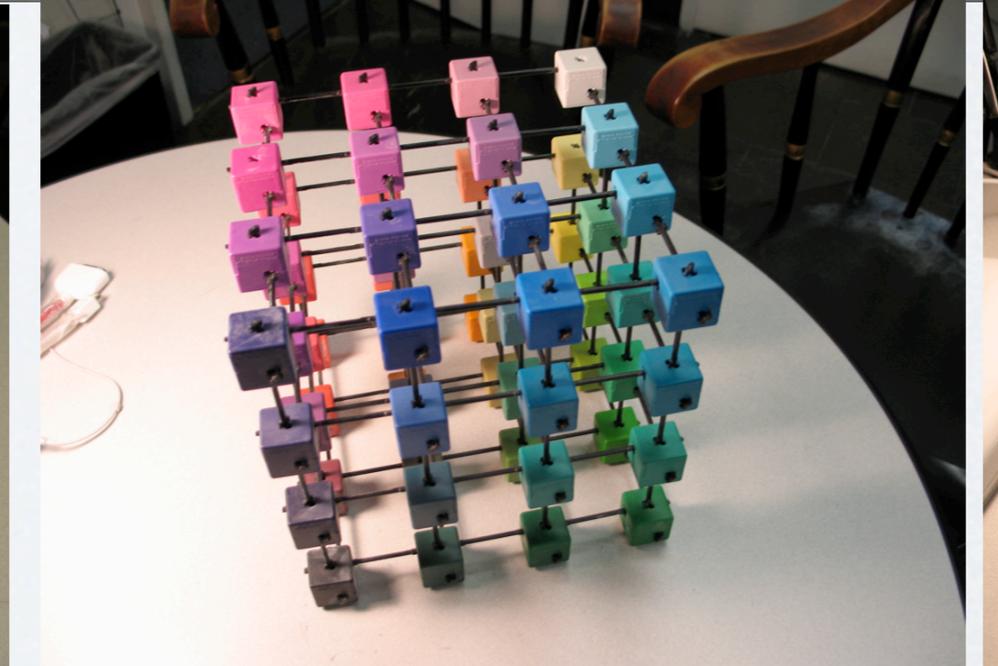
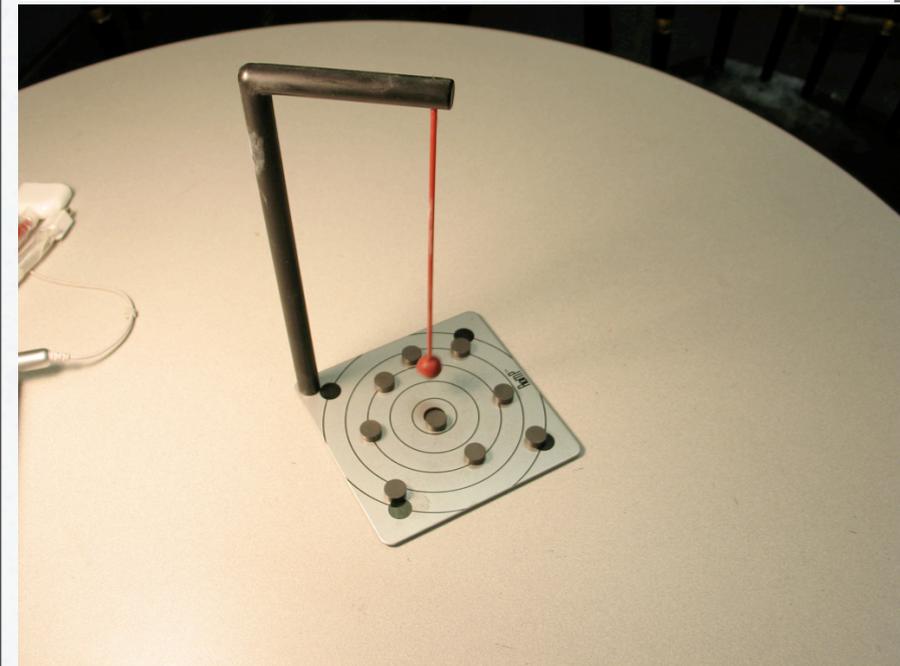
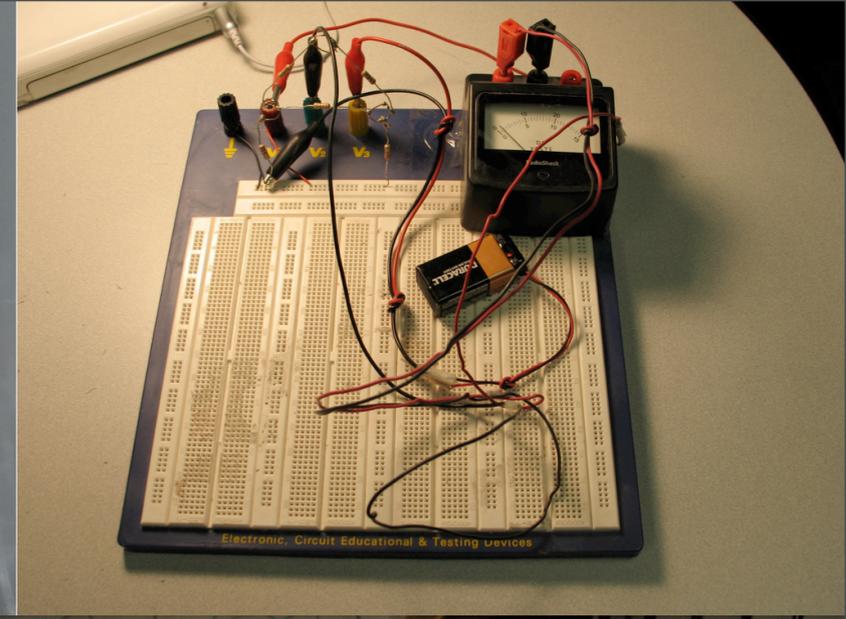
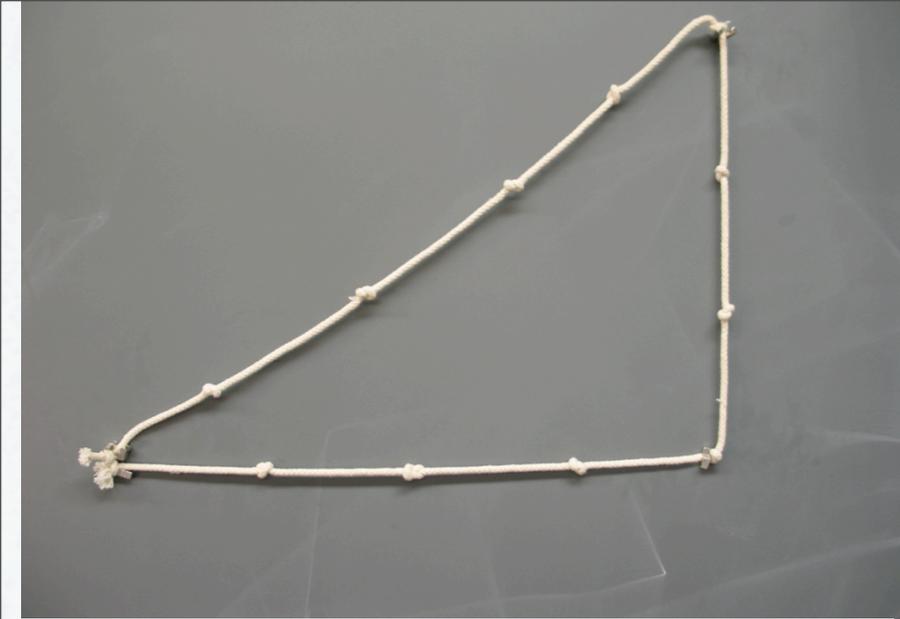
An application
of the cross product



In class Demonstrations

This is old fashioned “technology”
but still belongs to the category of

Examples:



Photography

Other coordinate
systems



Demonstrations



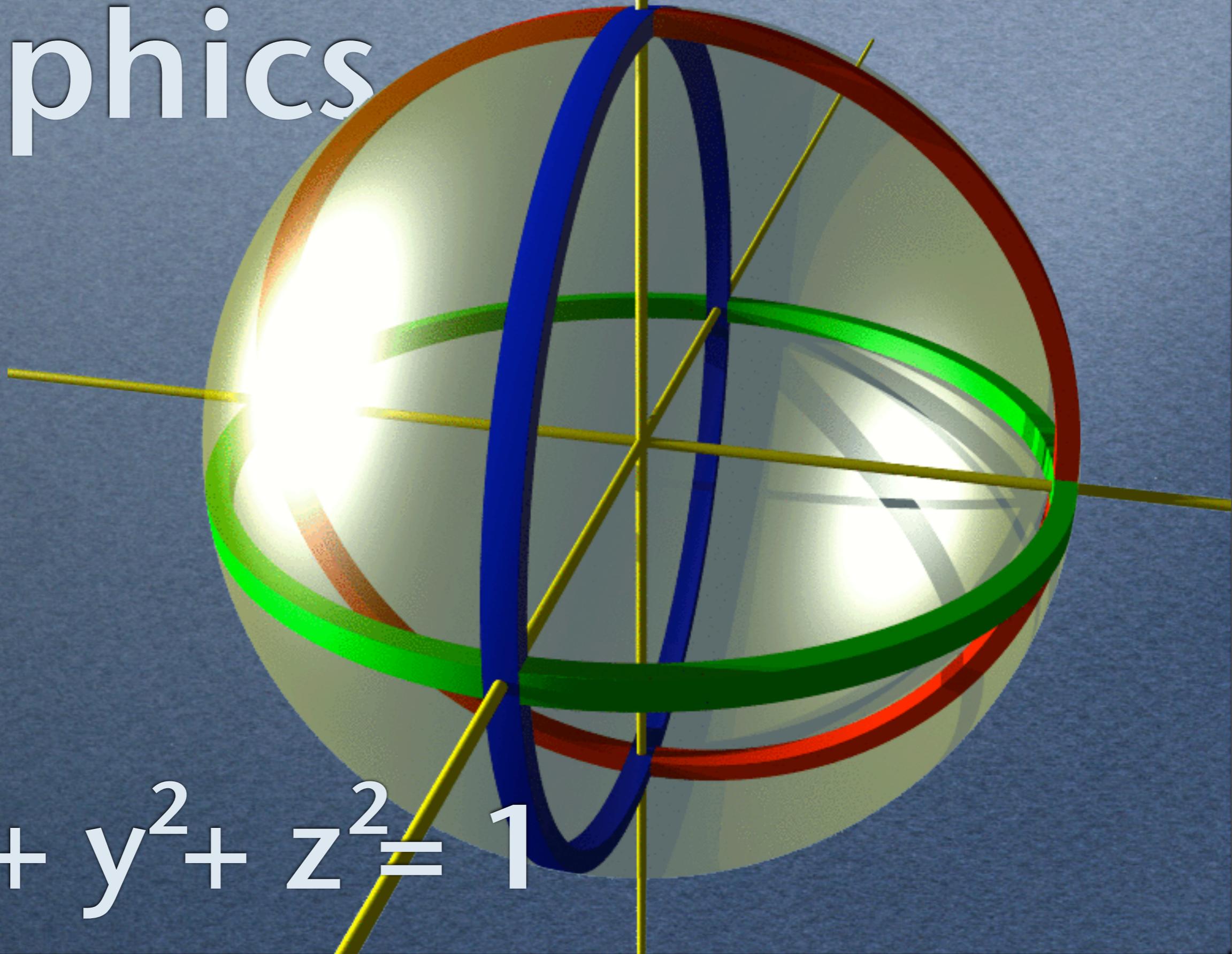
Dale Winter: Harvard University

Group work



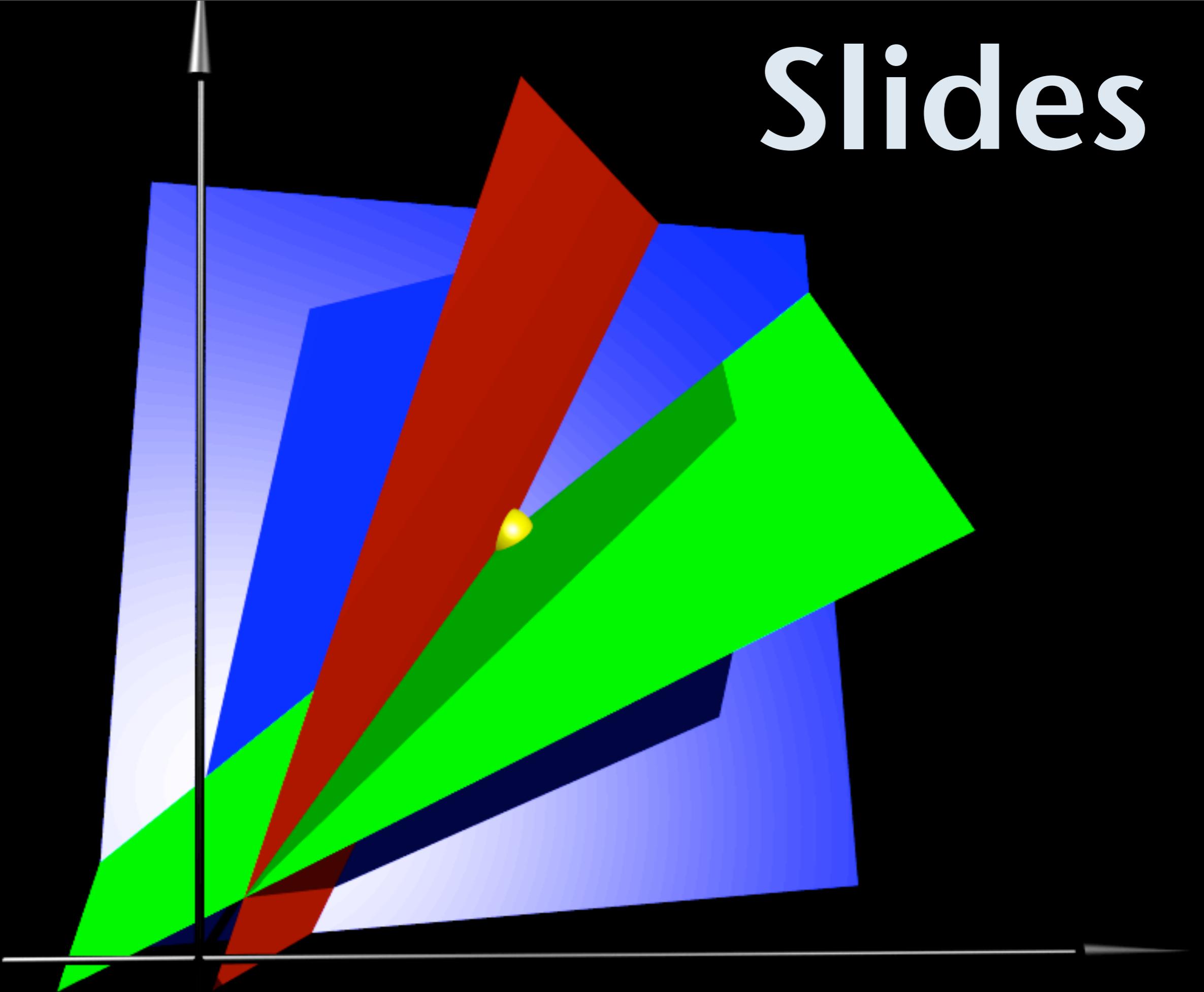
Harvard University

graphics



$$x^2 + y^2 + z^2 = 1$$

Slides



User generated content

- Collaboration, Wikis, Discussion, Galleries
- Monitoring or filtering issues, spam
- In mathematics: statements often are either right or wrong. Can be embarrassing to be kept online.

The screenshot shows the Marblebook website interface. At the top, there is a blue header with the "marblebook" logo and a navigation bar containing the text "login is free | no req". Below the header, a large, detailed image of a marble is displayed. To the left of the marble, there is a text block that reads: "Marblebook connects you you. Marblebook is separate mar of a multivari 2006. You can use M". Below this text, there are two bullet points: "Round up you know." and "See what' friends.". To the right of the main text, there is a grid of smaller, colorful marbles. At the bottom of the page, there is a banner for a 100 Euro stamp featuring Isaac Newton, with the text "ISAAC NEWTON 1643-1727", the equation $\Delta(mv) = F\Delta t$, and "DEUTSCHE BUNDESPOST 100".

Pitfalls

- Computer crash
- Cable problems
- Sound problems
- Fiddling with software
- Plugin problems
- Connection problems
- Unreadable slides
- Moving too fast
- Sexism, Gender
- Copyright problems
- Bad taste
- Fiddling with software
- Plugin problems
- Connection problems
- Unreadable slides
- Moving too fast



copyright

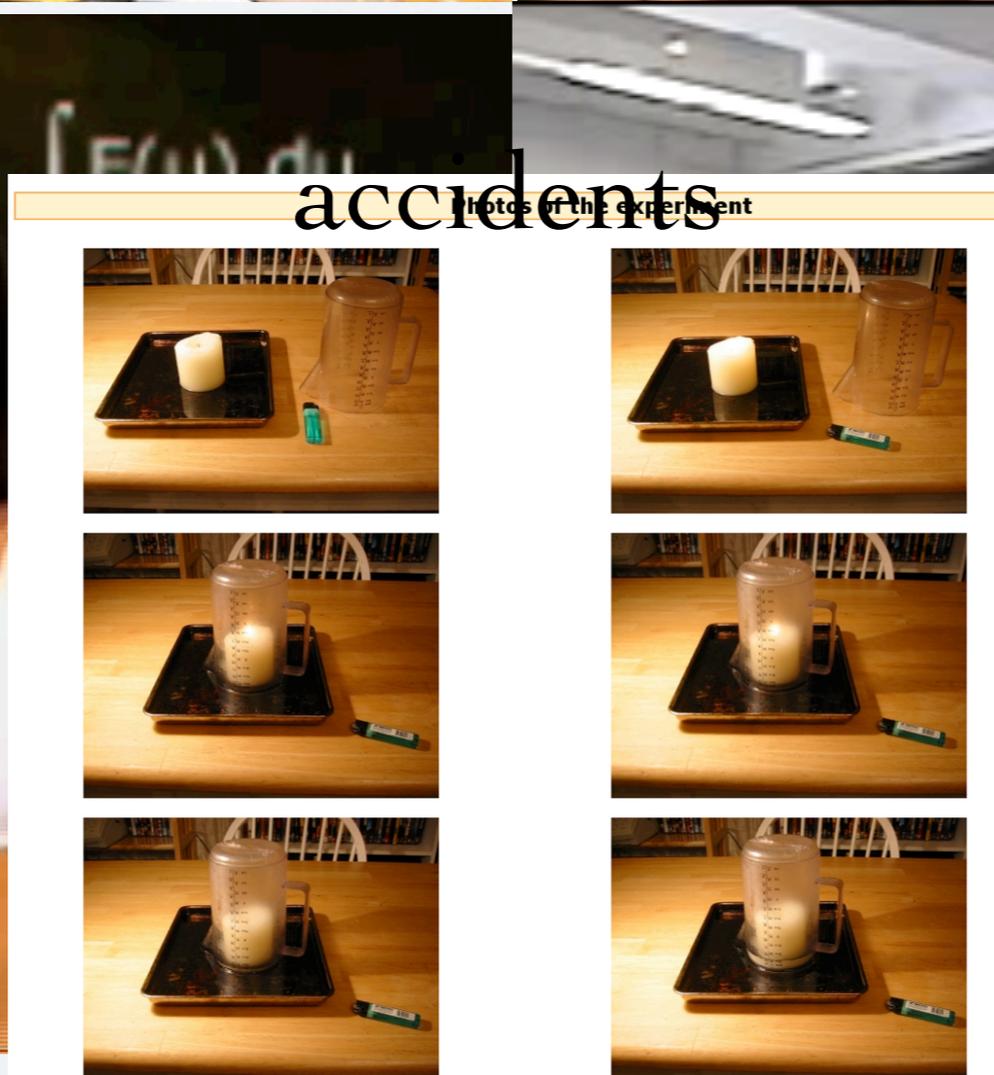
This scene is from Donald in Mathmagic land movie, available here as DVD.



bad
taste



sexism



accidents

photos of the experiment



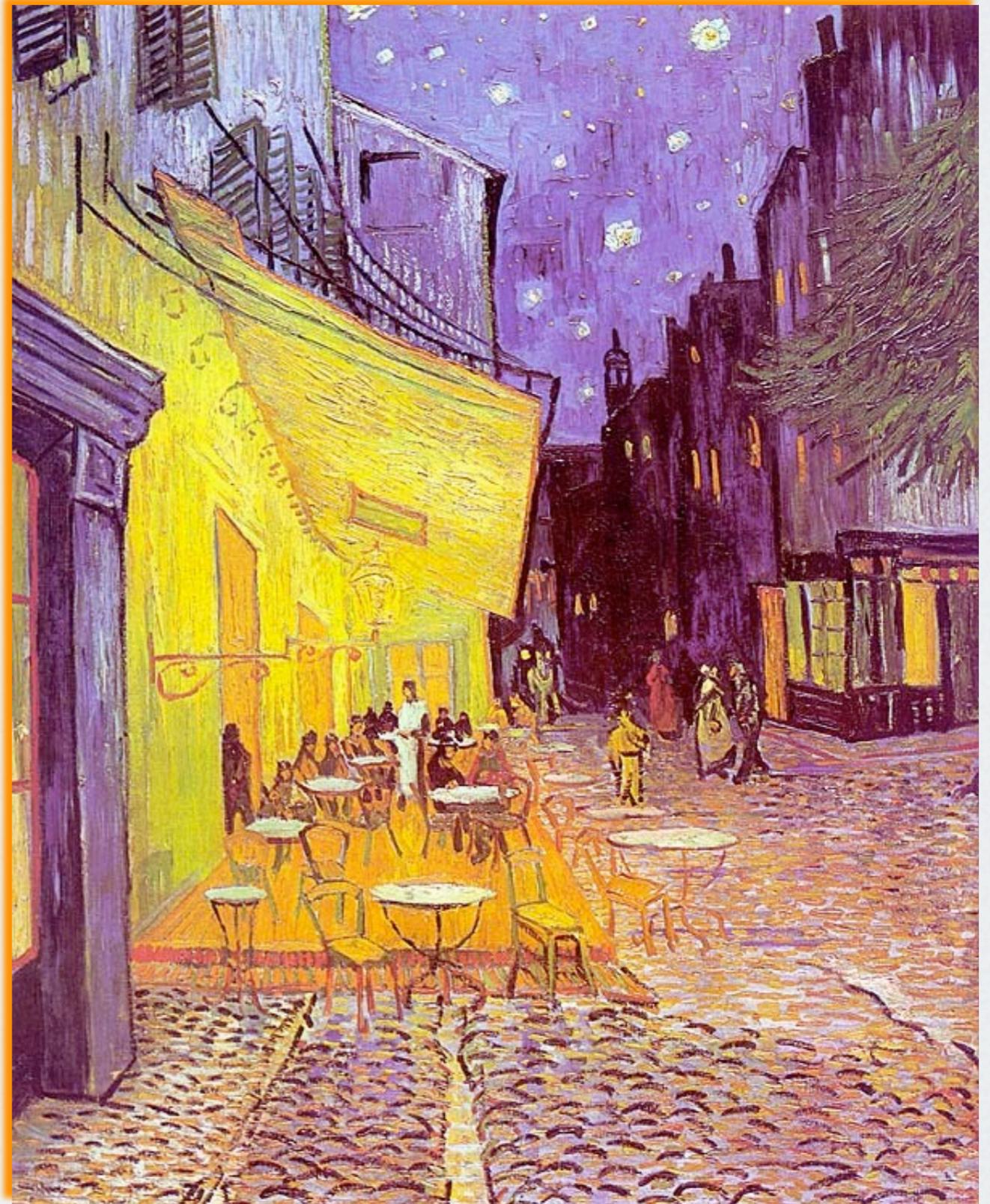
privacy

Conclusions:

- We live in a time where a plethora of possibilities and opportunities exist to enrich teaching.
- Benefits and risks are close together.
- In higher education, many things have not yet been explored.

A metaphor

If the classroom
is a restaurant
where the
teacher is the
cook and the
students are the
guests.



There are things which
are difficult to cook



And there are risks



But we have
wonderful
opportunities
to create a
great menu.



The end

I'm a preceptor at the Harvard mathematics department since 2000. I work in a group of people of specialists who teach undergraduate mathematics. Within this field, my speciality is webpedagogy.