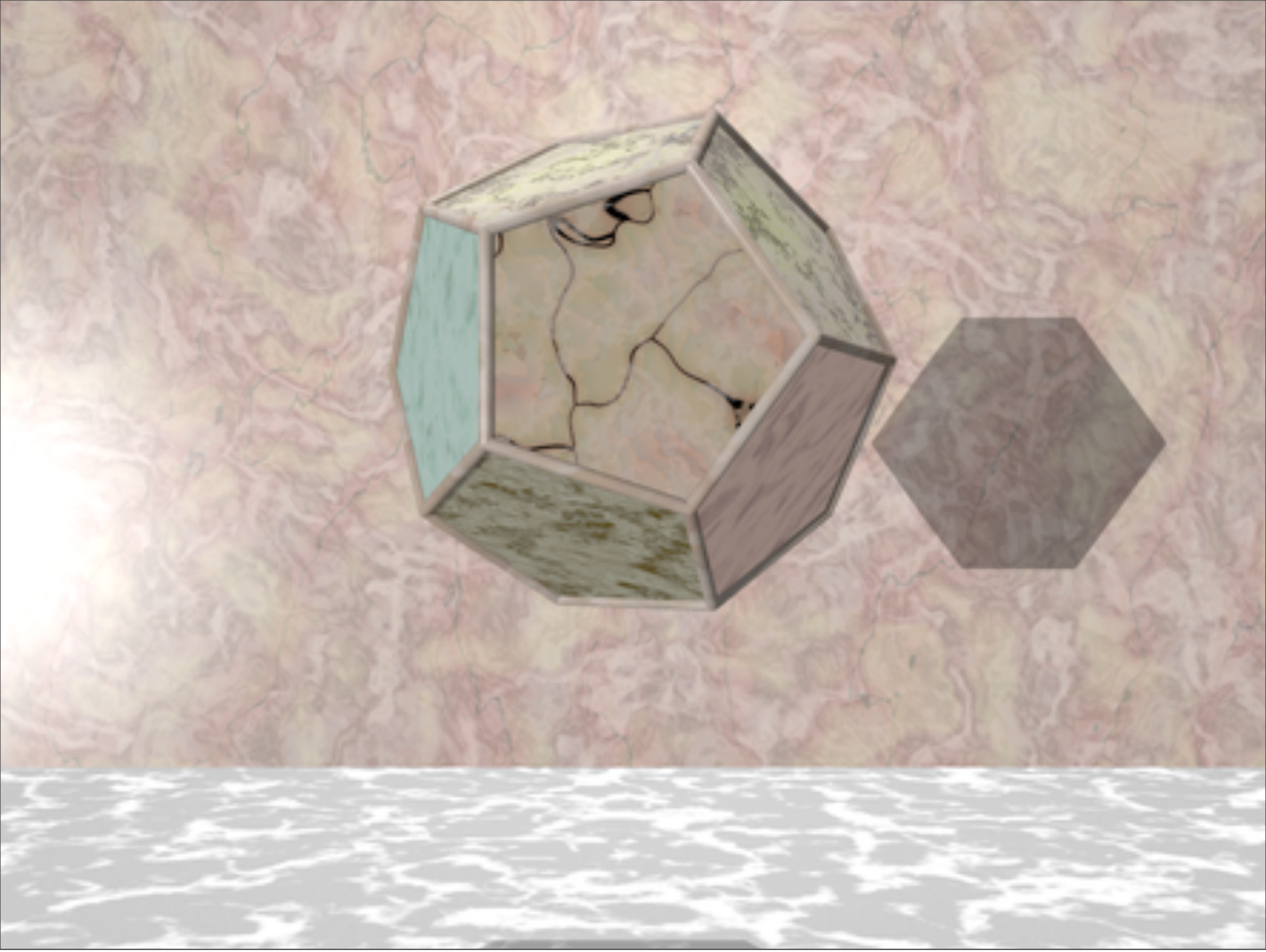
MATH 21B

LINEAR ALGEBRA AND DIFFERENTIAL EQUATIONS

Spring 2009



Wednesday, January 28, 2009

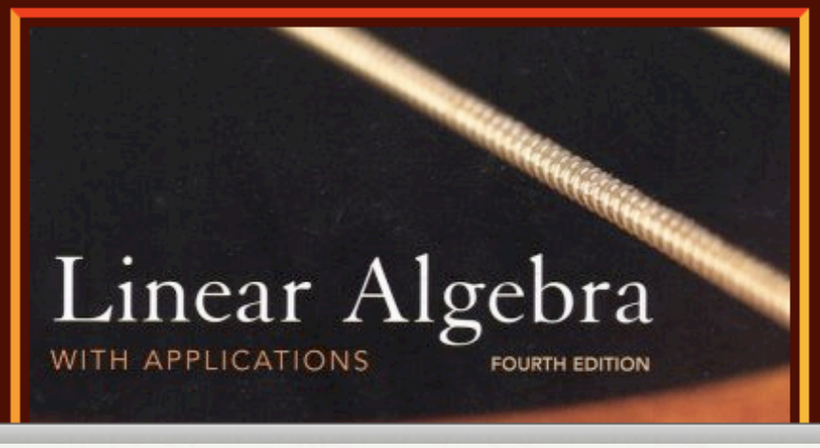
WEBSITE

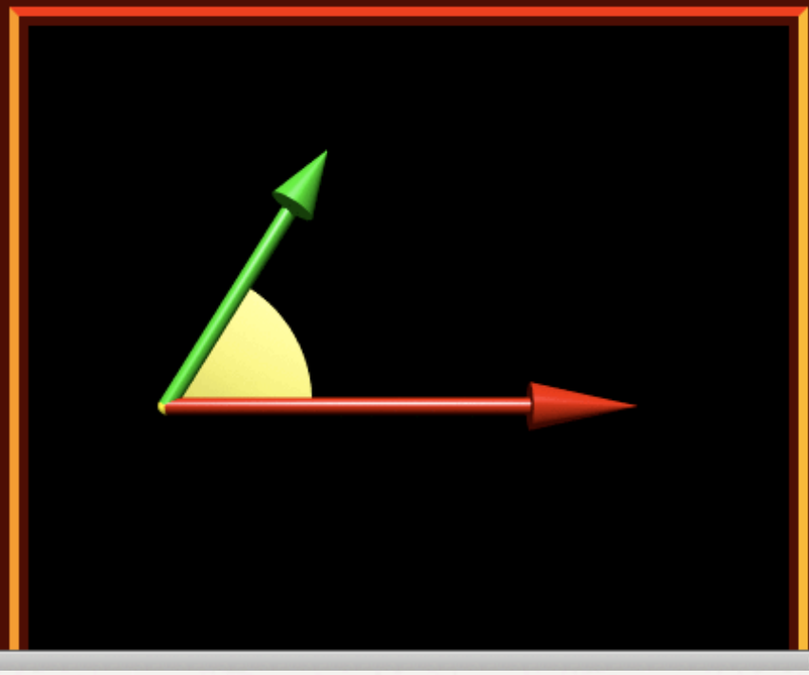
MATH 21 B

Mathematics Math21b Spring 2009
Linear Algebra and Differential Equations
MATH21B, SPRING 2009
Course Head: Oliver Knill
Office: SciCtr 434
Email: knill@math.harvard.edu

NEW | SYLLABUS | HOMEWORK | LINKS

- There is a mandatory intro lecture on Wednesday January 28 at 8:30-9:00 AM in Science Center B.
- Sectioning for this course has started: more information and advising schedule.
- We will use the 4'th edition of Otto Bretscher's book.





5/10

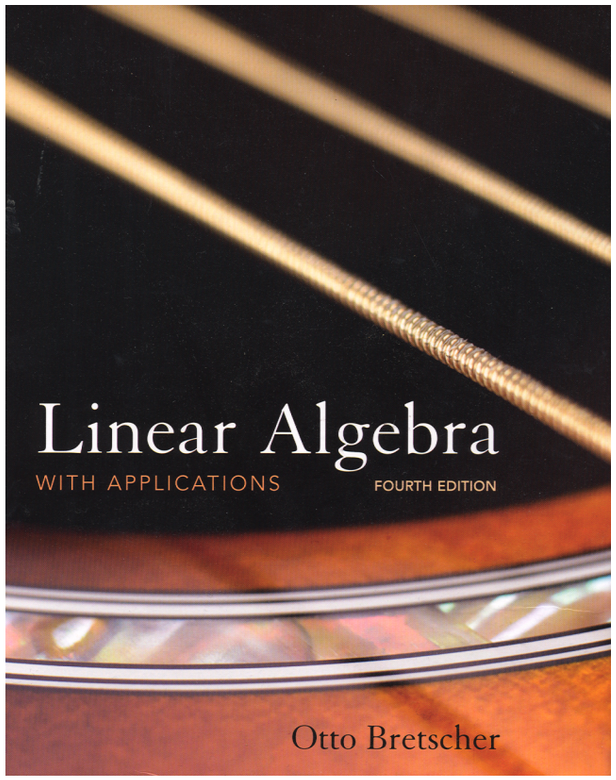
www.courses.fas.harvard.edu/~math21b

MATH21B

SYLLABUS 2009

Linear Algebra and Differential Equations is an introduction to linear algebra, including linear transformations, determinants, eigenvectors, eigenvalues, inner products and linear spaces. As for applications, the course introduces discrete dynamical systems and provides a solid introduction to differential equations, Fourier series as well as some partial differential equations. Other highlights include applications in statistics like Markov chains or data fitting with arbitrary functions.

TEXTBOOK



Book: **Otto Bretscher,** Linear Algebra with Applications, 4th edition 2009,

ISBN-13:978-0-13-600926-9. You need the 4th edition for the homework

Student solution manual optional.

SECTIONS

The course lectures (except reviews and intro meetings) are taught in sections. This assures you can discuss the material in class. Additional problem sessions as in math21a. Sections: MWF 10,MWF 11,MWF 12,TTH 10-11:30, TTh 11:30-13:00. MQC: 309

SECTIONING

START	END	SENT
MO JAN 26	THU JAN 29	FRI JAN 30
7 AM	12 PM	5 PM

More details:

http://www.math.harvard.edu/sectioning

IMPORTANT DATES

INTRO	1.EXAM	2.EXAM
28. JAN	3.MARCH	7. APRIL
8:30 AM	7 PM	7 PM
SCB	SCC	SCC

GRADES

PART	GRADE 1	GRADE 2
1. HOURLY	20	20
2. HOURLY	20	20
HOMEWORK	20	20
LAB	5	
FINAL	35	40

PREREQUISITES

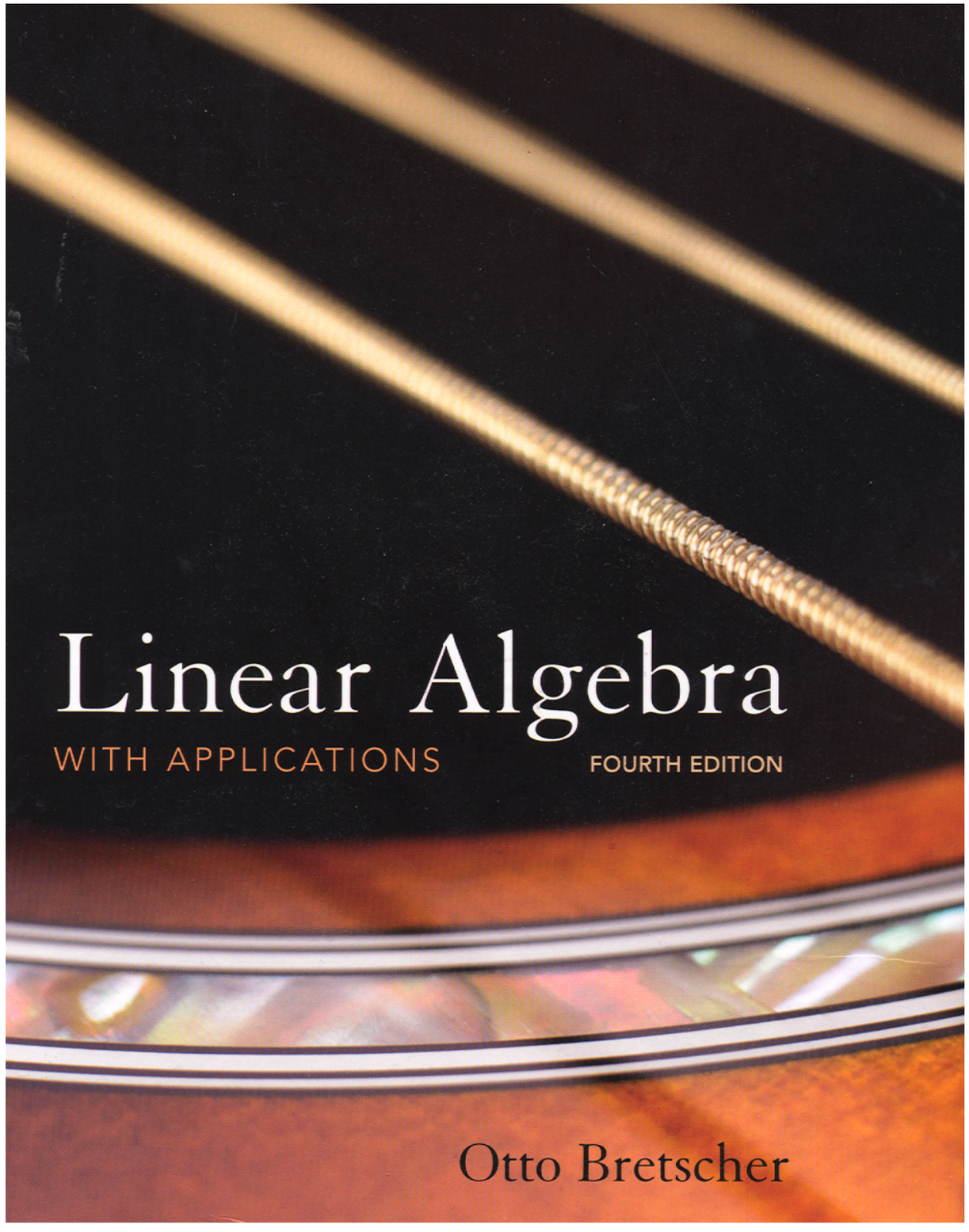
Single variable calculus.
Multivariable like 21a is advantage.

ORGANIZATION

Course Head: Oliver Knill

knill@math.harvard.edu

SC 434, Tel: (617) 495 5549



Book: **Otto Bretscher,** Linear Algebra with Applications, 4th edition 2009,

Start
Mo Jan 26
7 AM

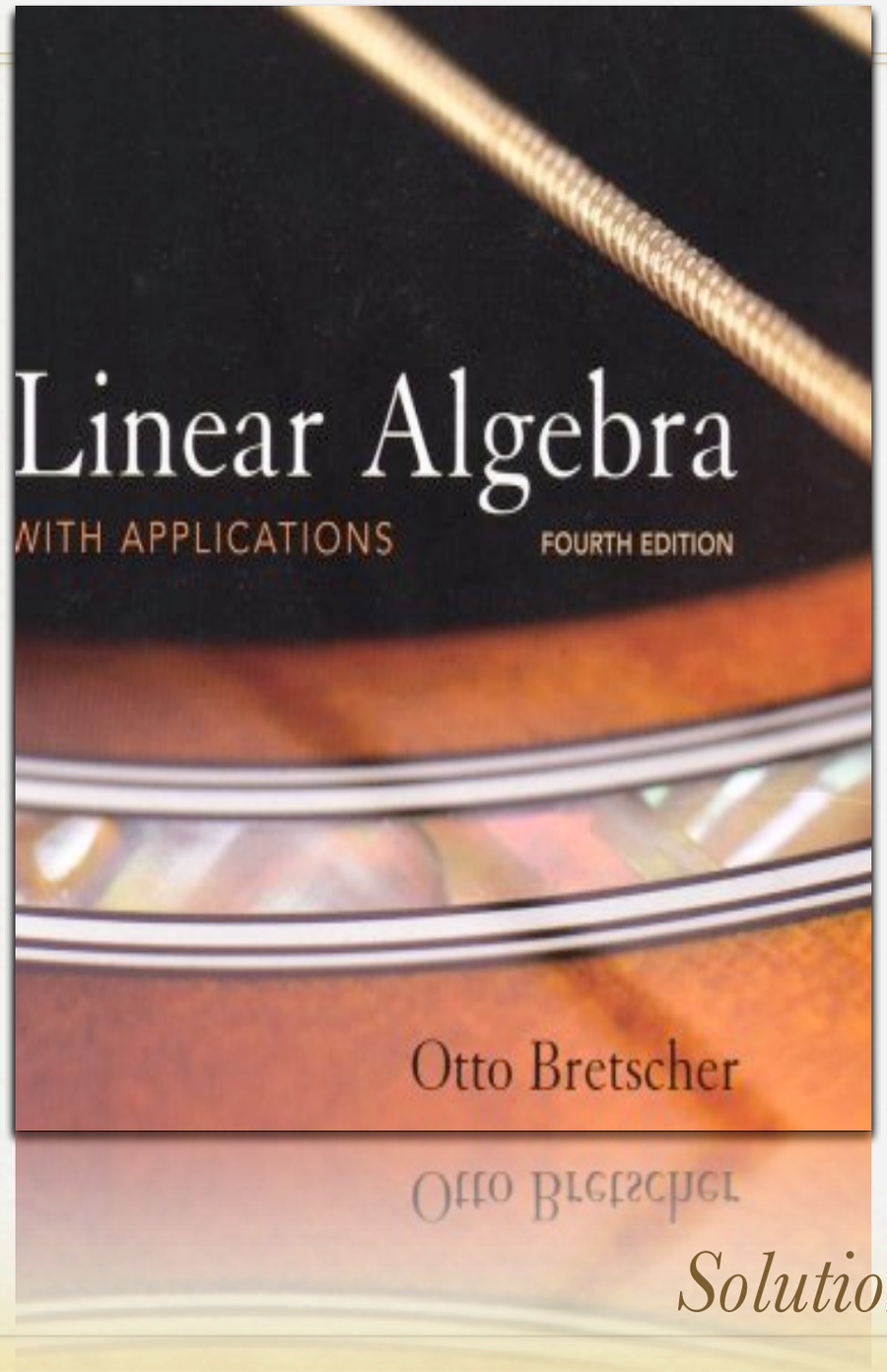
More details:

http://www.mat

Impo

Intro
28. Jan
8:30 AM
SCB

BOOK



Otto Bretscher
Linear Algebra
With Applications

4th edition

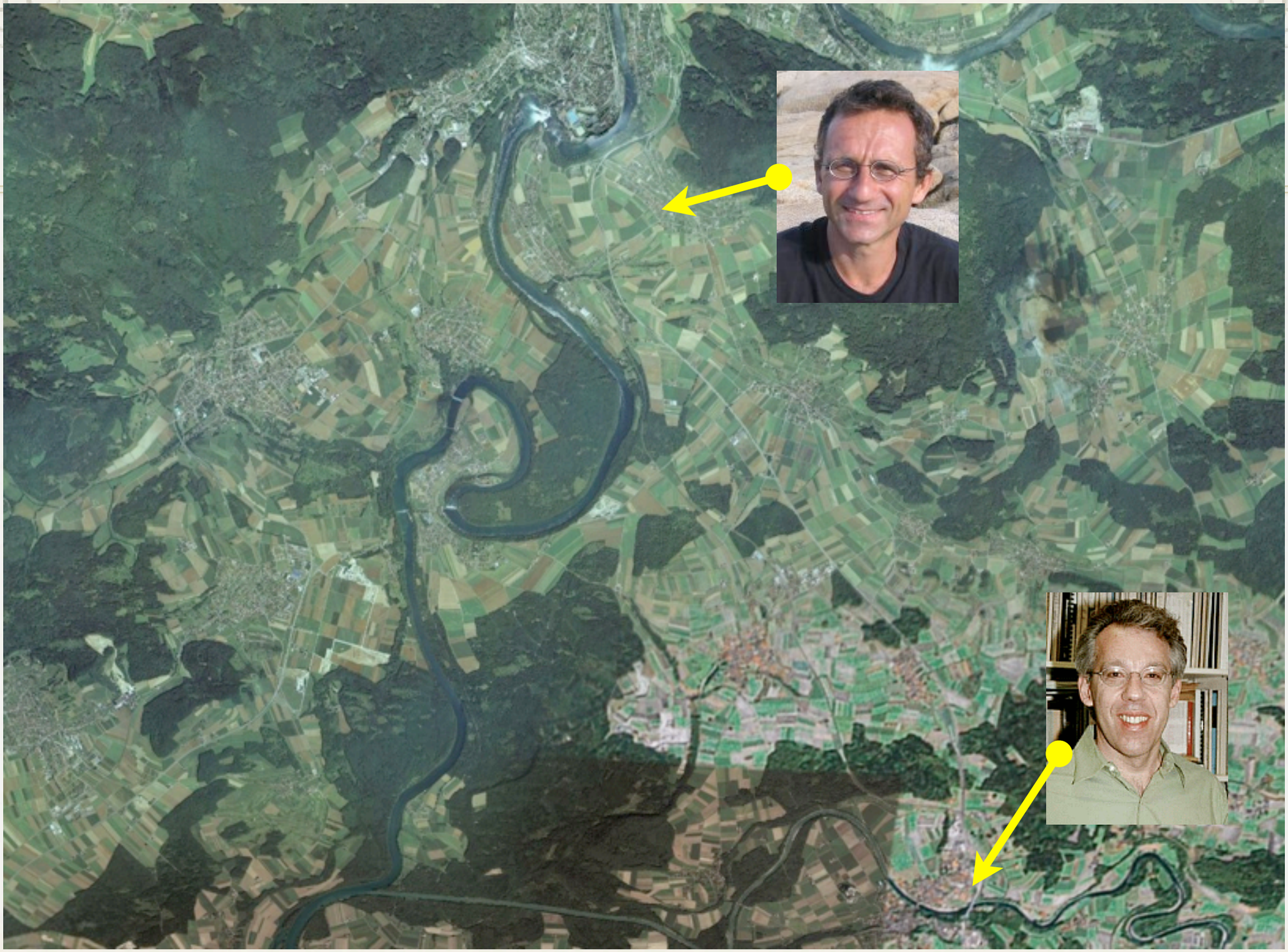
Solution manuals only appear in February 8th.

BOOK

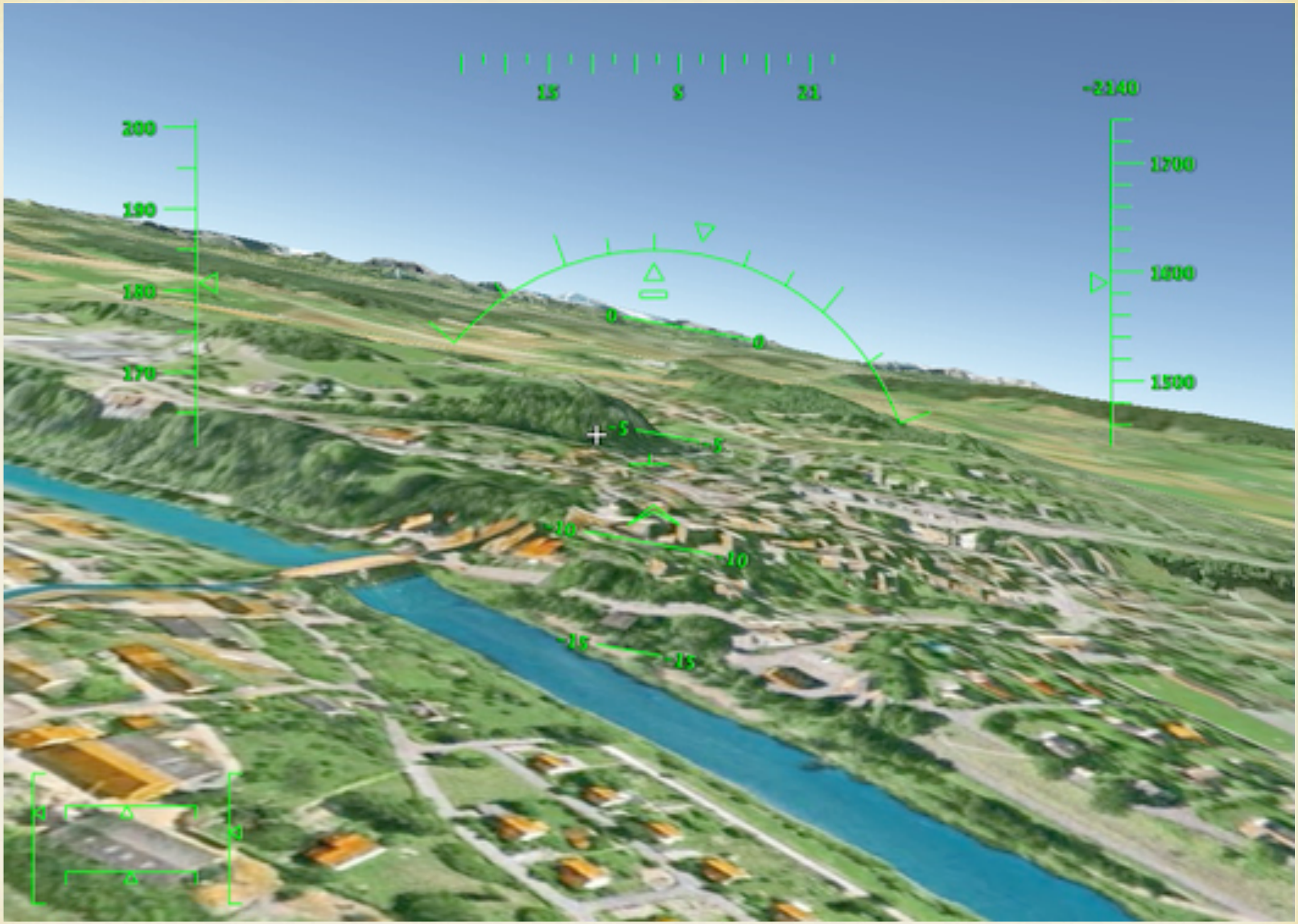
Otto Bretscher
Linear Algebra
With Applications

4th edition

Solution manuals only appear in February 8th.



Wednesday, January 28, 2009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170
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-10
-15
-15

EXAMS

First midterm: March 3, 2009, 7-8:30 PM, SCI C

Second midterm: April 7, 2009, 7-8:30 PM, SCI C

Final Exam: arrange by registrar

rap by Michael Shen

HOMEWORK

- Due every lecture
- 5 problems per class
- No extension
- 3 jokers

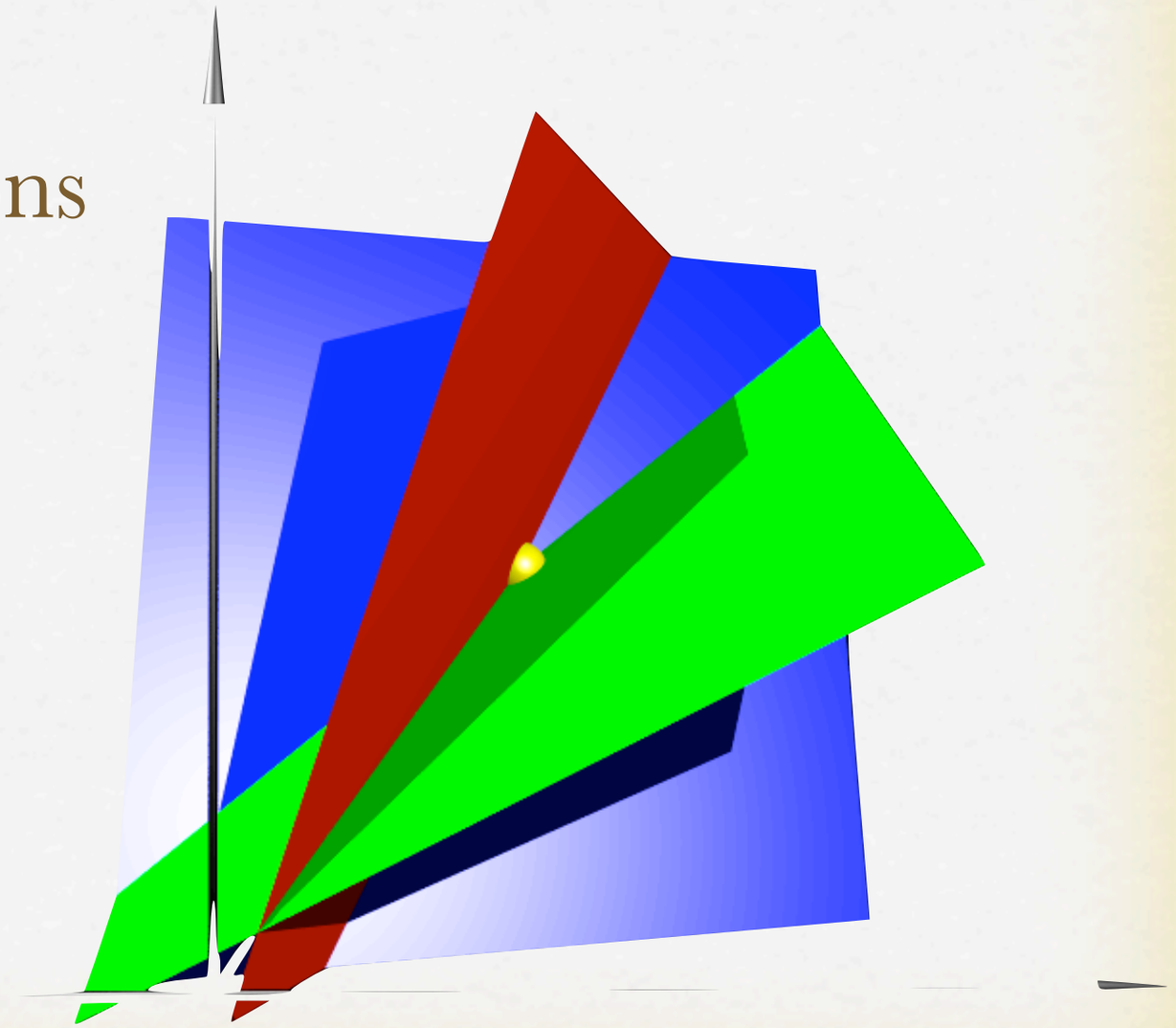
Week	Lecture Number	Assignment
Week 1	lecture 1	1.1: 10,24,40,46,48,28*,36* TF4,23 Due Wed 2/4 rsp Thu 2/5
Week 1	lecture 2	1.2: 6,12,18,30,42,32*,20* TF6,44 Due Fri 2/6 rsp Tue 2/10
Week 1	lecture 3	1.3: [12,14],28,34,48,62,26*,46* TF23,41, Due Mon 2/9 rsp Tue 2/10

MQC

- SC 309 this semester
- Sunday to Thursday
- 8:30-10:30

TOPICS I

- Linear Equations
- Linear Transformations
- Linear Subspaces
- Dimension
- Orthogonality
- Determinants



Wednesday, January 28, 2009

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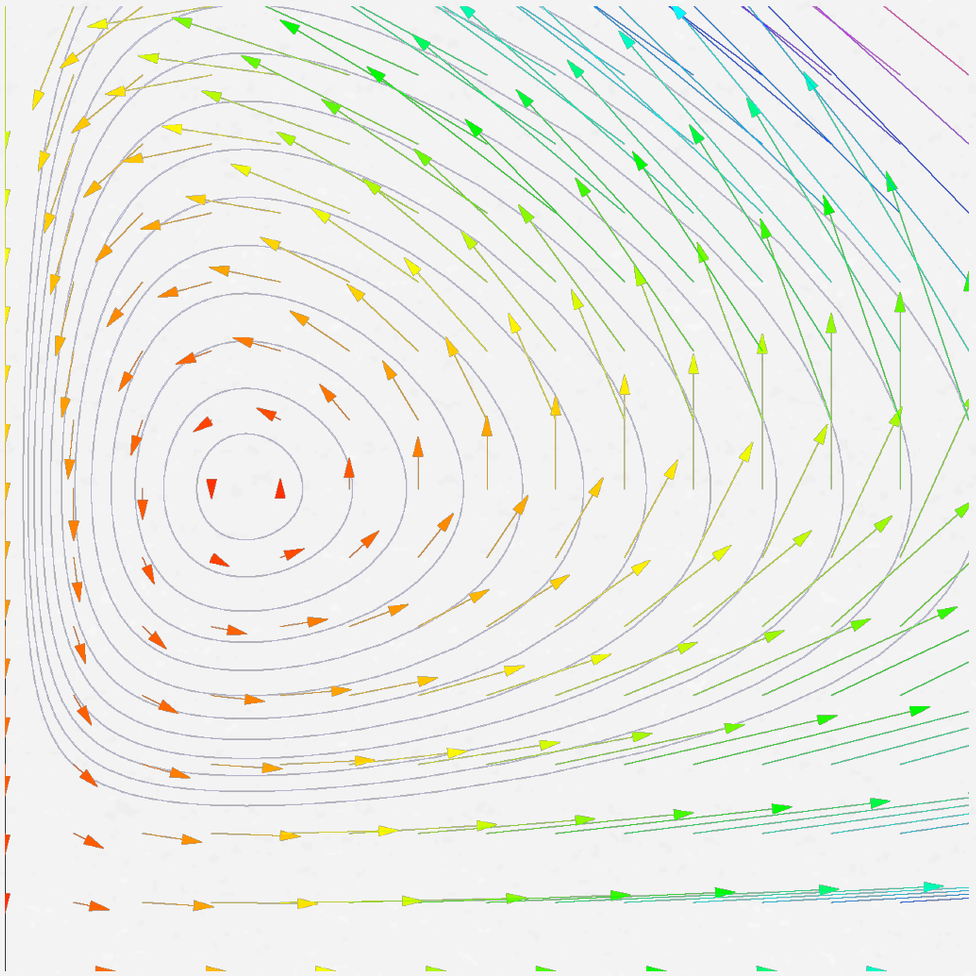
Wednesday, January 28, 2009

TOPICS II

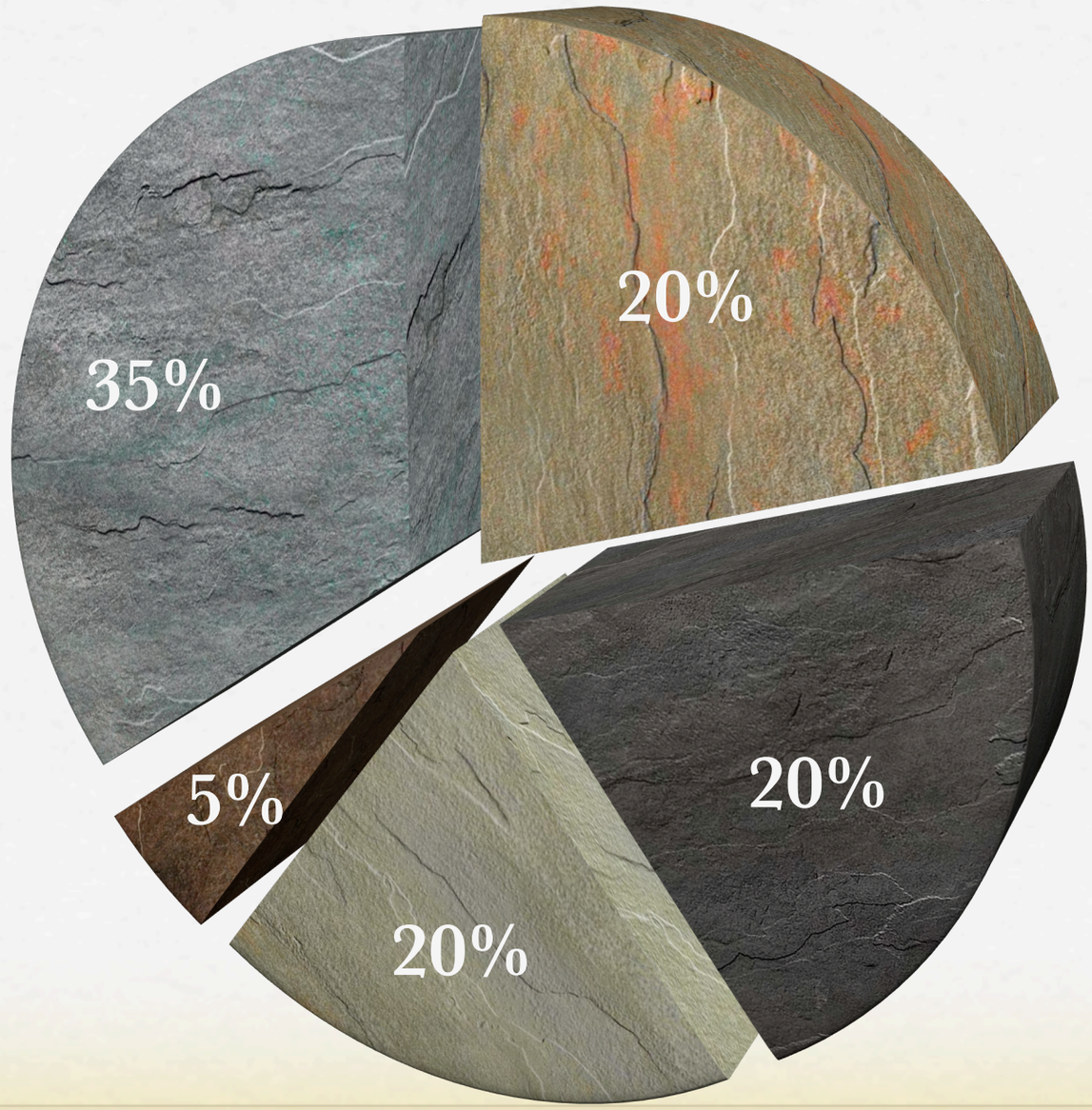
- Eigensystems
- Diagonalization
- Stability
- Differential equations
- Fourier Theory
- Partial differential equations



GRADE I

Midterm1 Midterm2 Homework Project Final

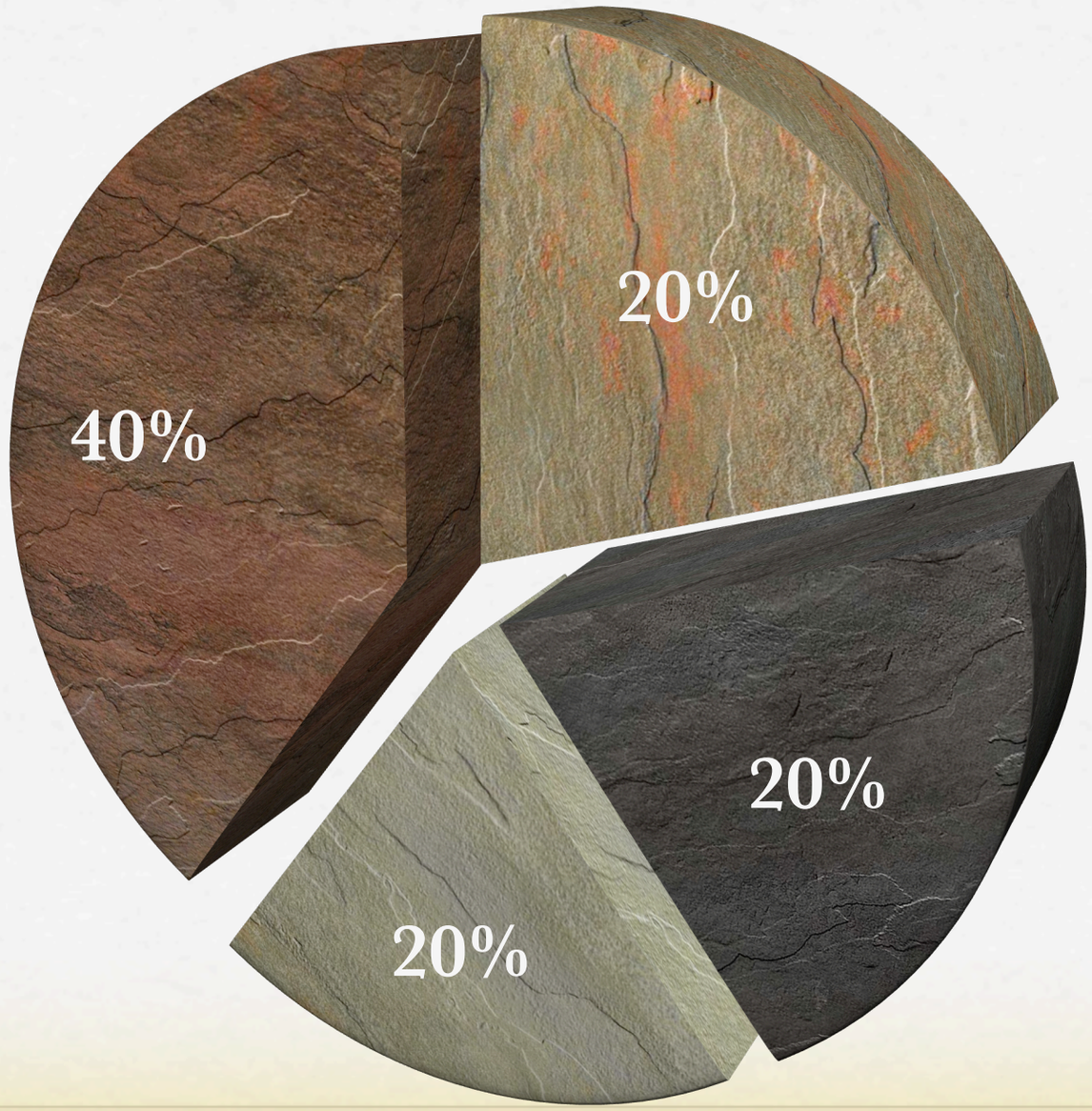
$$\begin{bmatrix} 20 \\ 20 \\ 20 \\ 5 \\ 35 \end{bmatrix} = \vec{v}$$



GRADE II

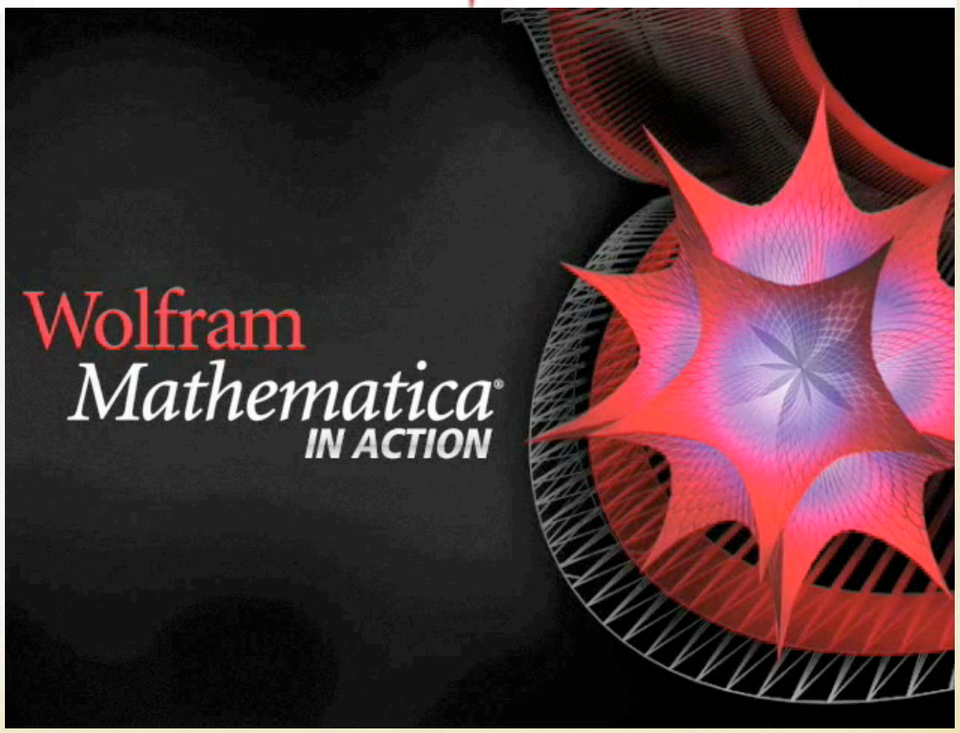
Midterm1 Midterm2 Homework Final

$$\begin{bmatrix} 20 \\ 20 \\ 20 \\ 40 \end{bmatrix} = \vec{v}$$



MATHEMATICA 7

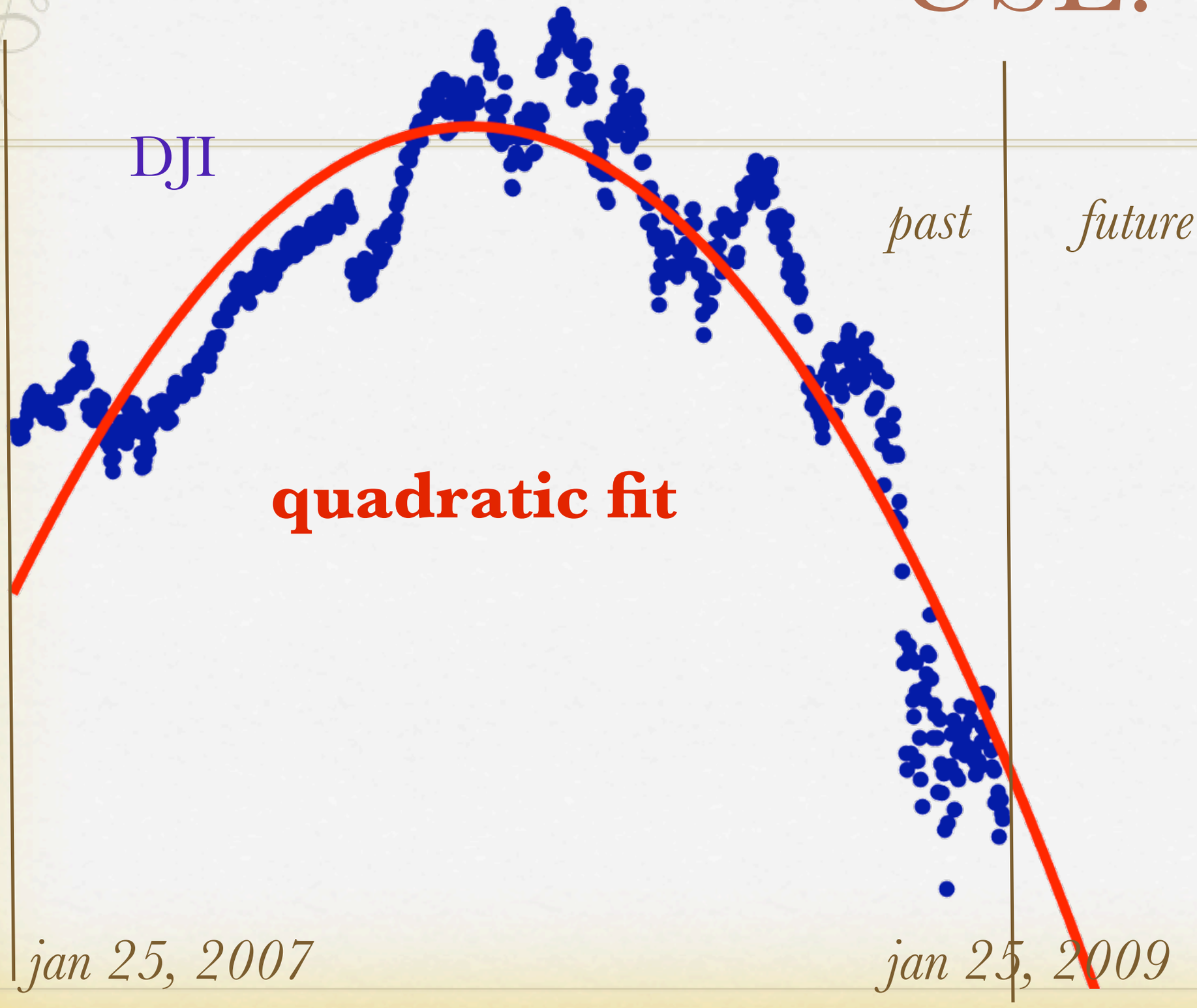
- Can be done in a few hours
- Can only improve grades
- Should be fun



WHY MATH21B?

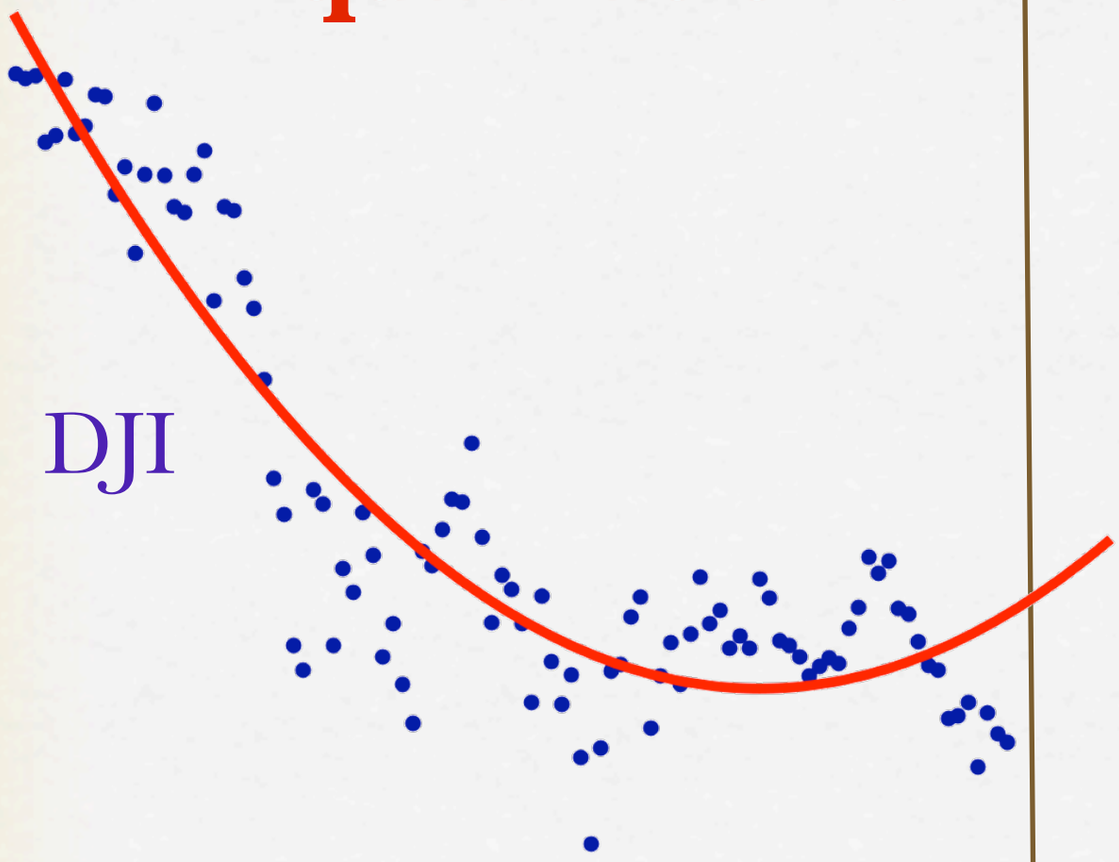
- understand the math of data analysis
- build models in economics
- use differential equations in biology
- complete your math background
- know the 100‘000 th term of the Fibonnacci sequence
- learn quantum mechanics later
- be able to understand abstract structures

USE?

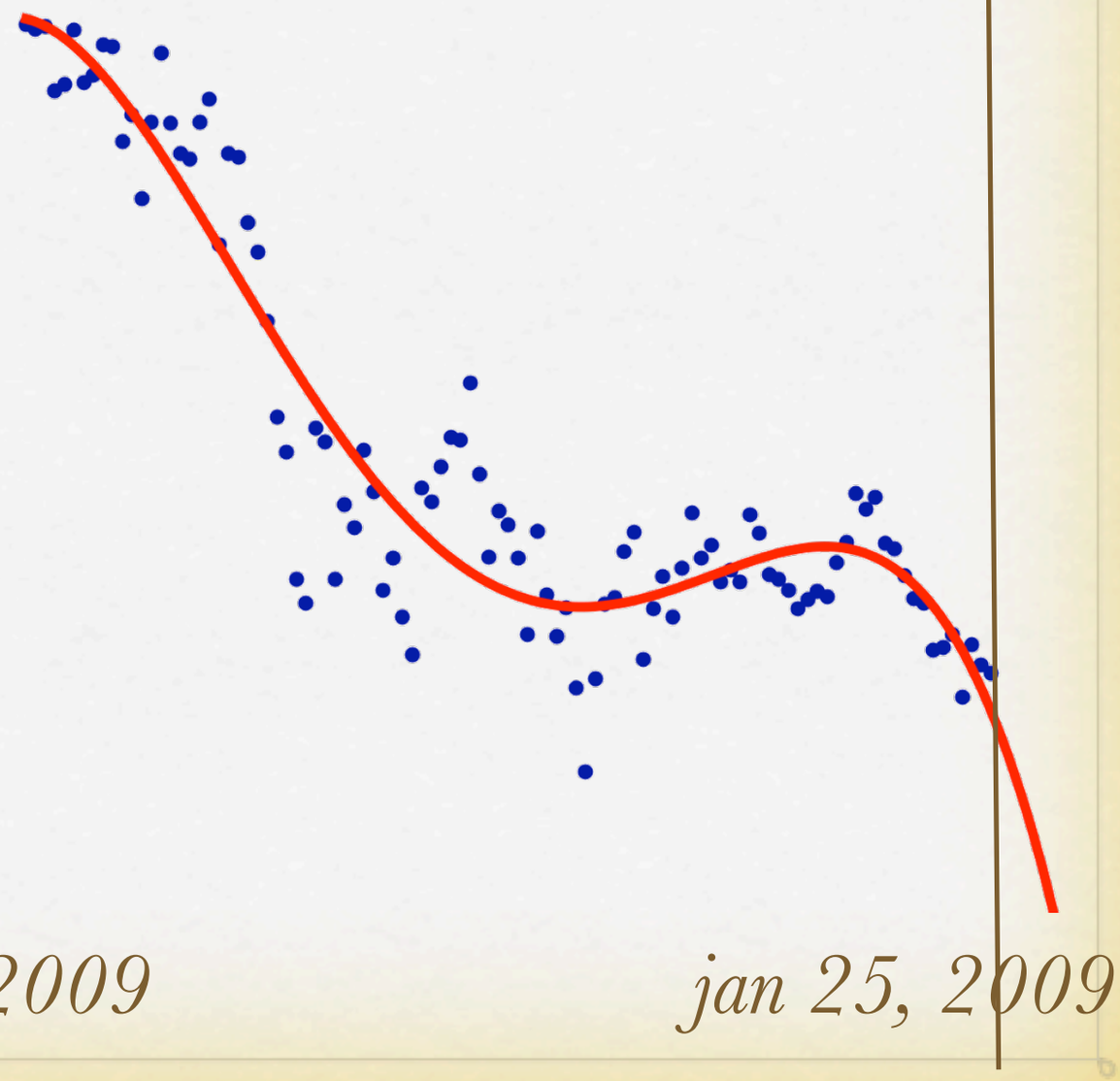


HOPE OR DOOM?

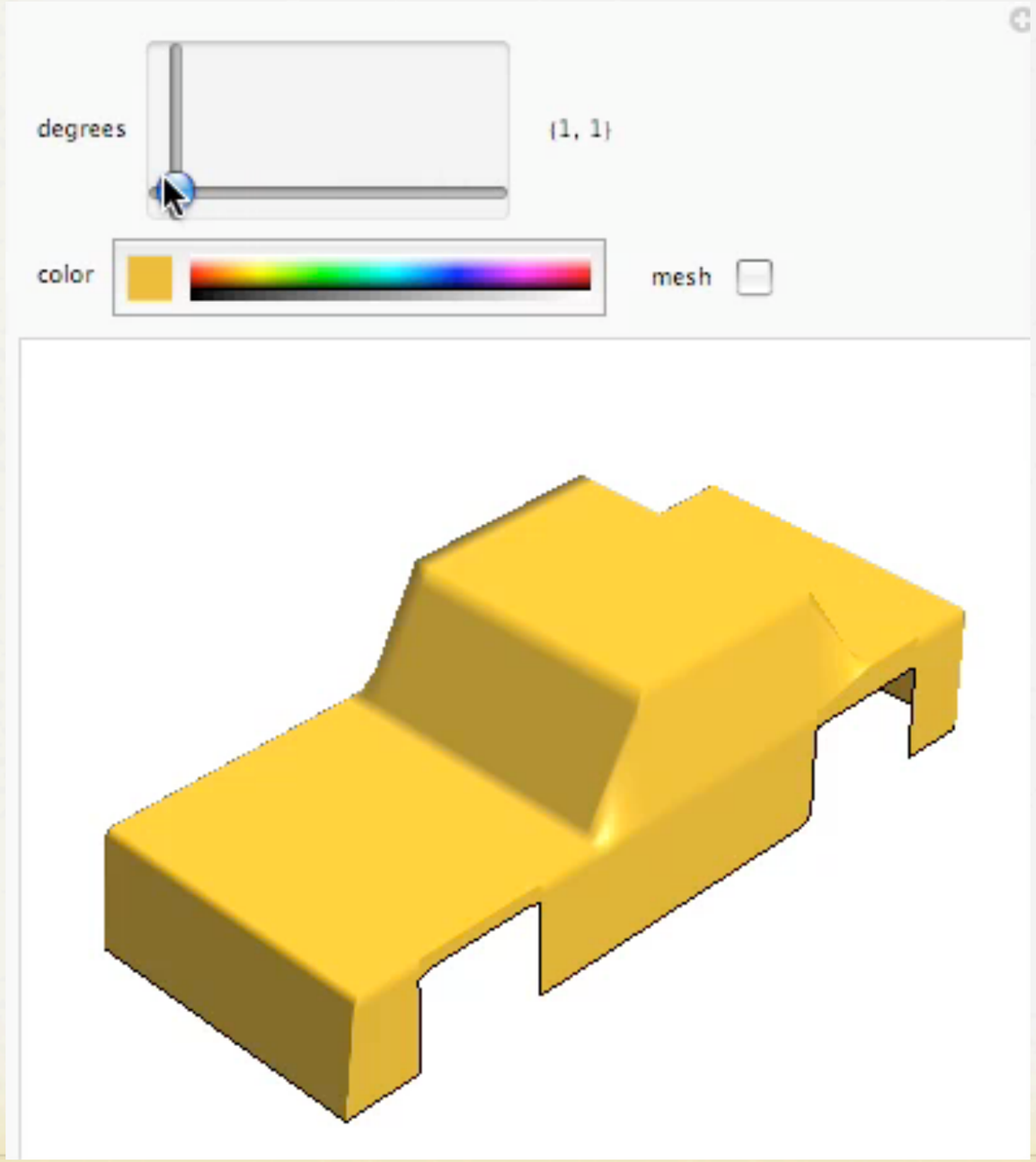
quadratic fit



quartic fit

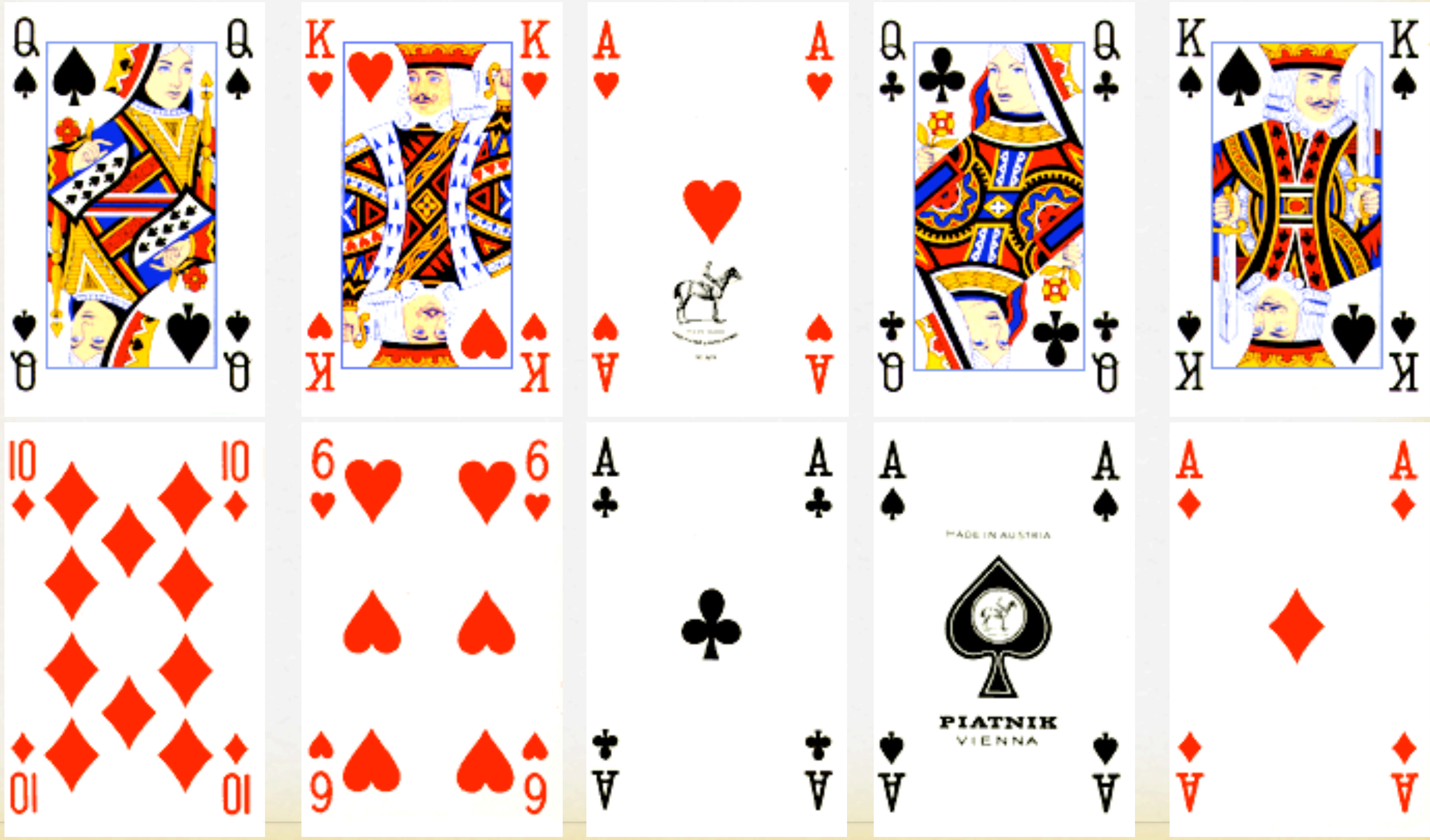


OTHER DATA FITTING



Mathematica by Yu-Sung Chang

STATISTICS AND PROBABILITY

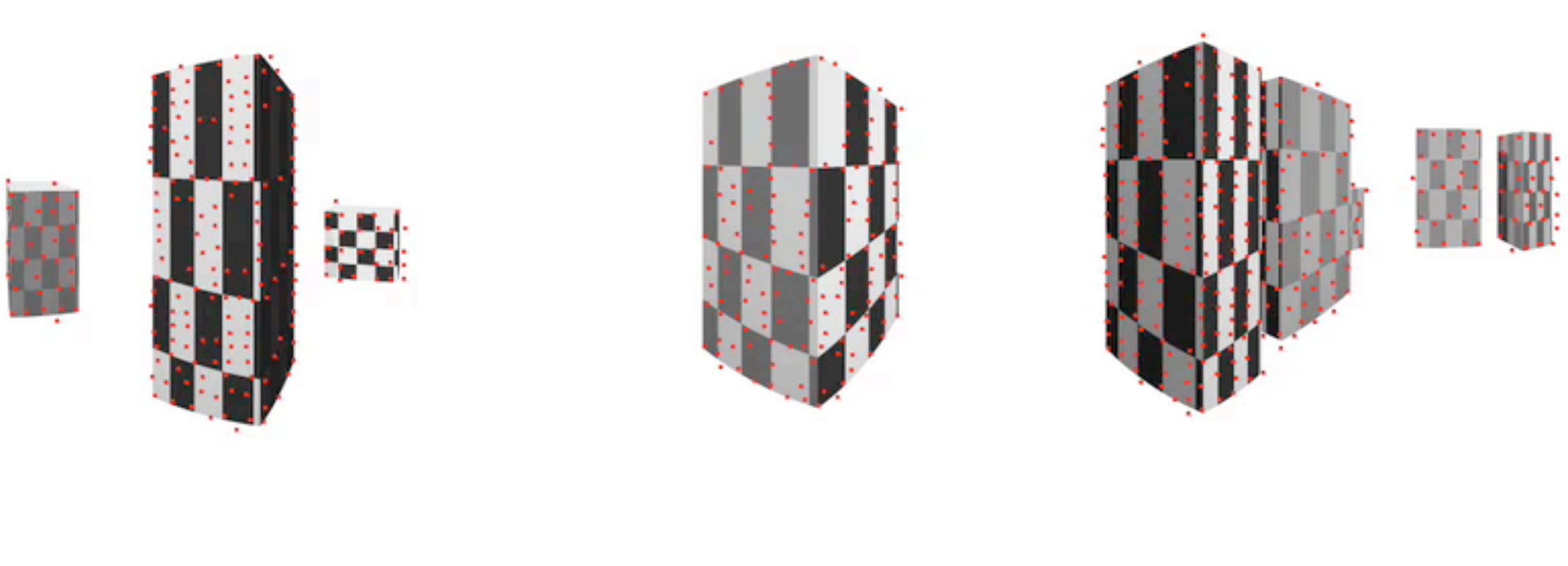


A DRUNK MOUSE

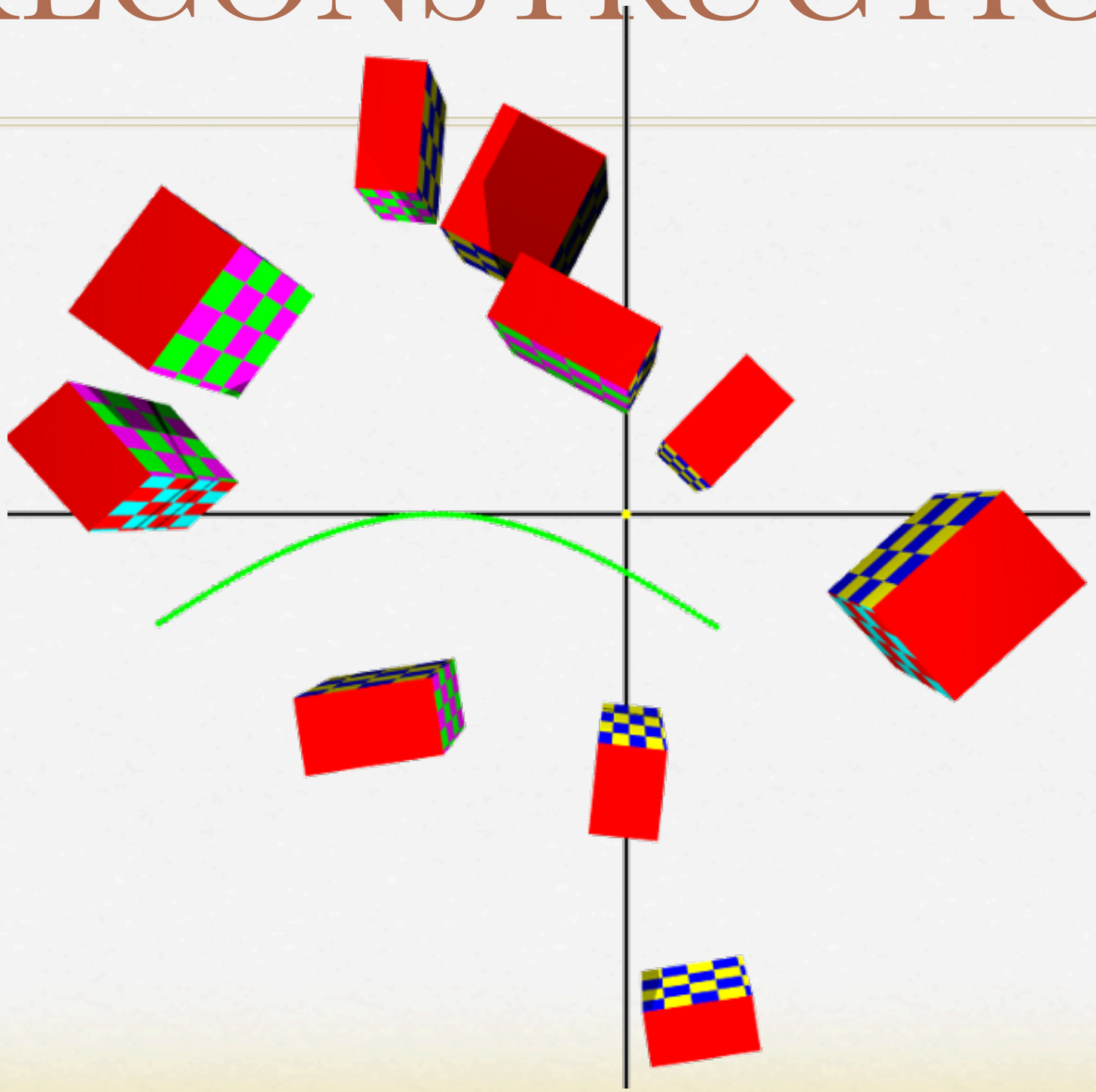
A DRUNK SPARROW

Wednesday, January 28, 2009

COMPUTER GRAPHICS



RECONSTRUCTION



Metercorp
NITRO
EMPTY
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MADE IN U.S.A.
TORQUE
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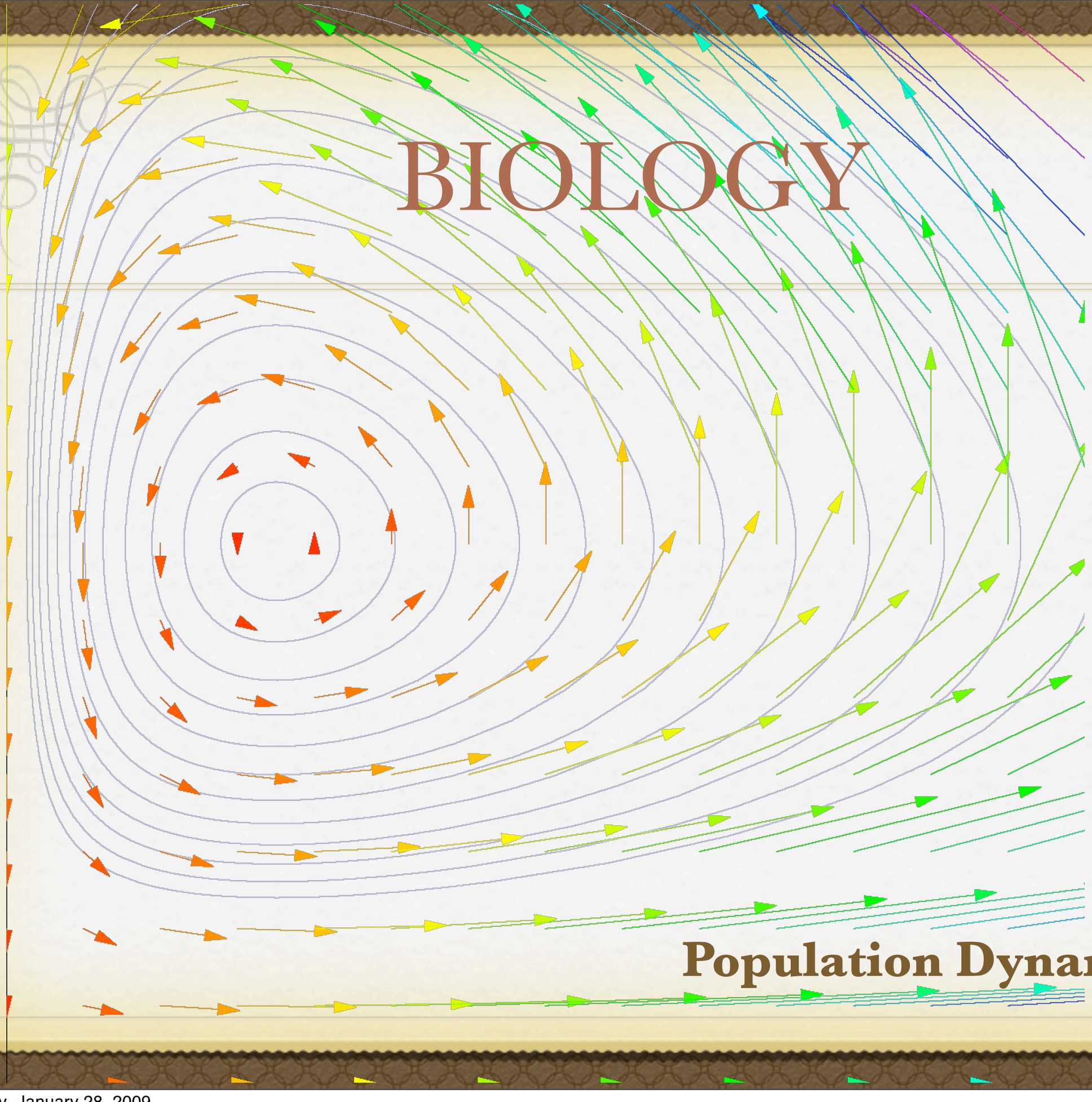
40:00

GAMES

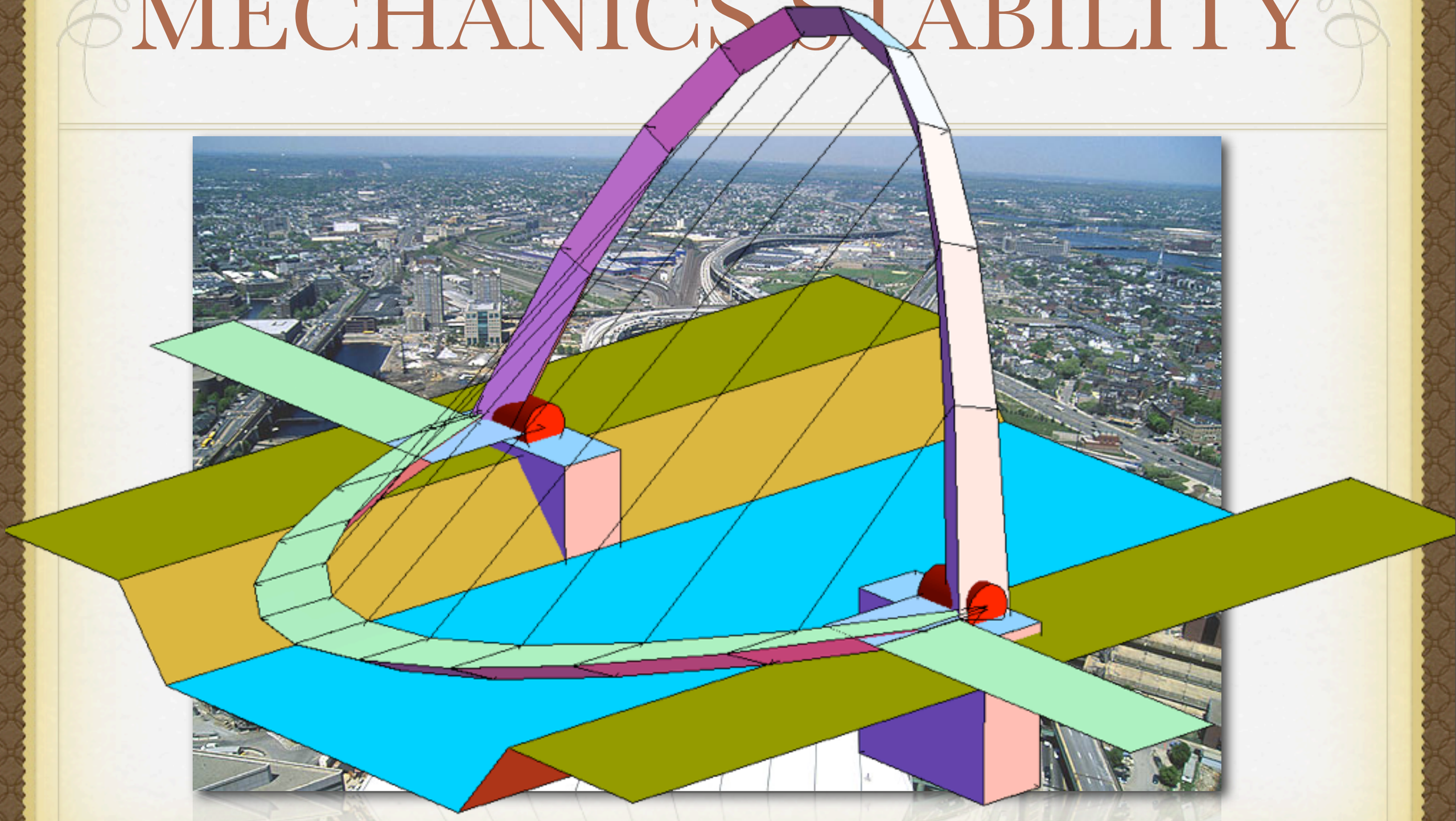
BIOLOGY



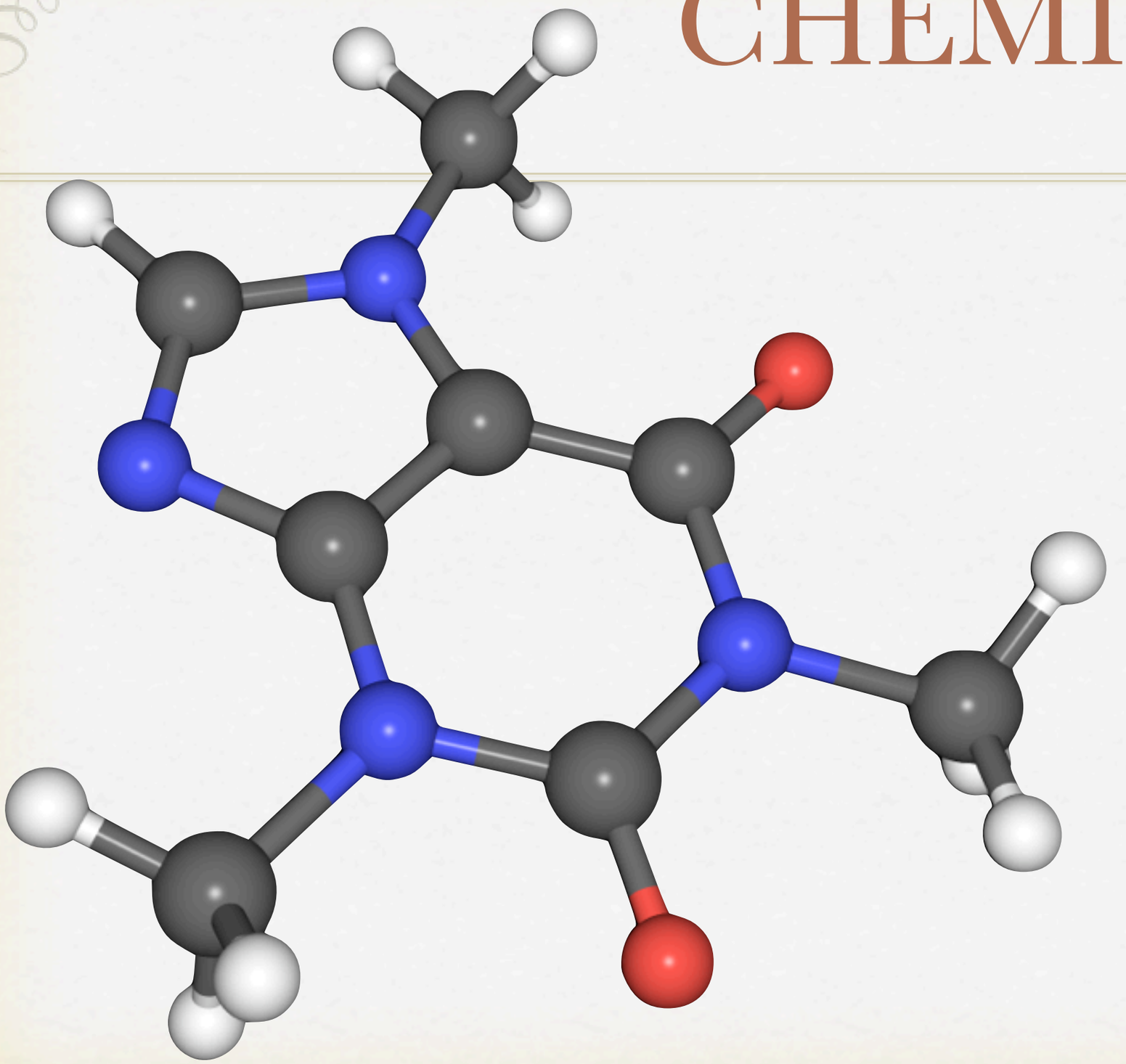
Population Dynamics

MECHANICS STABILITY

MECHANICS STABILITY

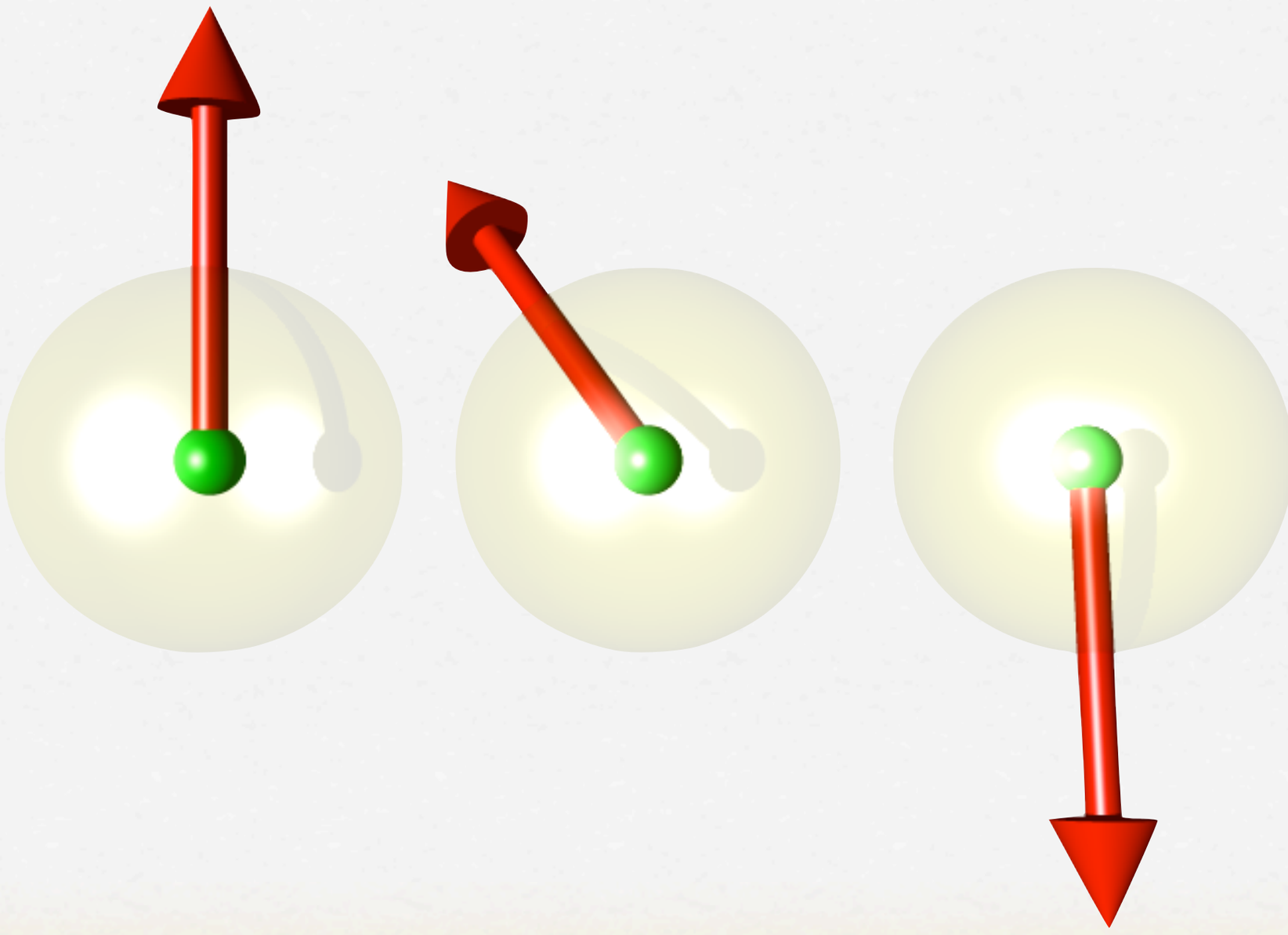


CHEMISTRY

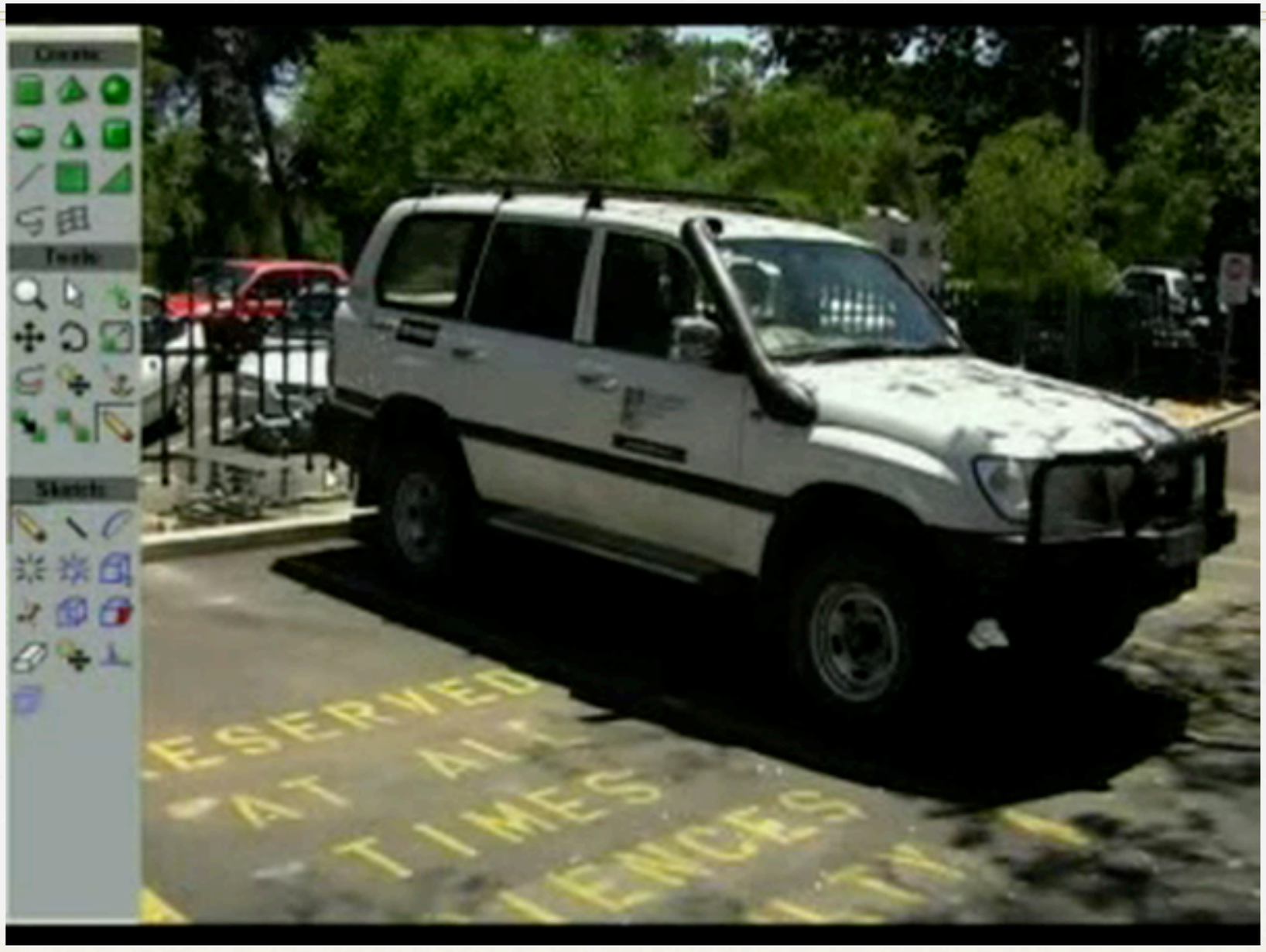


CODES NUMBER THEORY

QUANTUM COMPUTING

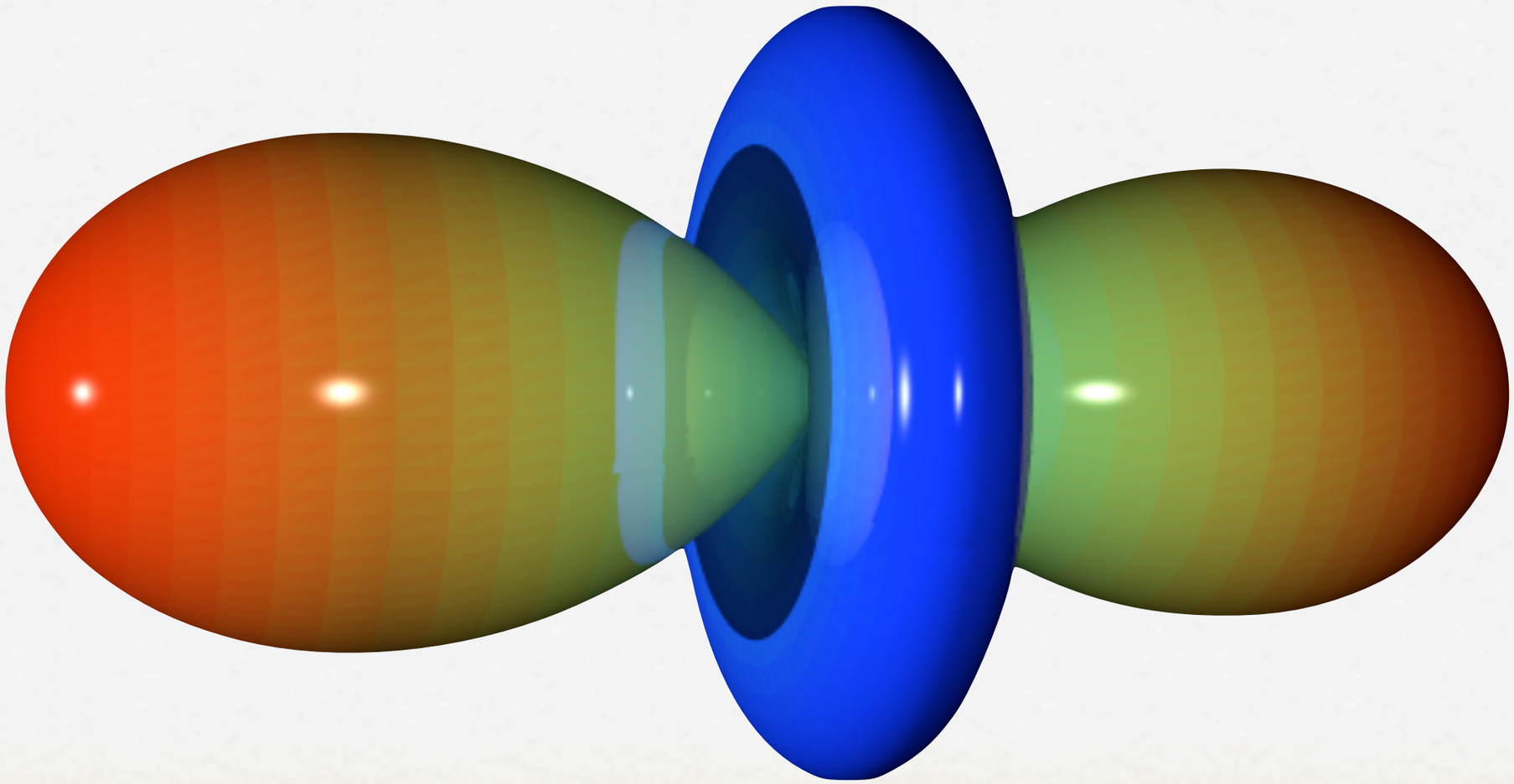


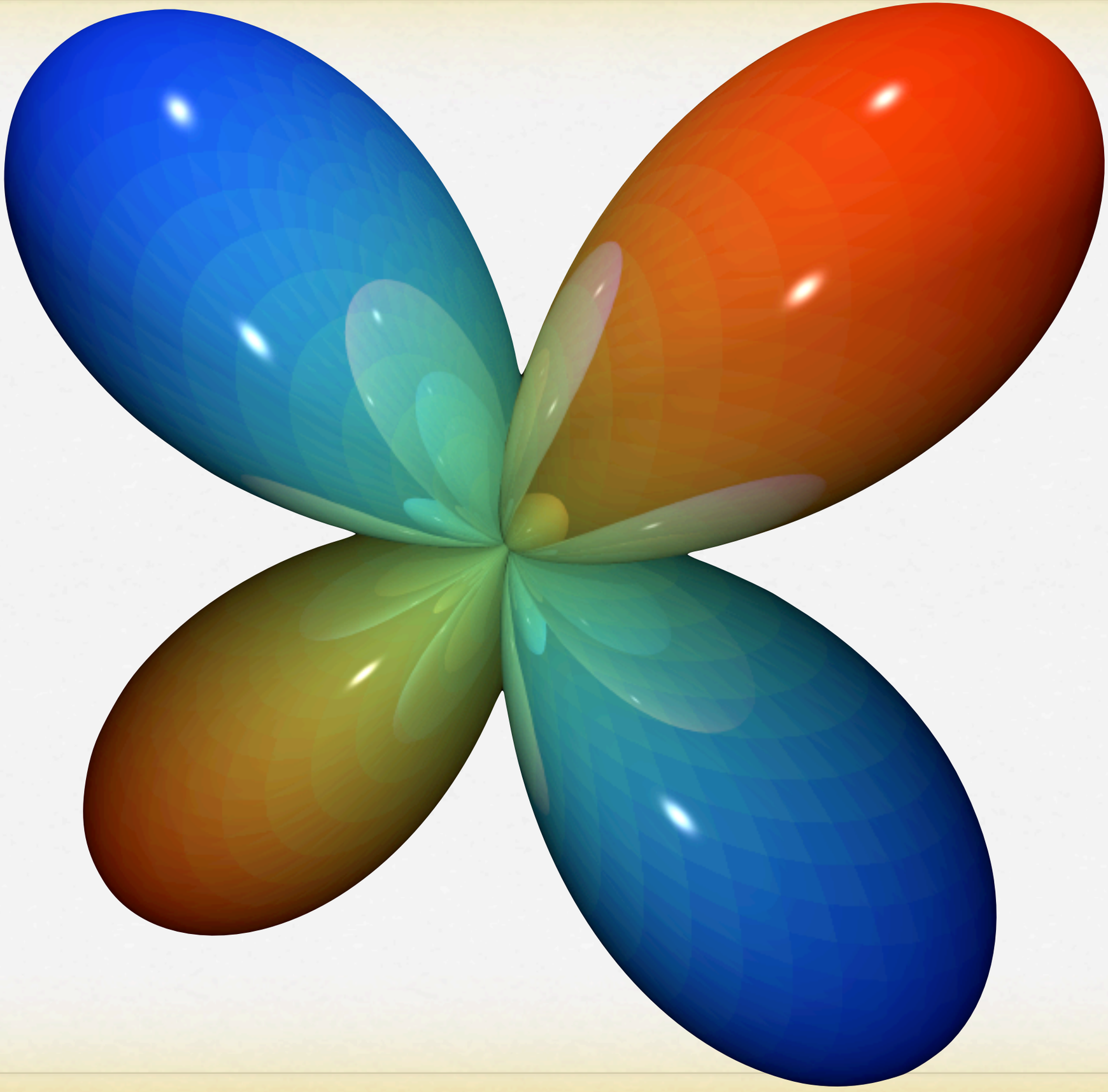
COMPUTER VISION



Australian Centre for Visual Technologies

QUANTUM MECHANICS



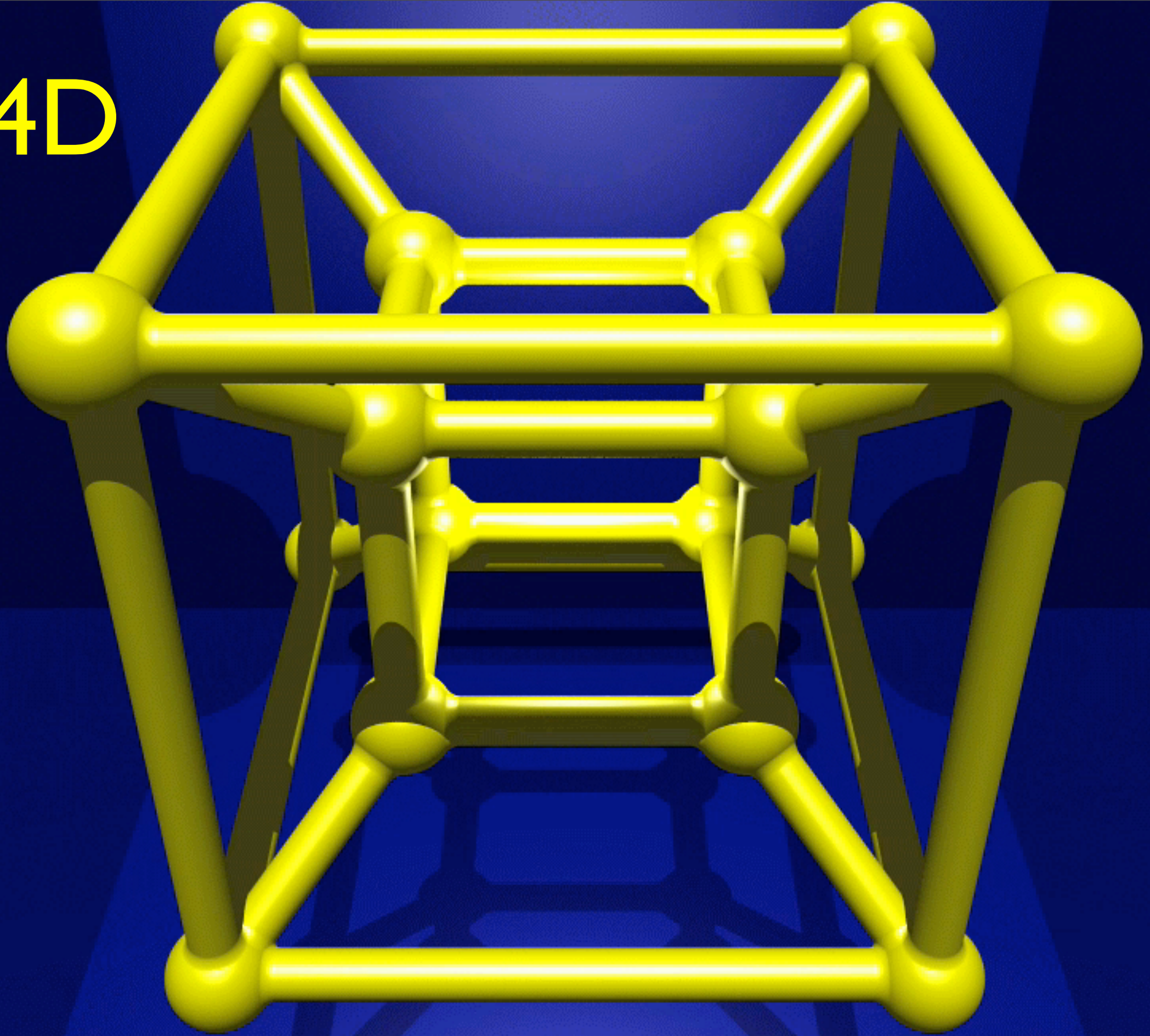


BIOLOGICAL GROWTH

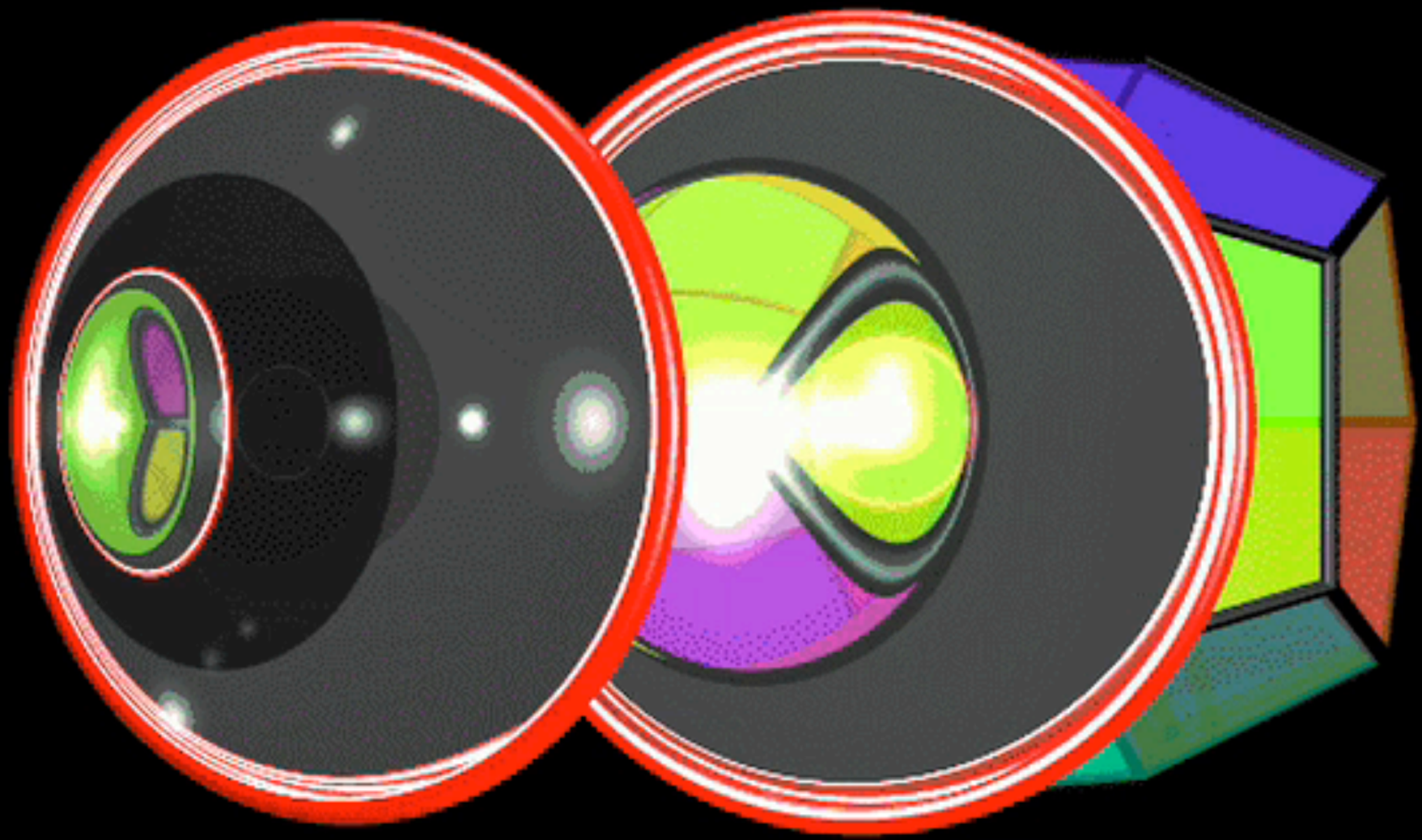
PART. DIFF. EQUATIONS

WAVE EQUATION

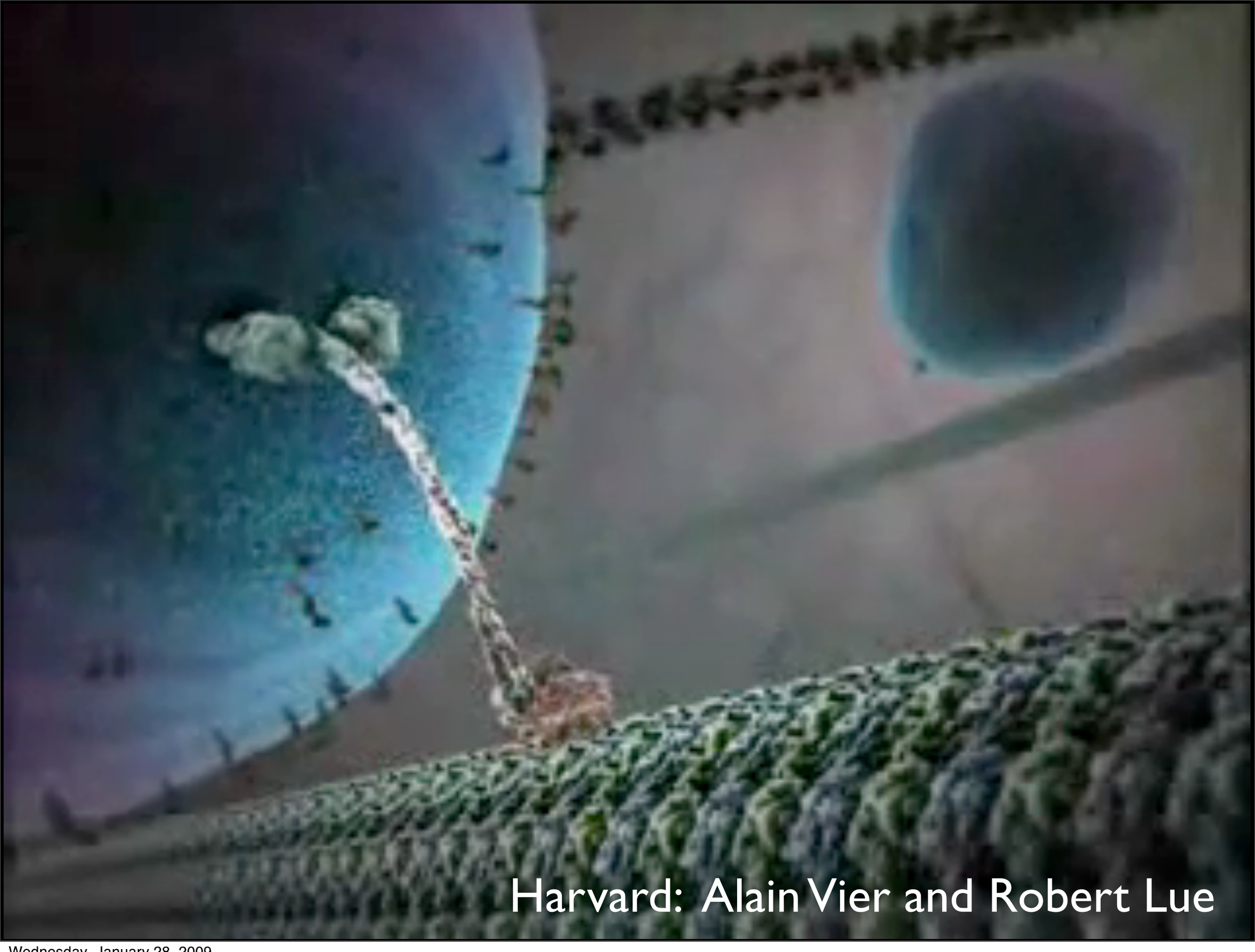
4D



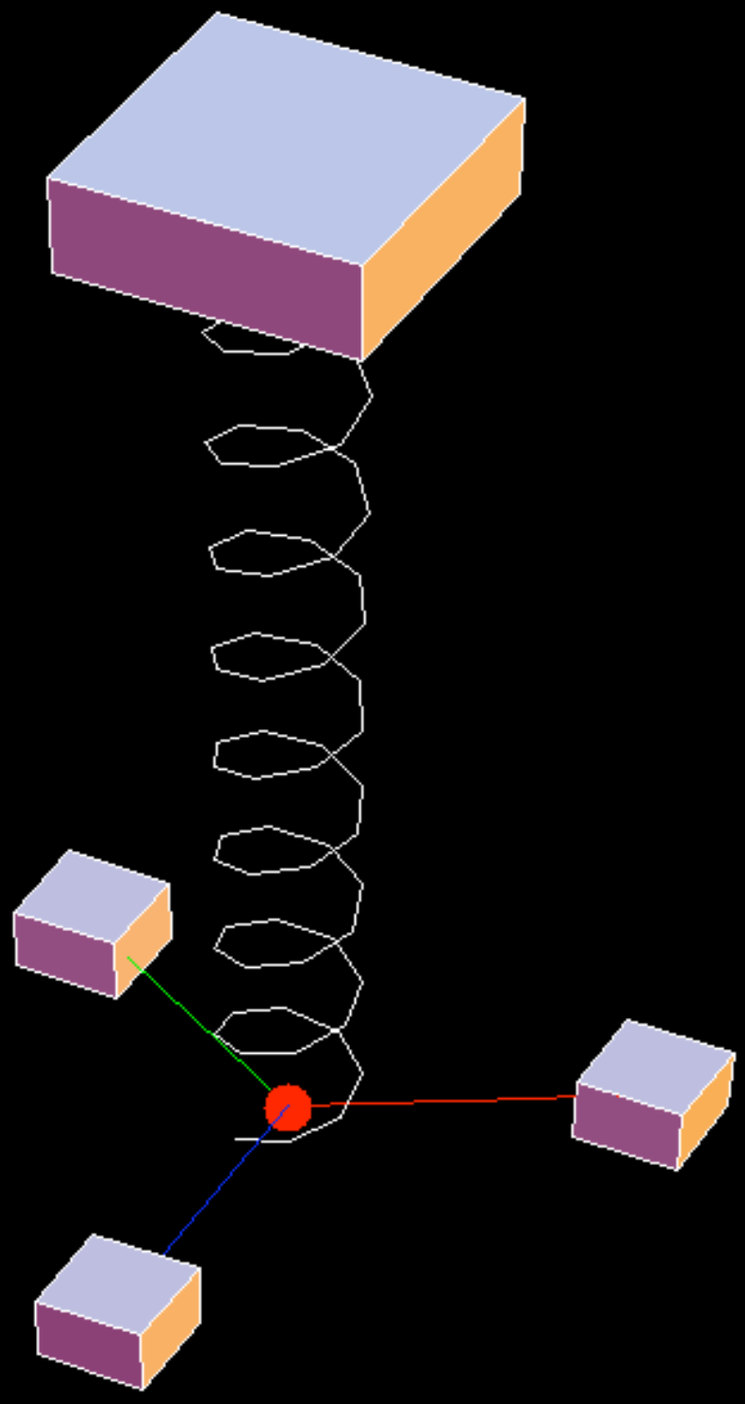
OPTICS



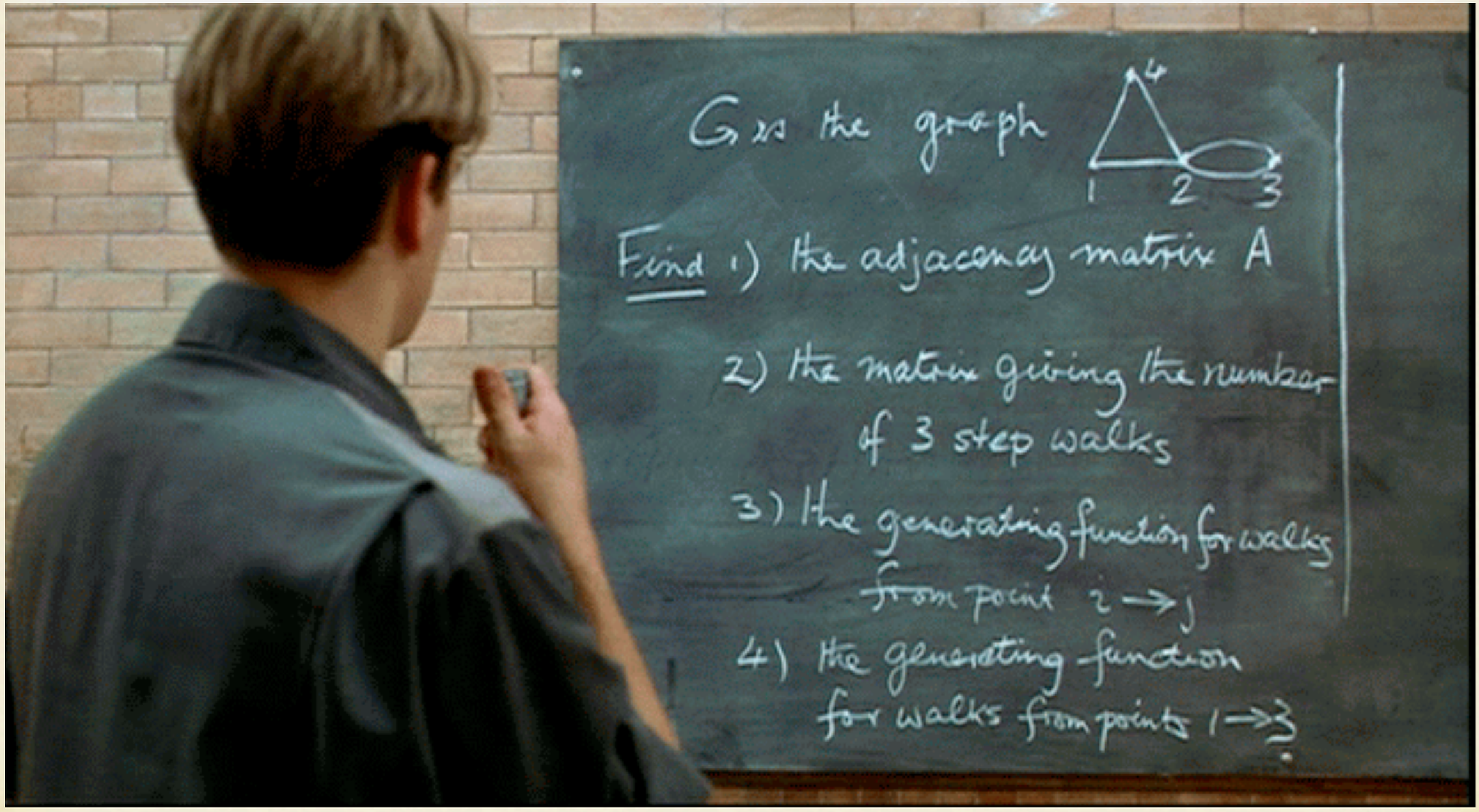
ERROR CORRECTION


Harvard: Alain Vier and Robert Lue

MECHANICAL SYSTEMS



GRAPHS

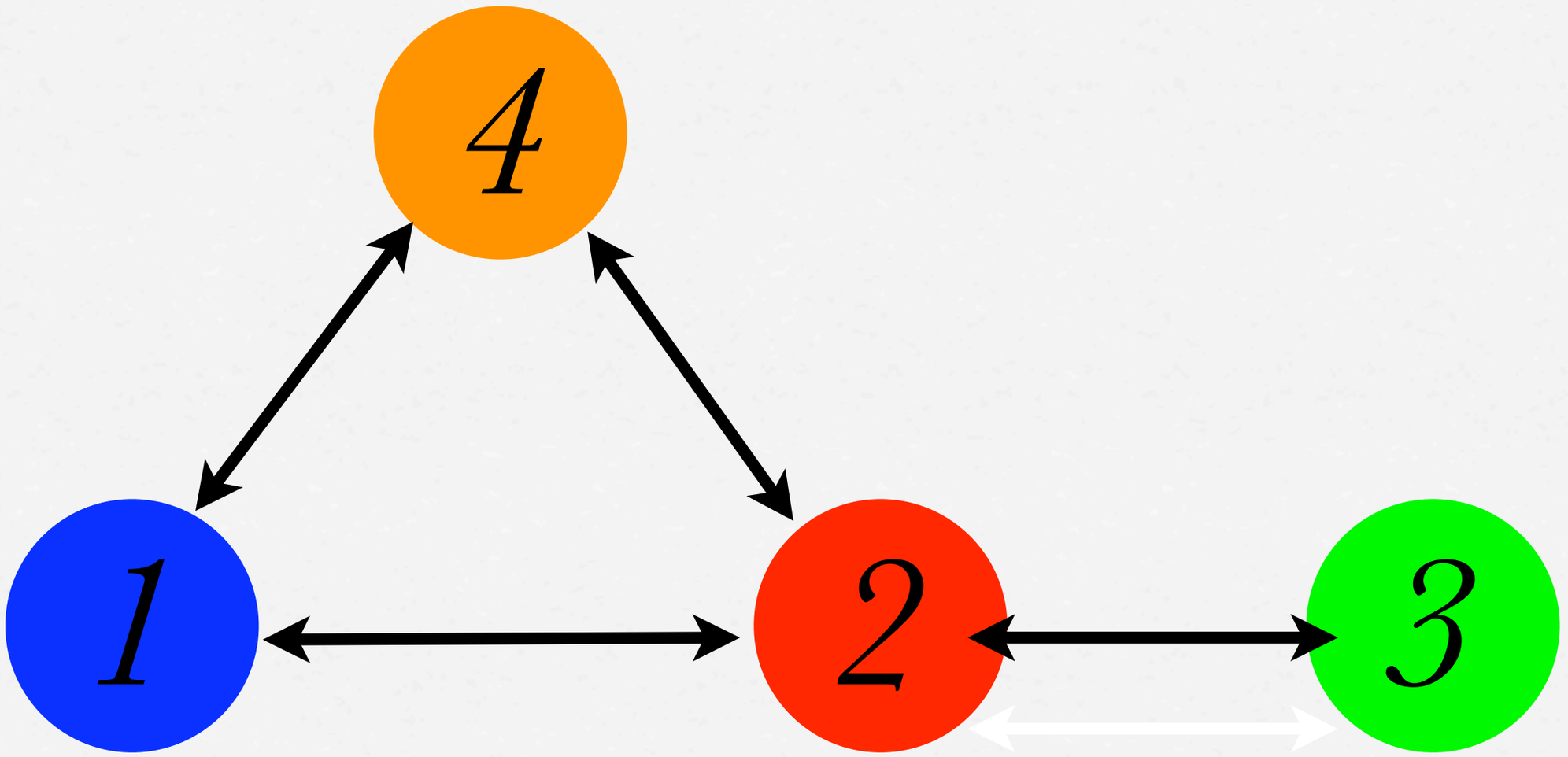

G is the graph
4
1
2
3
Find 1) the adjacency matrix A
2) the matrix giving the number of 3 step walks
3) the generating function for walks from point i → j
4) the generating function for walks from points 1 → 3

FOURIER

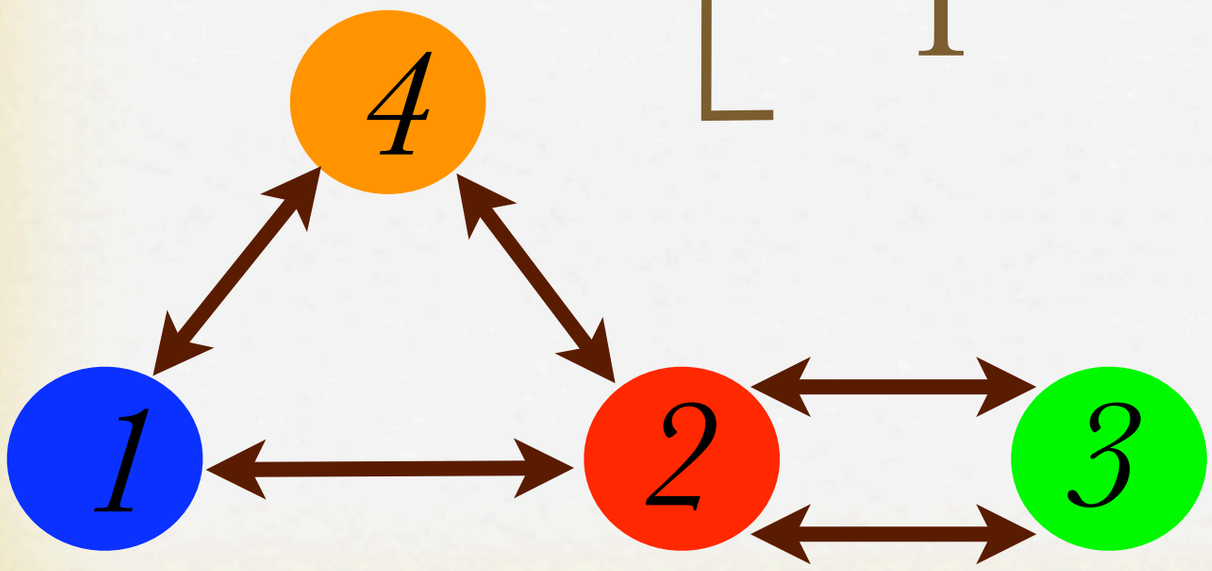
FIBBONNACCI

1,1,2,3,5,8,13,21,.....

NETWORKS



$$L = \begin{bmatrix} 0 & 1 & 0 & 1 \\ 1 & 0 & 2 & 1 \\ 0 & 2 & 0 & 0 \\ 1 & 1 & 0 & 0 \end{bmatrix}$$

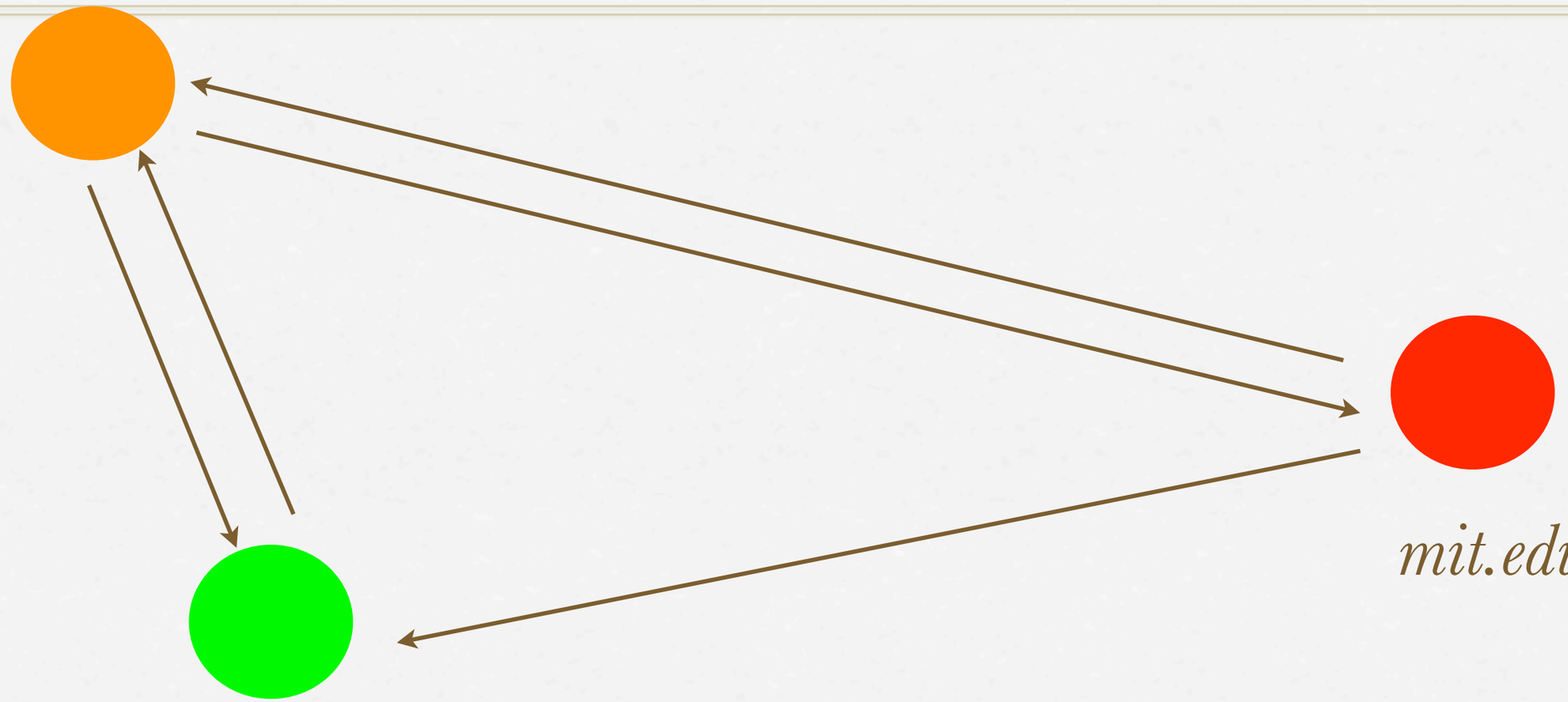


APPLICATION: PAGE RANK

Assume we know the link structure of the web . We want to know the probability that a random surfer visits a given page.

EXAMPLE

harvard.edu



mit.edu

courses.fas.harvard.edu/~math21b

LINEAR ALGEBRA

$$T = \begin{bmatrix} 0 & 1 & 1/2 \\ 1/2 & 0 & 1/2 \\ 1/2 & 0 & 0 \end{bmatrix}$$

harvard.edu

mit.edu

courses.fas.harvard.edu/~math21b

d=0.85 "damping factor

$$T = \begin{bmatrix} 0 & 1 & 1/2 \\ 1/2 & 0 & 1/2 \\ 1/2 & 0 & 0 \end{bmatrix}$$

$$(1\text{-}dT)^{-1} \begin{bmatrix} 1\text{-}d \\ 1\text{-}d \\ 1\text{-}d \end{bmatrix} = \begin{bmatrix} 4.3 \\ 4.3 \\ 2.4 \end{bmatrix}$$

ACTUAL:

www.harvard.edu	9
www.mit.edu	9
www.courses.fas.harvard.edu/~math21b	5

THIS ILLUSTRATES

- There are many applications
- Here: Markov processes from probability
- A simple idea in linear algebra can make billions

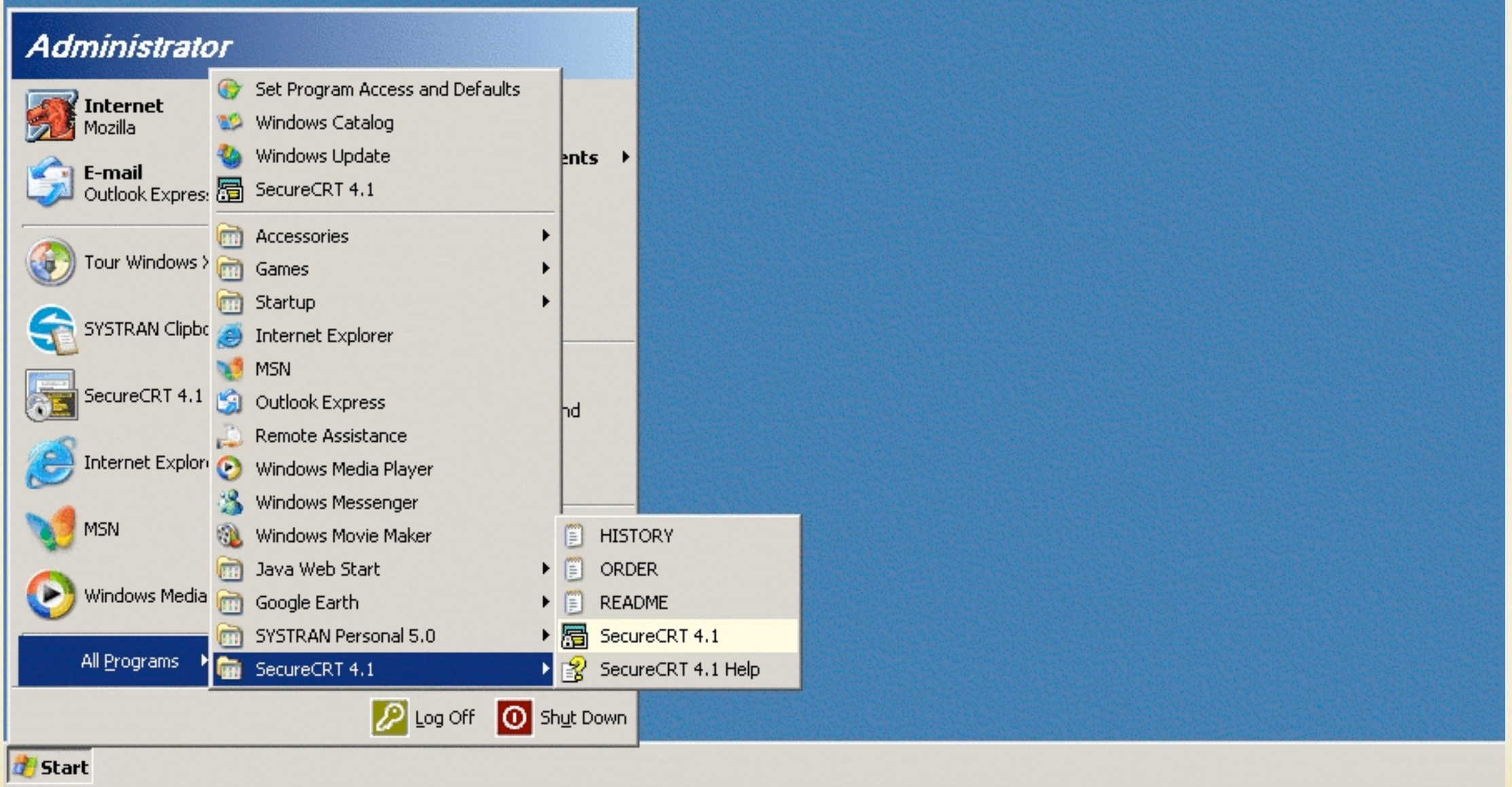
SECTIONS

- *MWF 10-11, 11-12, 12-13*
- *TTh 10:00-11:30, 11:30-13:00*

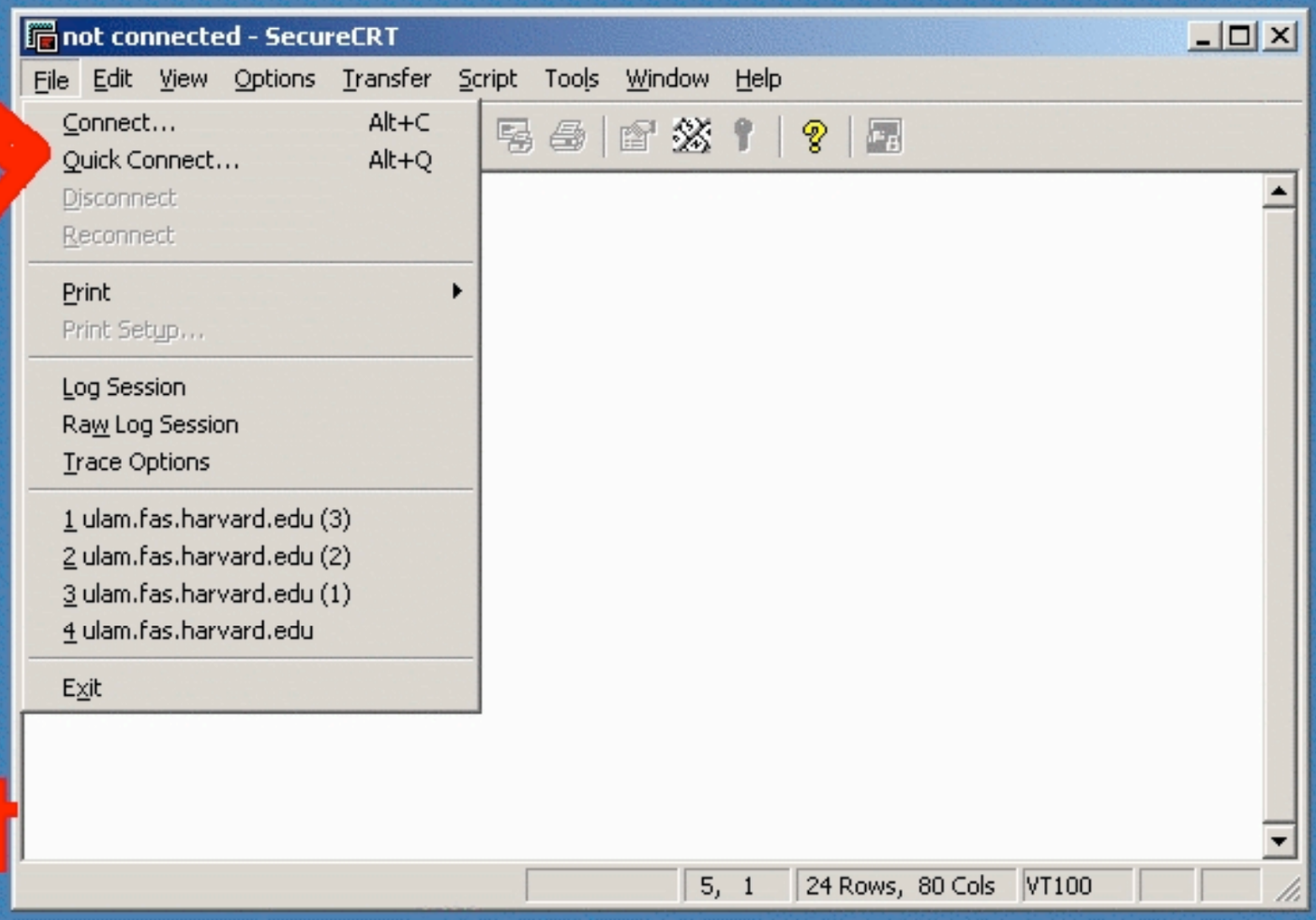
HOW TO SECTION

- ssh section@ulam.fas.harvard.edu
- enter preferences
- done in 1 minute

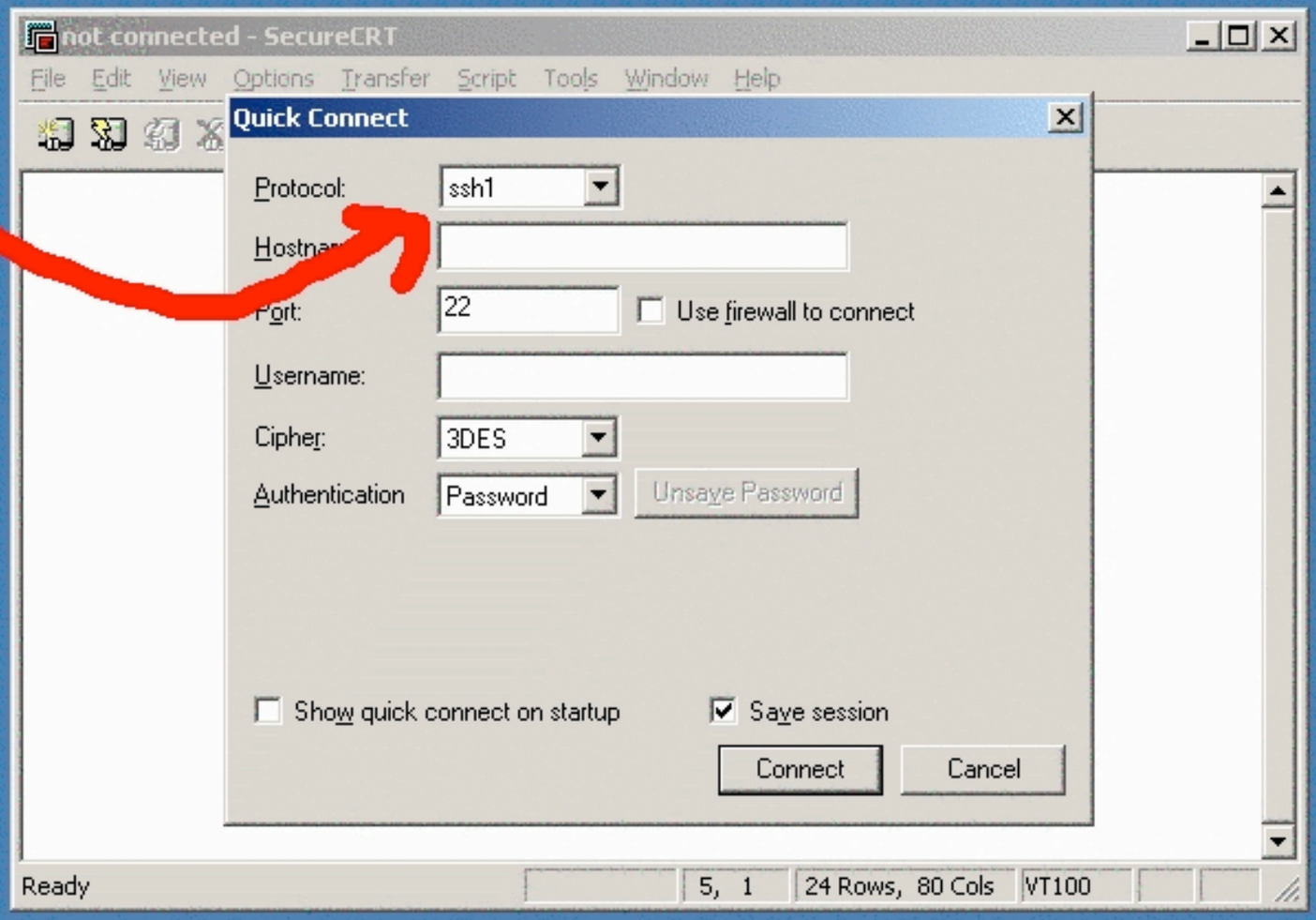
Hacker interface

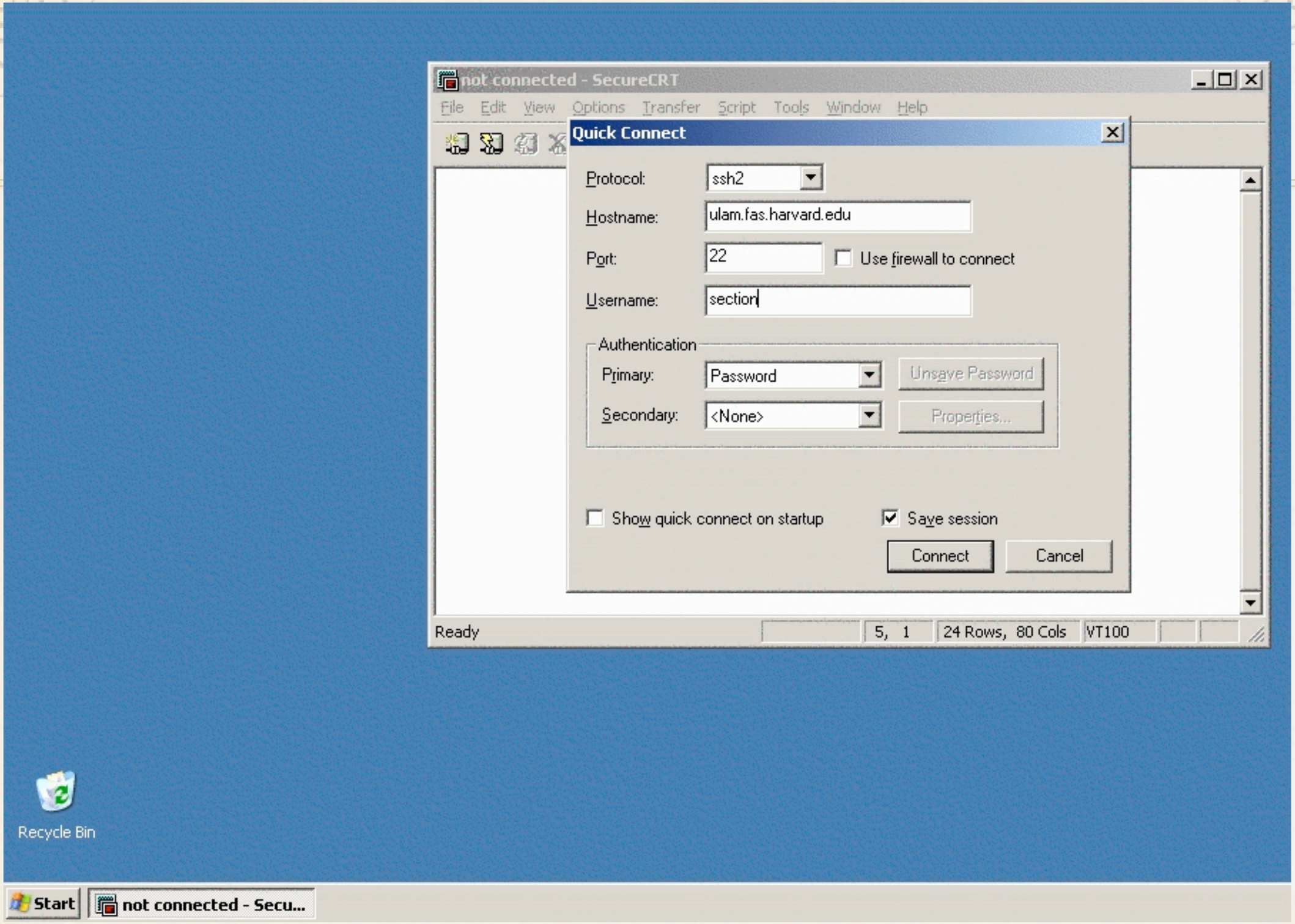

Administrator
Internet
Mozilla
E-mail
Outlook Expres
Tour Windows
SYSTRAN Clipbc
SecureCRT 4.1
Internet Explor
MSN
Windows Media
All Programs
Set Program Access and Defaults
Windows Catalog
Windows Update
SecureCRT 4.1
Accessories
Games
Startup
Internet Explorer
MSN
Outlook Express
Remote Assistance
Windows Media Player
Windows Messenger
Windows Movie Maker
Java Web Start
Google Earth
SYSTRAN Personal 5.0
SecureCRT 4.1
HISTORY
ORDER
README
SecureCRT 4.1
SecureCRT 4.1 Help
Log Off
Shut Down
Start

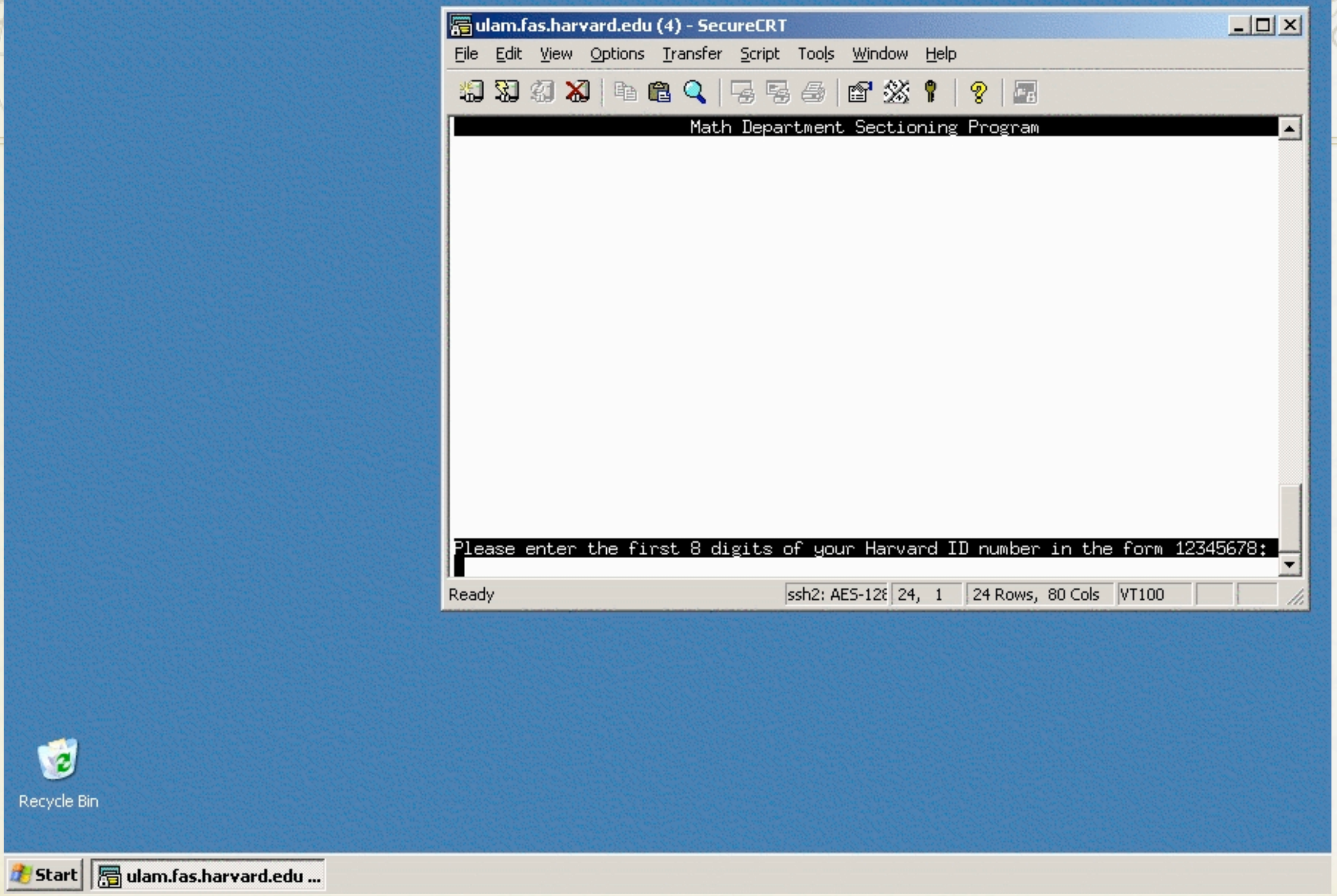
Chose Quick Connect

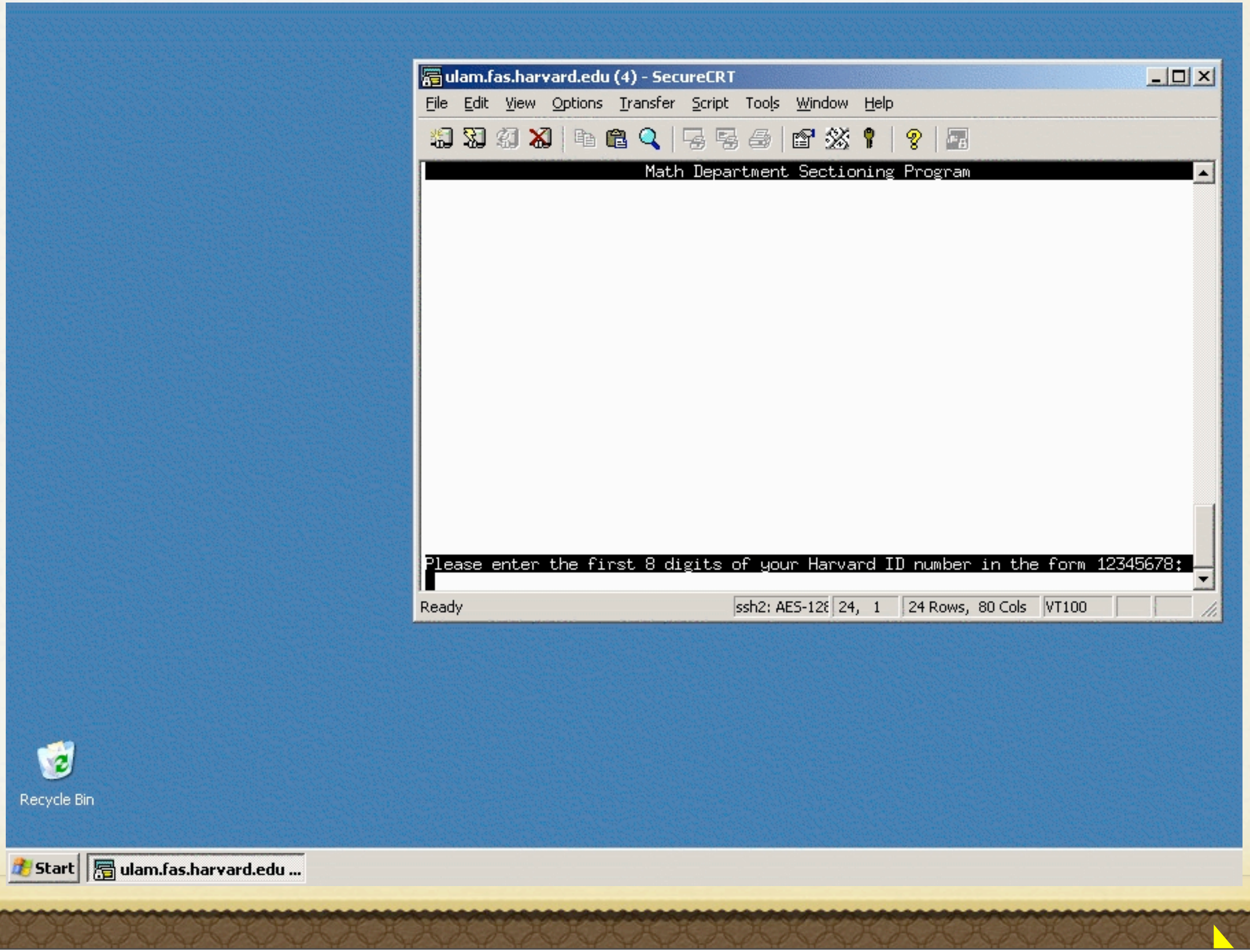


Change to ssh2




not connected - SecureCRT
File Edit View Options Transfer Script Tools Window Help
Quick Connect
Protocol: ssh2
Hostname: ulam.fas.harvard.edu
Port: 22
Use firewall to connect
Username: section
Authentication
Primary: Password
Unsave Password
Secondary: <None>
Properties...
Show quick connect on startup
Save session
Connect
Cancel
Ready
5, 1
24 Rows, 80 Cols
VT100
Recycle Bin
Start
not connected - Secu...


ulam.fas.harvard.edu (4) - SecureCRT
File Edit View Options Transfer Script Tools Window Help
Math Department Sectioning Program
Please enter the first 8 digits of your Harvard ID number in the form 12345678:
Ready
ssh2: AES-128
24, 1
24 Rows, 80 Cols
VT100
Recycle Bin
Start
ulam.fas.harvard.edu ...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Recycle Bin
Start
ulam.fas.harvard.edu ...

ulam.fas.harvard.edu (4) - SecureCRT

File Edit View Options Transfer Script Tools Window Help

Math Department Sectioning Program

Welcome to the Math Department Sectioning Program. Please confirm that the following information is correct:

```
     Last name: Milano
    Given name: Susan
 Email address: euler@math.harvard.edu
        Gender: Male
          Year: Senior
 Concentration: Applied Mathematics
         House: Freshman
```

Is the above information correct? [Y/N]

Ready ssh2: AES-128 24, 1 24 Rows, 80 Cols VT100

Recycle Bin

Start ulam.fas.harvard.edu ...

ulam.fas.harvard.edu (4) - SecureCRT

File Edit View Options Transfer Script Tools Window Help

Math Department Sectioning Program

Select a Course

Math1a
Math1b
math21a
math21b
mathxa

Esc Back Enter Select Prev Next Space NextPage - PrevPage / Search

Ready | ssh2: AES-128 | 4, 78 | 24 Rows, 80 Cols | VT100

Recycle Bin

Start | ulam.fas.harvard.edu ...

ulam.fas.harvard.edu (4) - SecureCRT

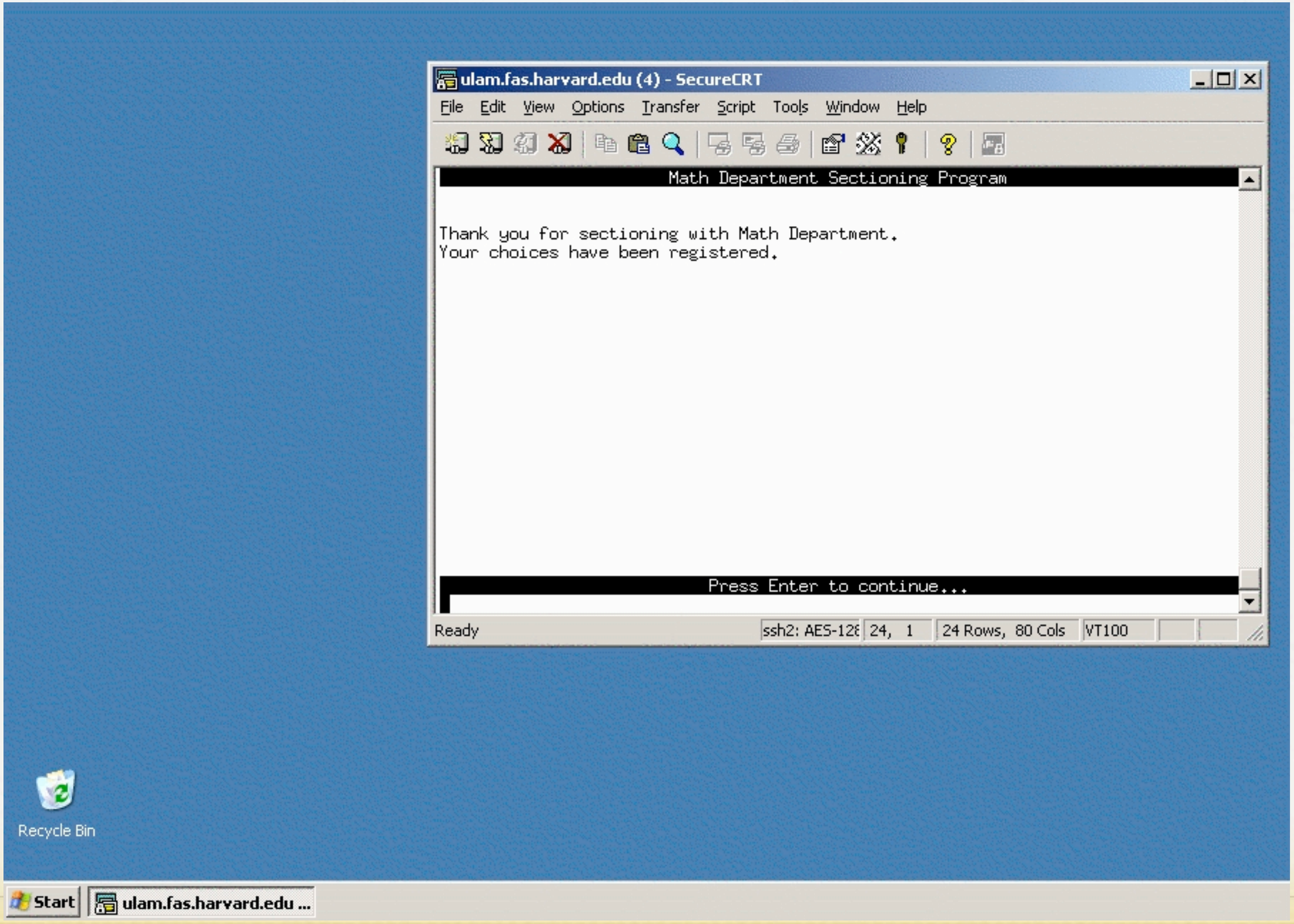
File Edit View Options Transfer Script Tools Window Help

```
                    Math Department Sectioning Program
Please select your section choices in order of preference.  Type D when done.

 0: MWF 9-10    w/sufficient enrollment    [1 section]
 1: MWF 10-11                              [1 section]
 2: MWF 10-11   BioChem                    [1 section]
 3: MWF 10-11   Physics                    [1 section]
 4: MWF 11-12                              [1 section]
 5: MWF 11-12   PieChem                    [1 section]
 6: MWF 12-1                               [1 section]
 7: TTh 10-11:                             [1 section]
 8: TTh 11:30-                             [1 section]

Done  Enter De/Select  Prev  Next  PageUp  Space PageDown  / Search
```

Ready | ssh2: AES-128 | 4, 77 | 24 Rows, 80 Cols | VT100

Recycle Bin

Start | ulam.fas.harvard.edu ...


ulam.fas.harvard.edu (4) - SecureCRT
File Edit View Options Transfer Script Tools Window Help
Math Department Sectioning Program
Thank you for sectioning with Math Department.
Your choices have been registered.
Press Enter to continue...
Ready
ssh2: AES-128
24, 1
24 Rows, 80 Cols
VT100
Recycle Bin
Start
ulam.fas.harvard.edu ...

19B/21B/A21B?

19B/21B/A21B?

- 19b with statistics
- 21b with differential equations
- App21b more engineering

21B/APPLIED 21B

DO WE NEED 21A?

- No, but it can be helpful
- We will use partial differentiation
- Knowing about projections can help?

UNTIL NEXT WEEK

- Come with an open mind
- Look over the book
- Later in the course, we need complex numbers.

THAT'S IT!

THE END

Don’t forget to Section!