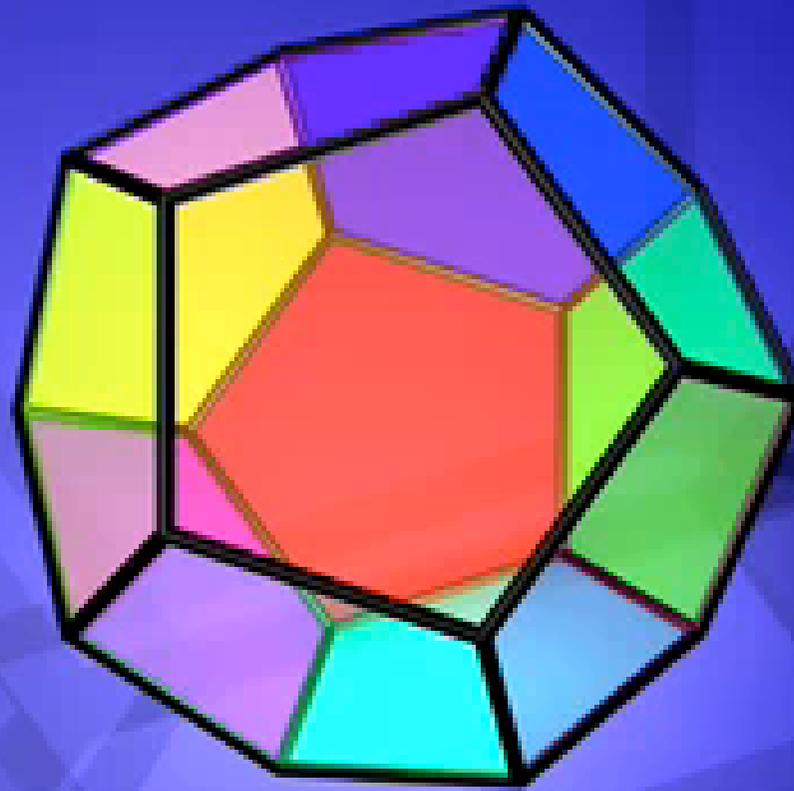


Math21b
Linear Algebra and
Differential Equations
Spring 2007

Course head: Oliver Knill



Math21b, Spring 2007

~math21b

MATH
21B

NEW

SYLLABUS

CALENDAR

SECTION

HOMEWORK

EXAM

EXHIBIT

HANDOUT

LAB

FAQ

LINKS

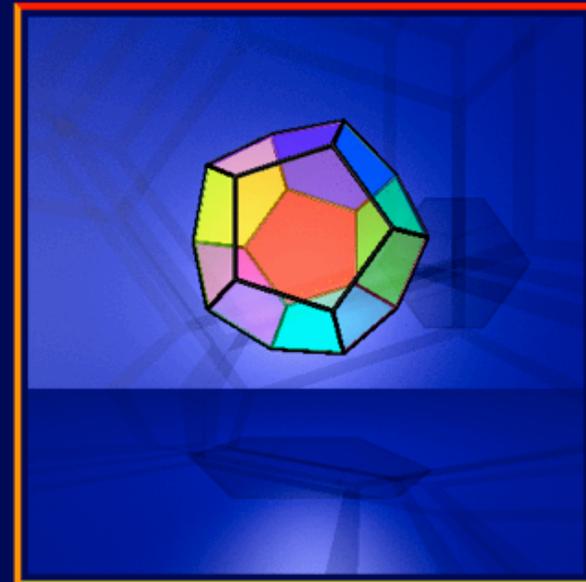
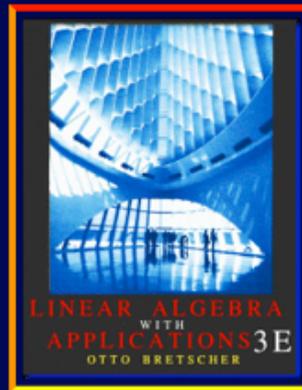
Mathematics Math21b Spring 2007
Linear Algebra and Differential Equations
NEWS

Course Head: [Oliver Knill](#)

Office: SciCtr 434

Email: knill@math.harvard.edu

- There is a introduction meeting on Wednesday, January 31 at 8:30 AM in Science Center D
- For information on how to section for this course, start [here](#). The sectioning process starts on Monday.
- Lectures start the week after, on Monday, February 5'th
- We will use the 3rd edition of Otto Bretschers Book as in previous semesters. You do not necessarily need the solution book which gives you solutions for the odd numbered problems.



Please send questions and comments to math21b@fas.harvard.edu

Math21b | [Oliver Knill](#) | Spring 2007 | [Department of Mathematics](#) | [Faculty of Art and Sciences](#) | [Harvard University](#)

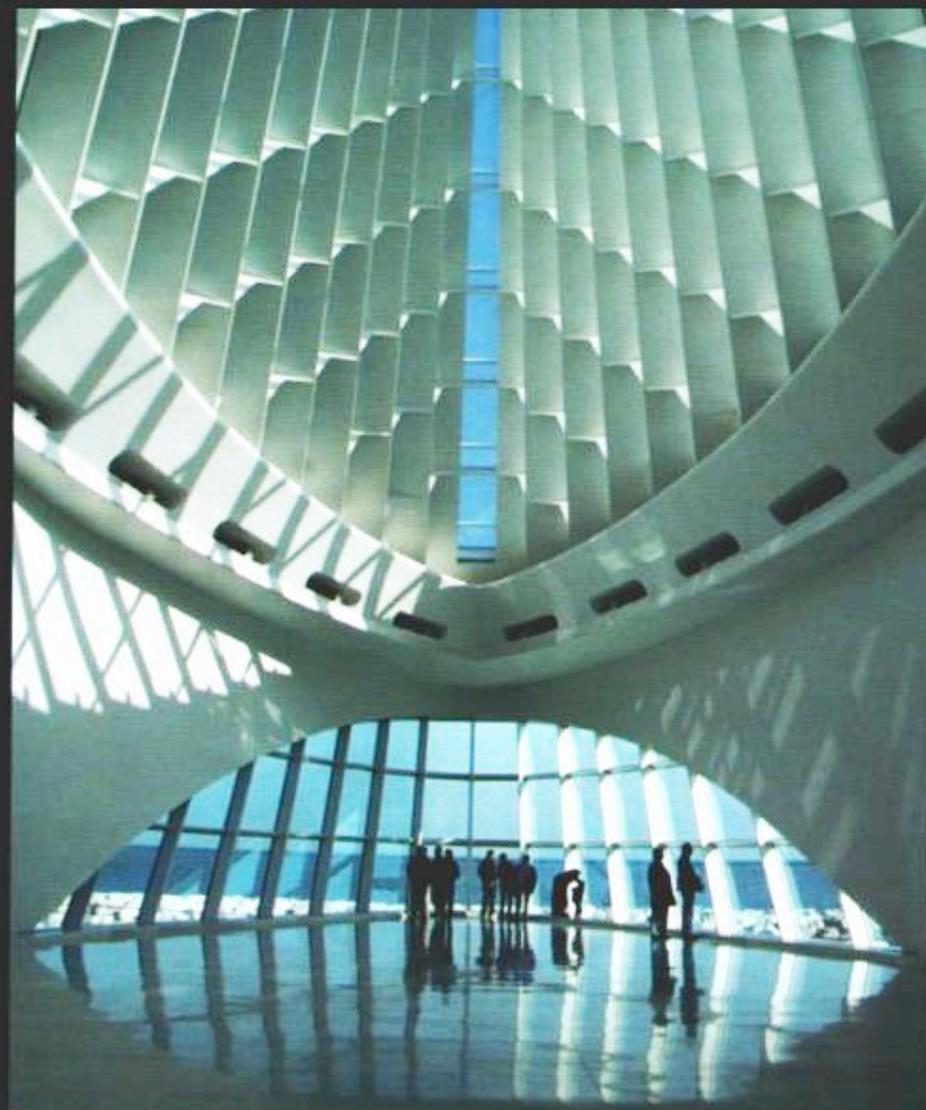
Textbook



by Otto Bretscher

3rd Edition!

Solution manual
optional



LINEAR ALGEBRA
WITH
APPLICATIONS 3E
OTTO BRETSCHER

Rheinfall



Oliver



Uhwiesen

Otto



Andelfingen



Exams



1. Midterm: March 7, 7-8:30 PM, Hall C



2. Midterm: April 10, 7-8:30 PM, Hall C



Final Exam, will be arranged by registrar

Homework



Due every lecture



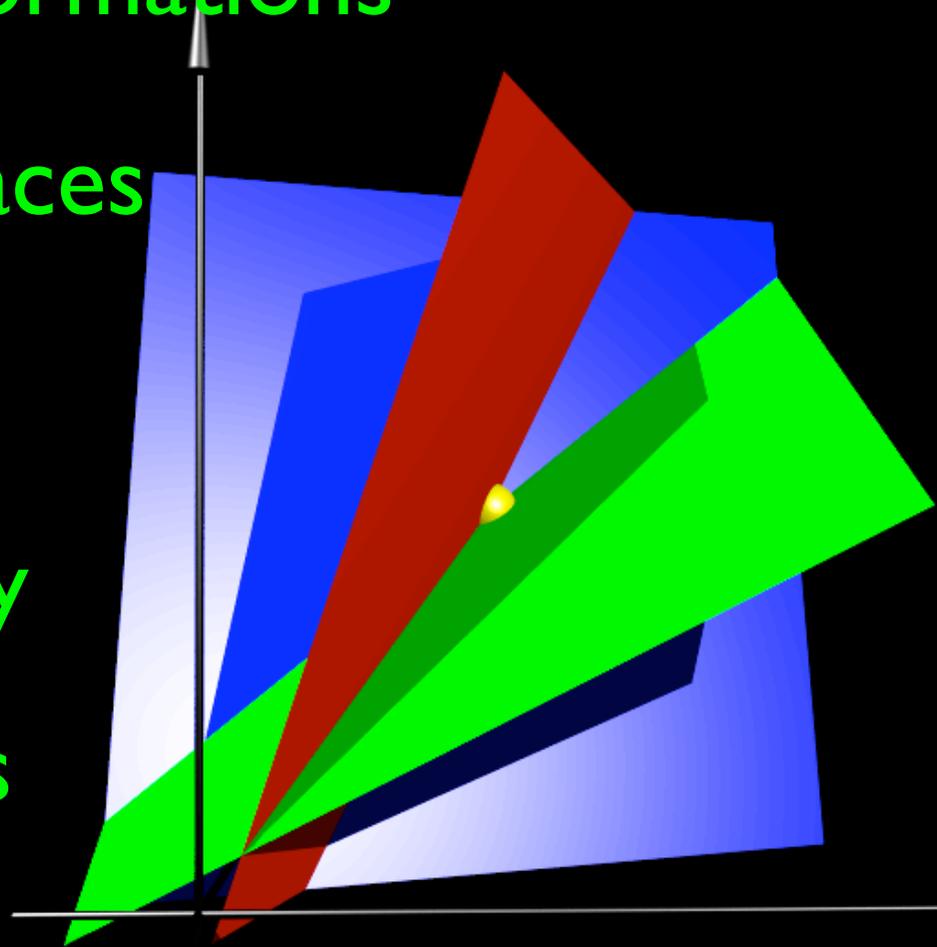
No extensions



3 Homework jokers

Topics

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









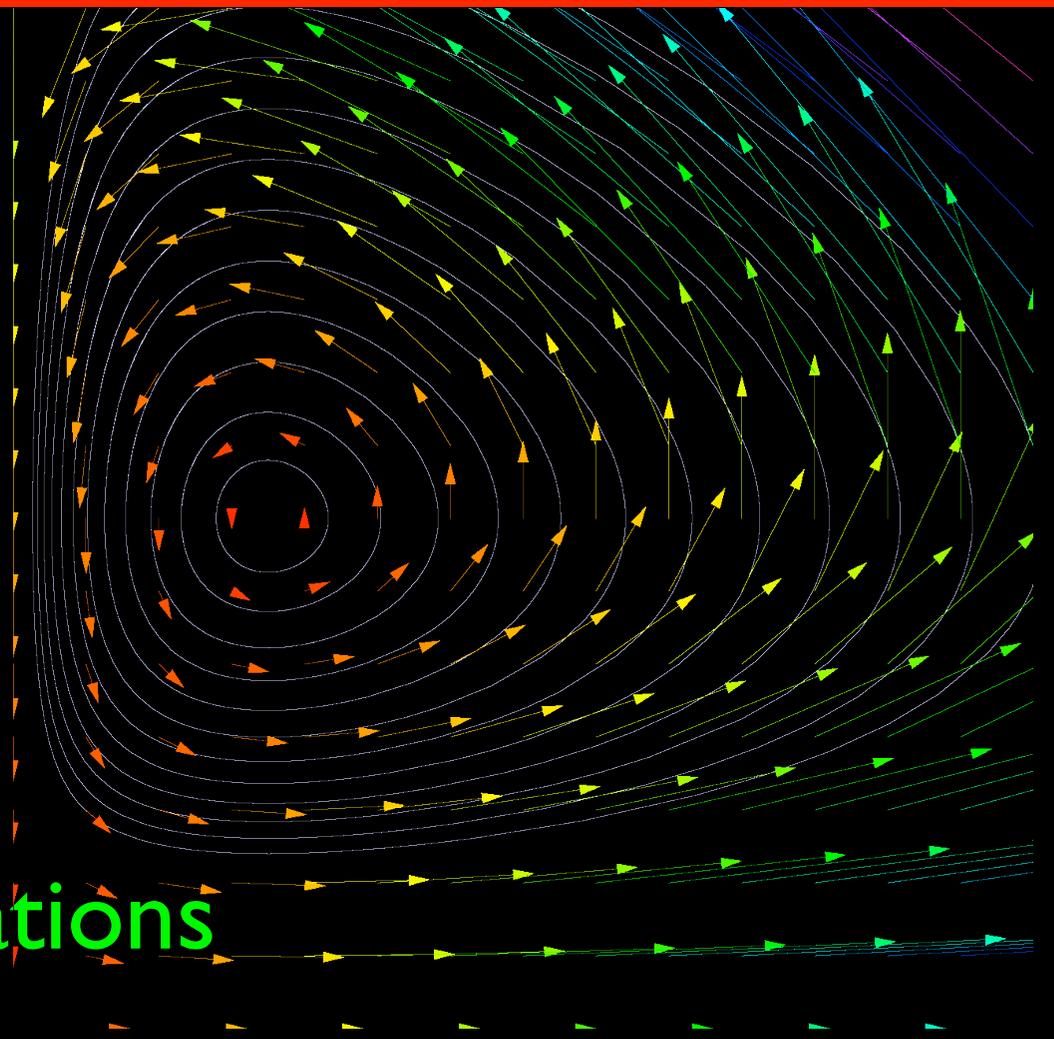






Topics

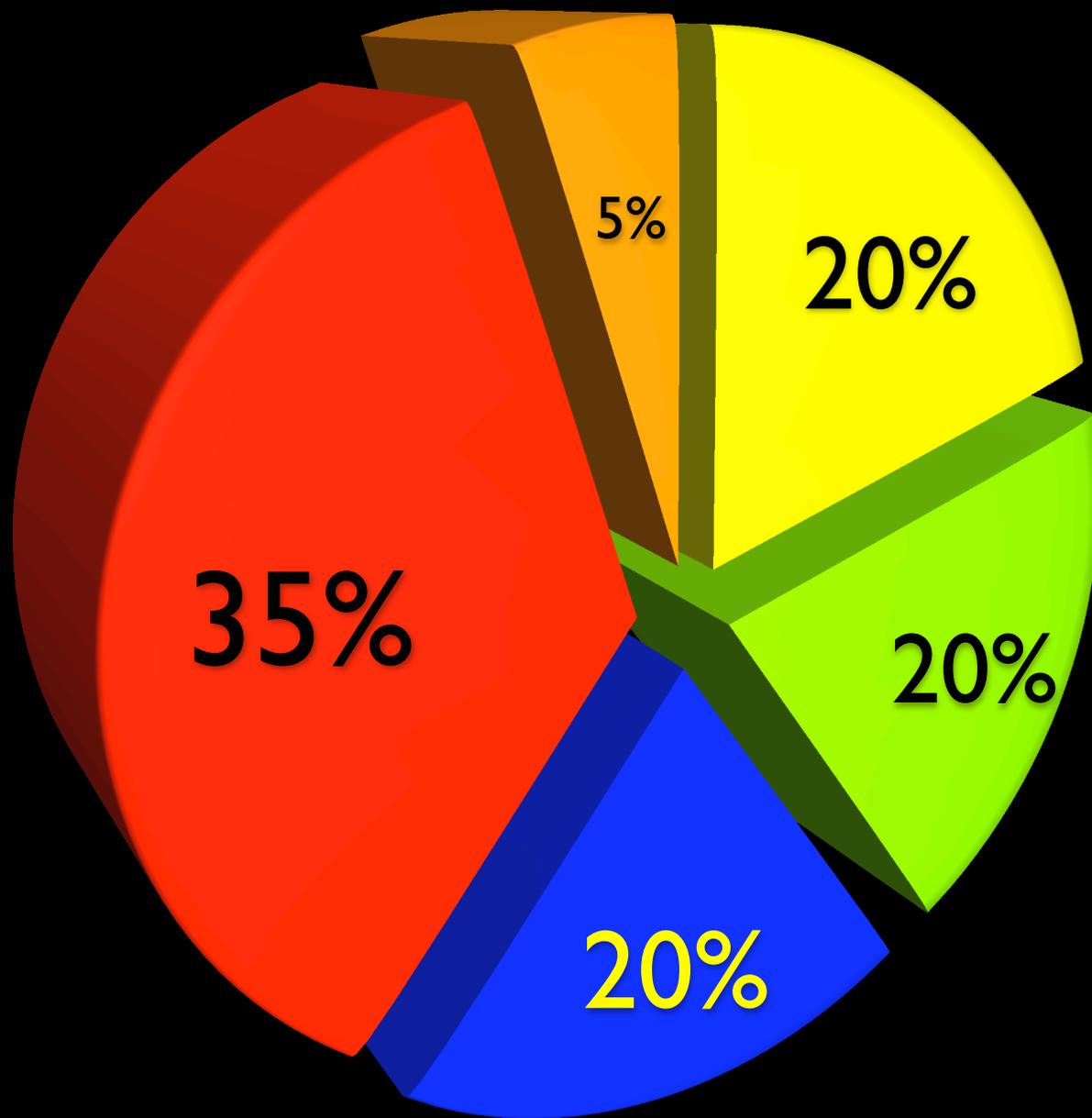
- ★ Eigensystems
- ★ Diagonalization
- ★ Stability
- ★ Differential equations
- ★ Fourier theory
- ★ Partial differential equations



- 1. Midterm
- 2. Midterm
- Homework
- Final
- Lab

Grade I

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



● I.Midterm

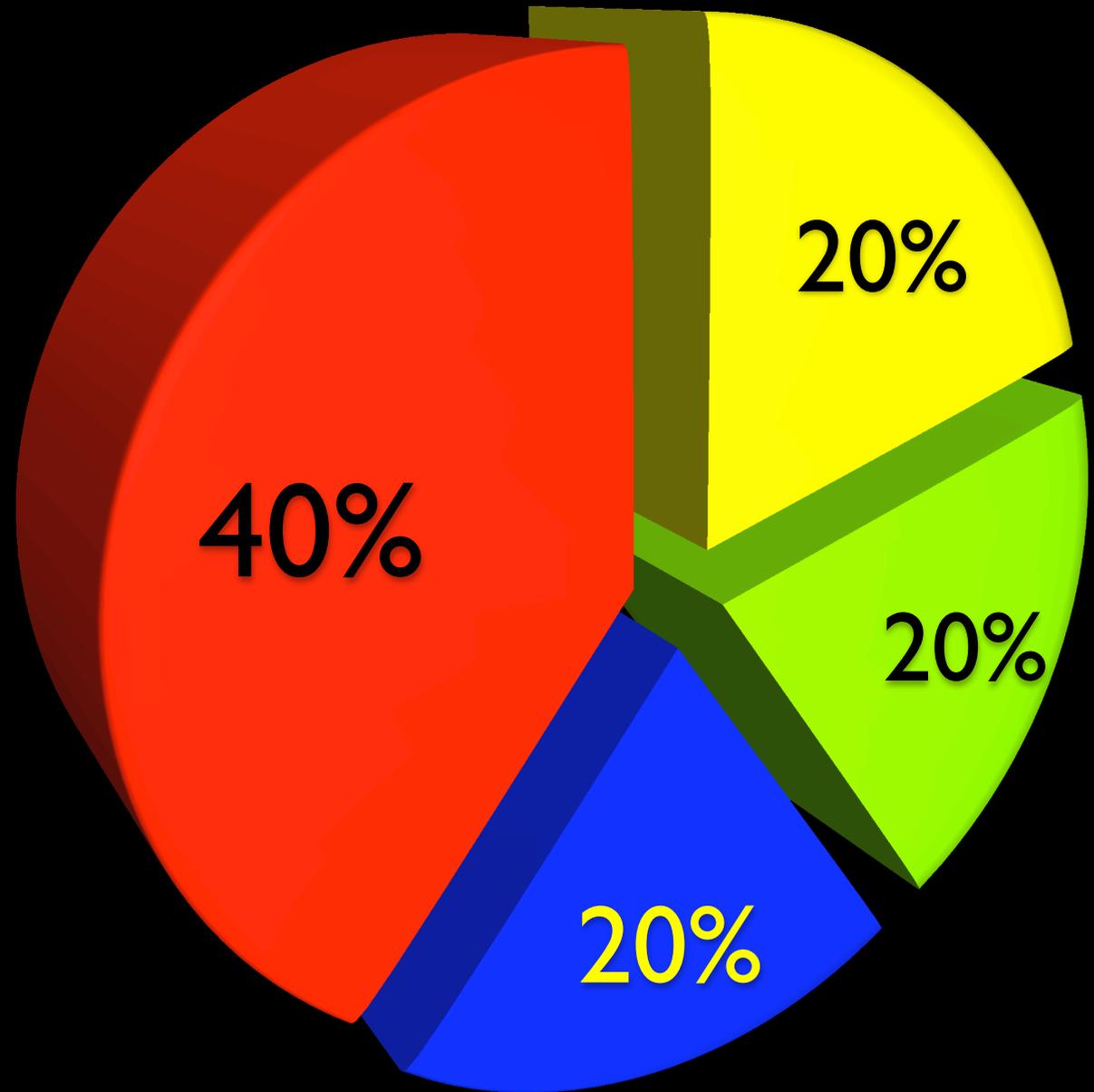
● 2. Midterm

● Homework

● Final

Grade II

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



$$\text{Grade} = \max(\text{Grade I}, \text{Grade II})$$

Lab



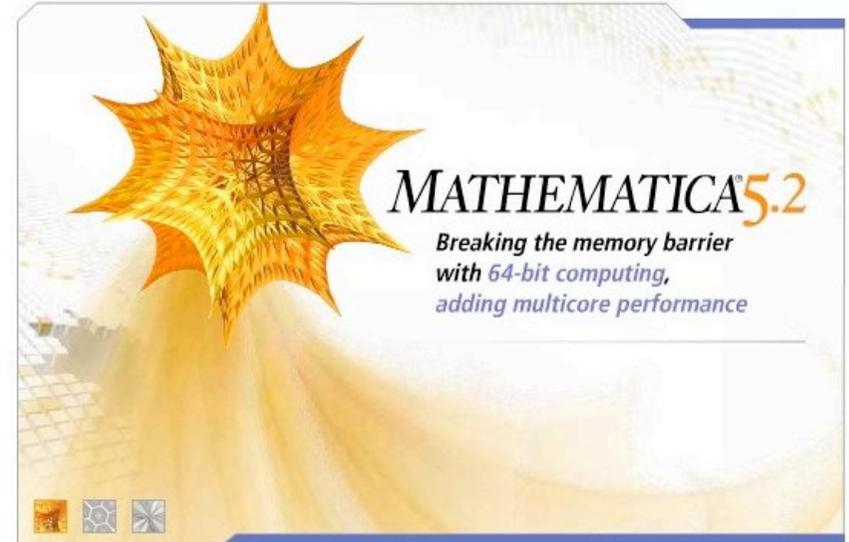
can be done in
the time of doing
a HW.



only can improve
your final grade



should be fun



LATEST NEWS | [Wolfram Workbench introduces the state of the art for technical development >>](#)



NEW
*Free Online
Mathematica Seminar*
Register now >>



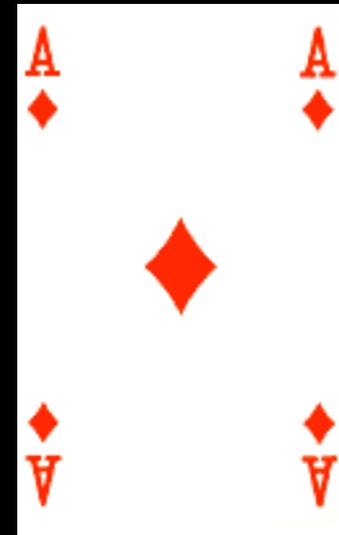
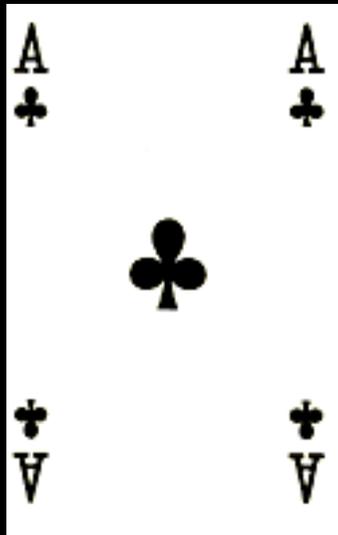
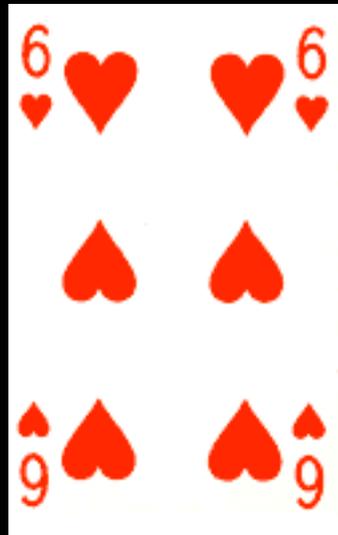
*Are you on a
Mathematica campus?*
Getting *Mathematica*
is easier than you think.

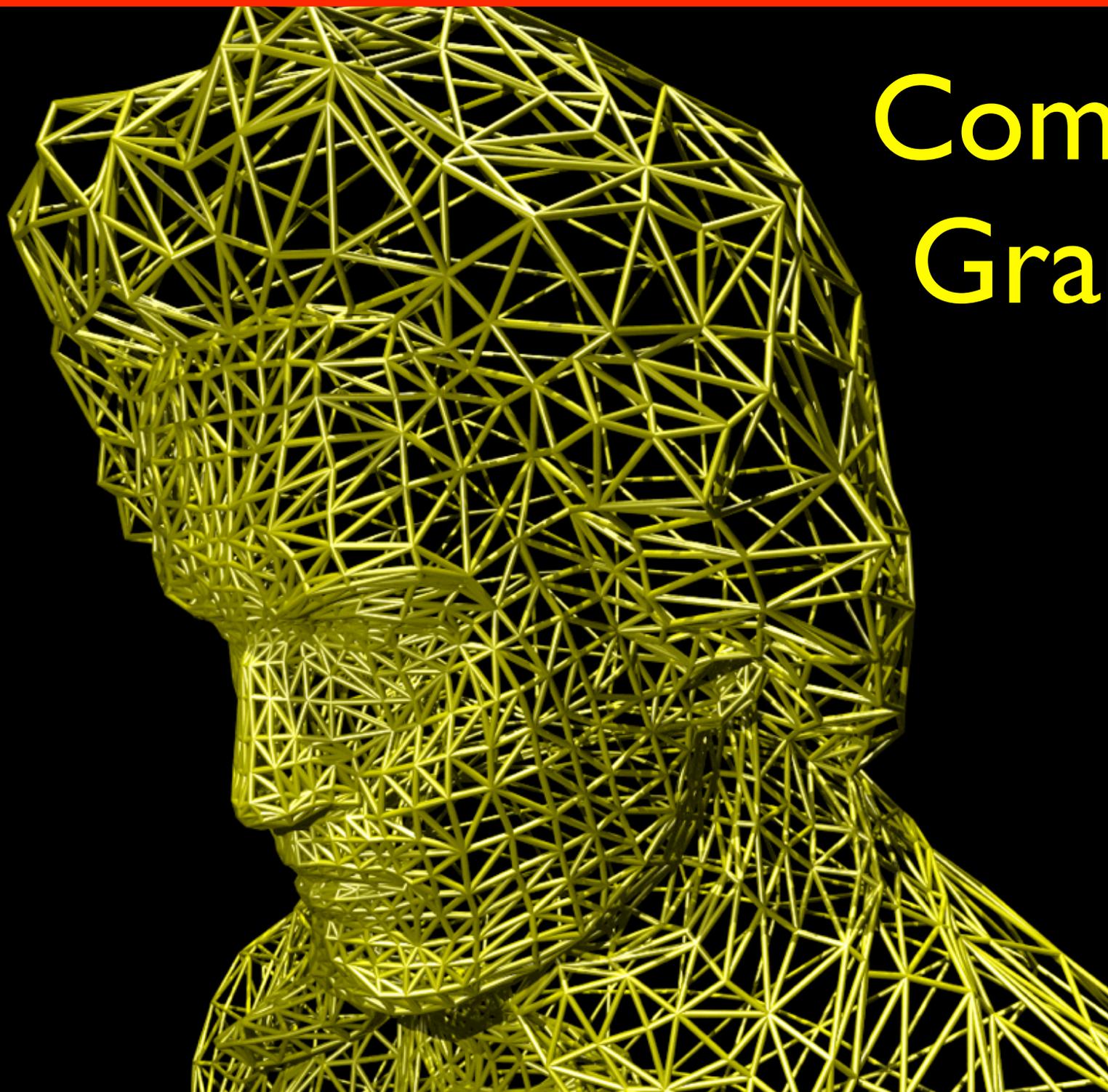


NEW
*Wolfram Workbench
High-Throughput
Software Development*

Where is linear algebra
used?

Probability theory





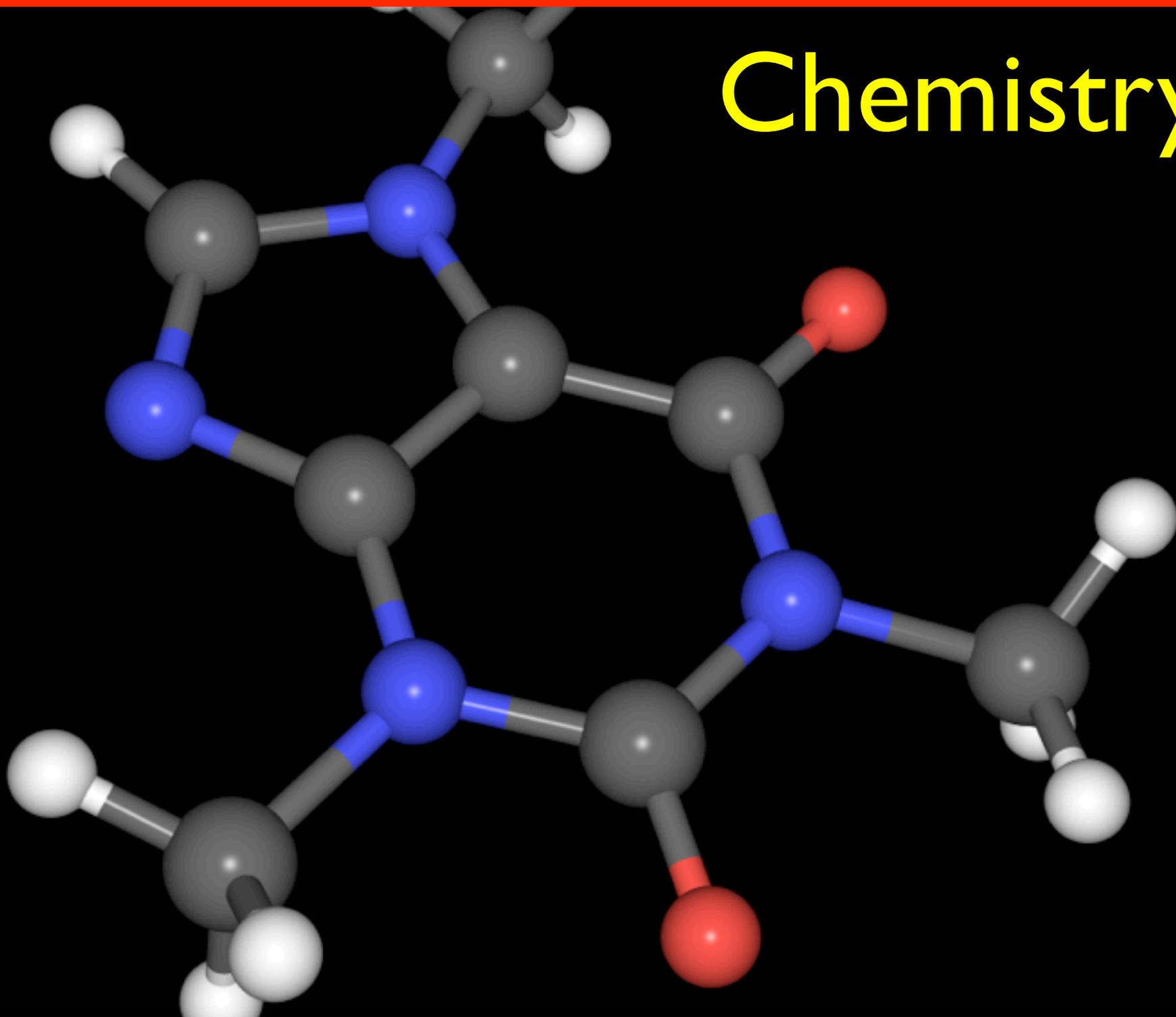
Computer Graphics

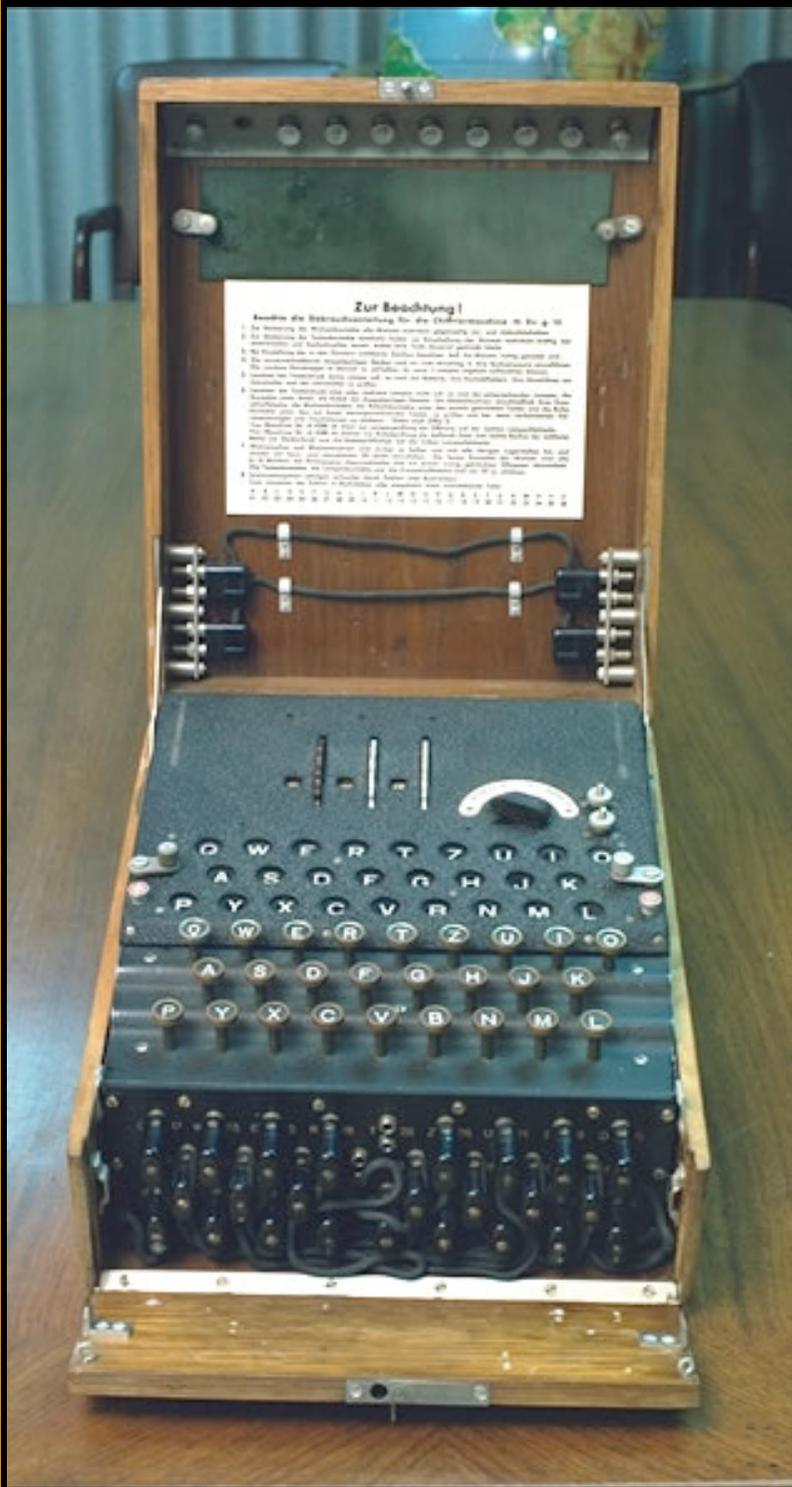


Mechanics Stability



Chemistry

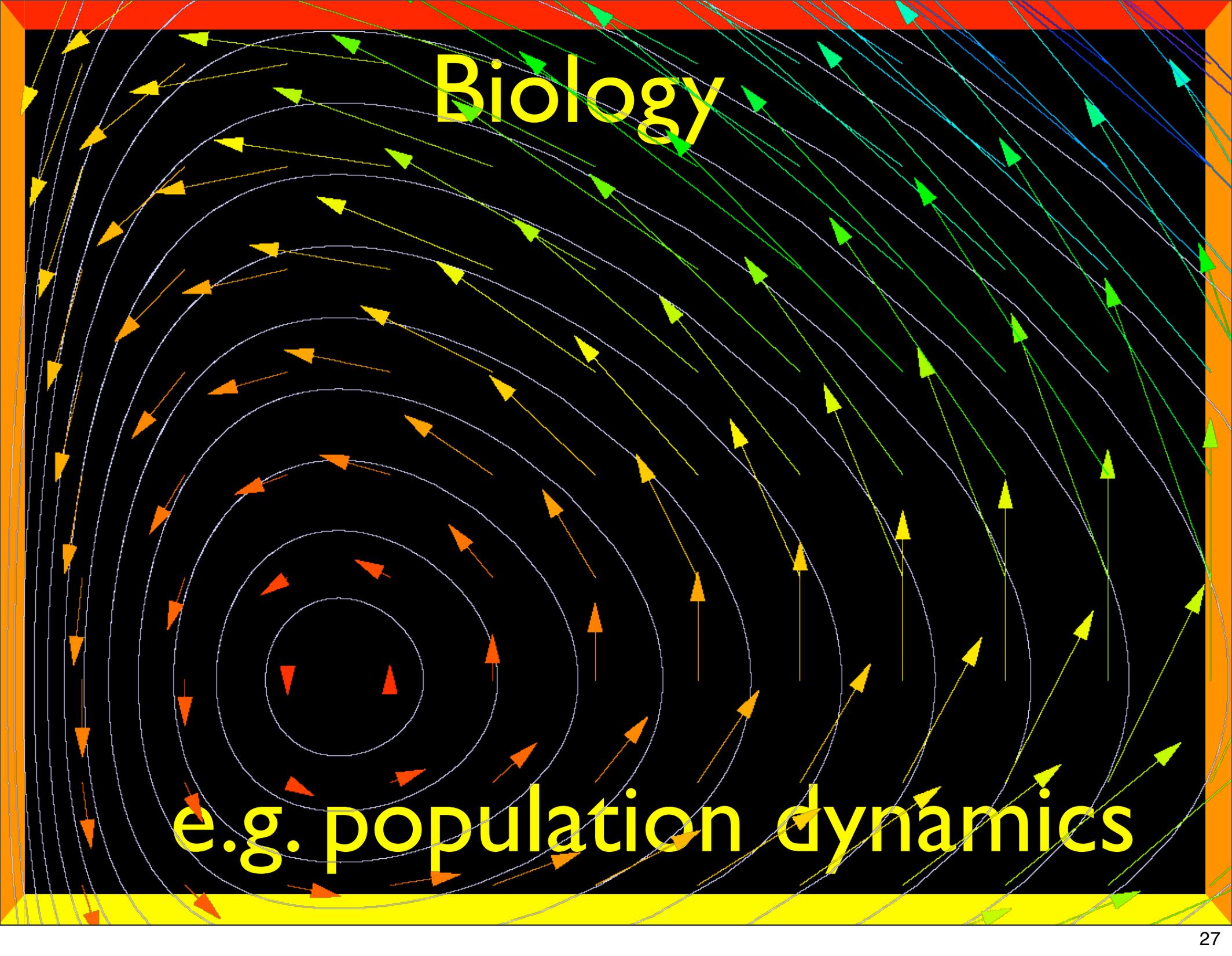




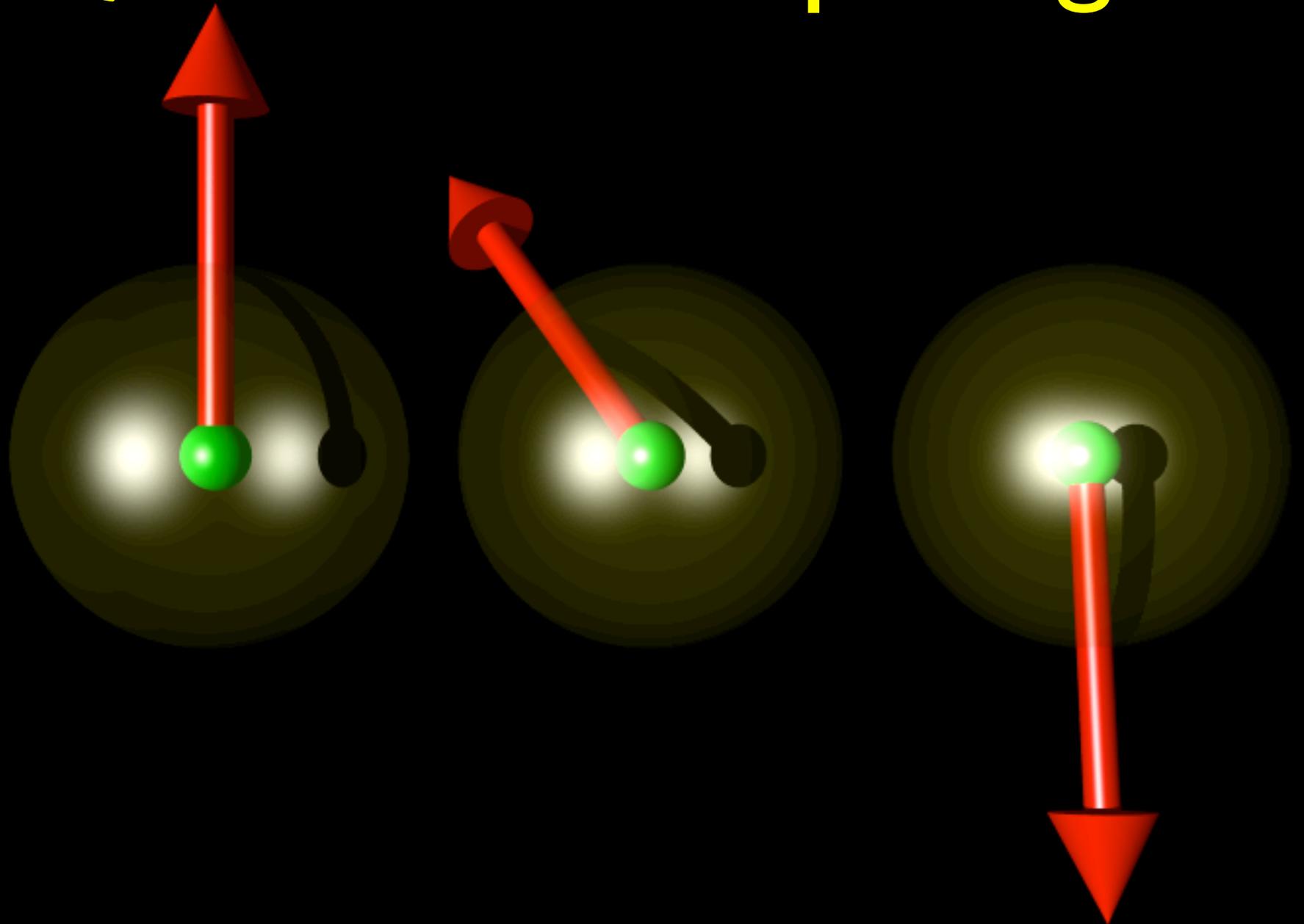
Codes and Number Theory

Biology

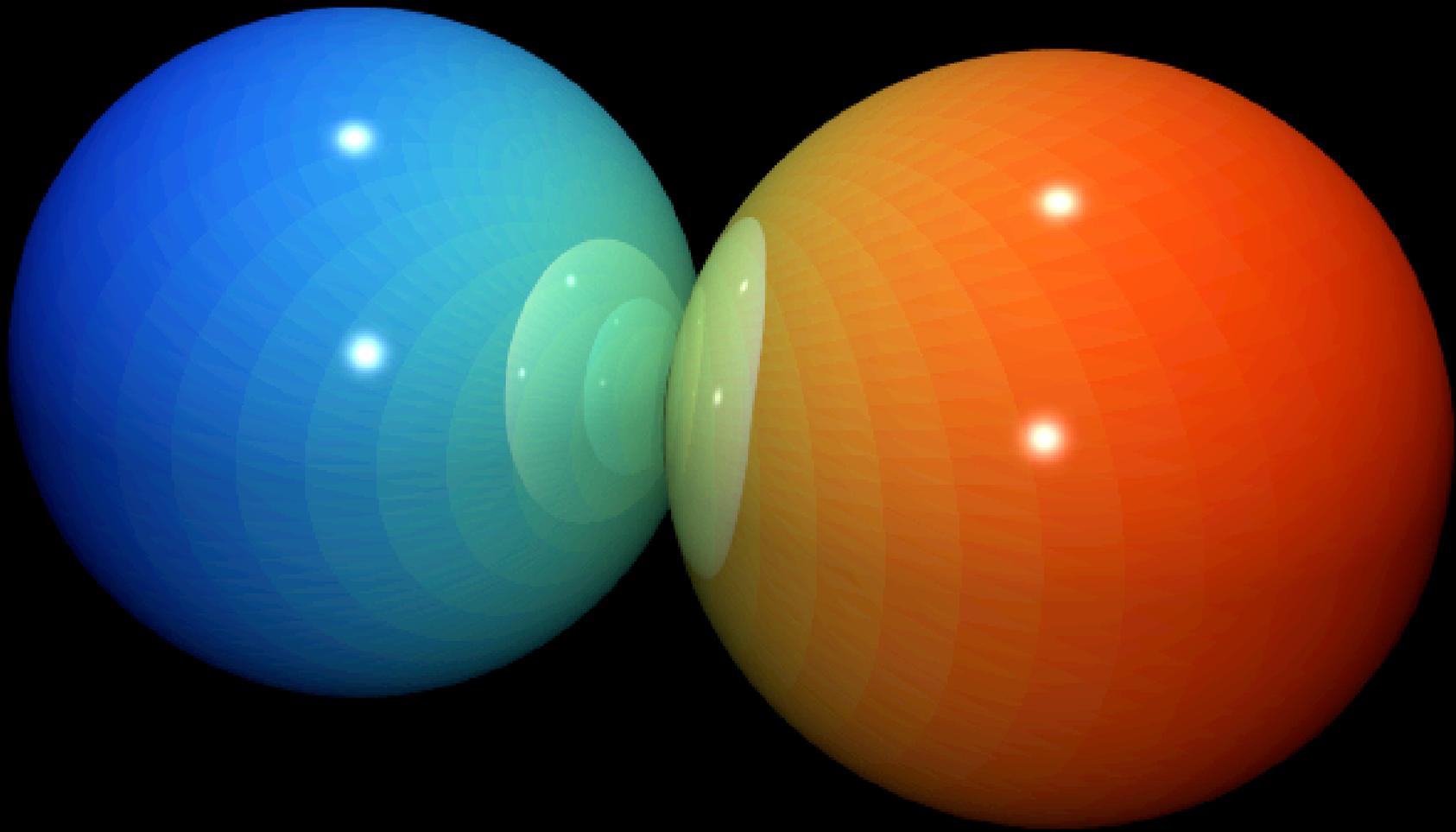
e.g. population dynamics

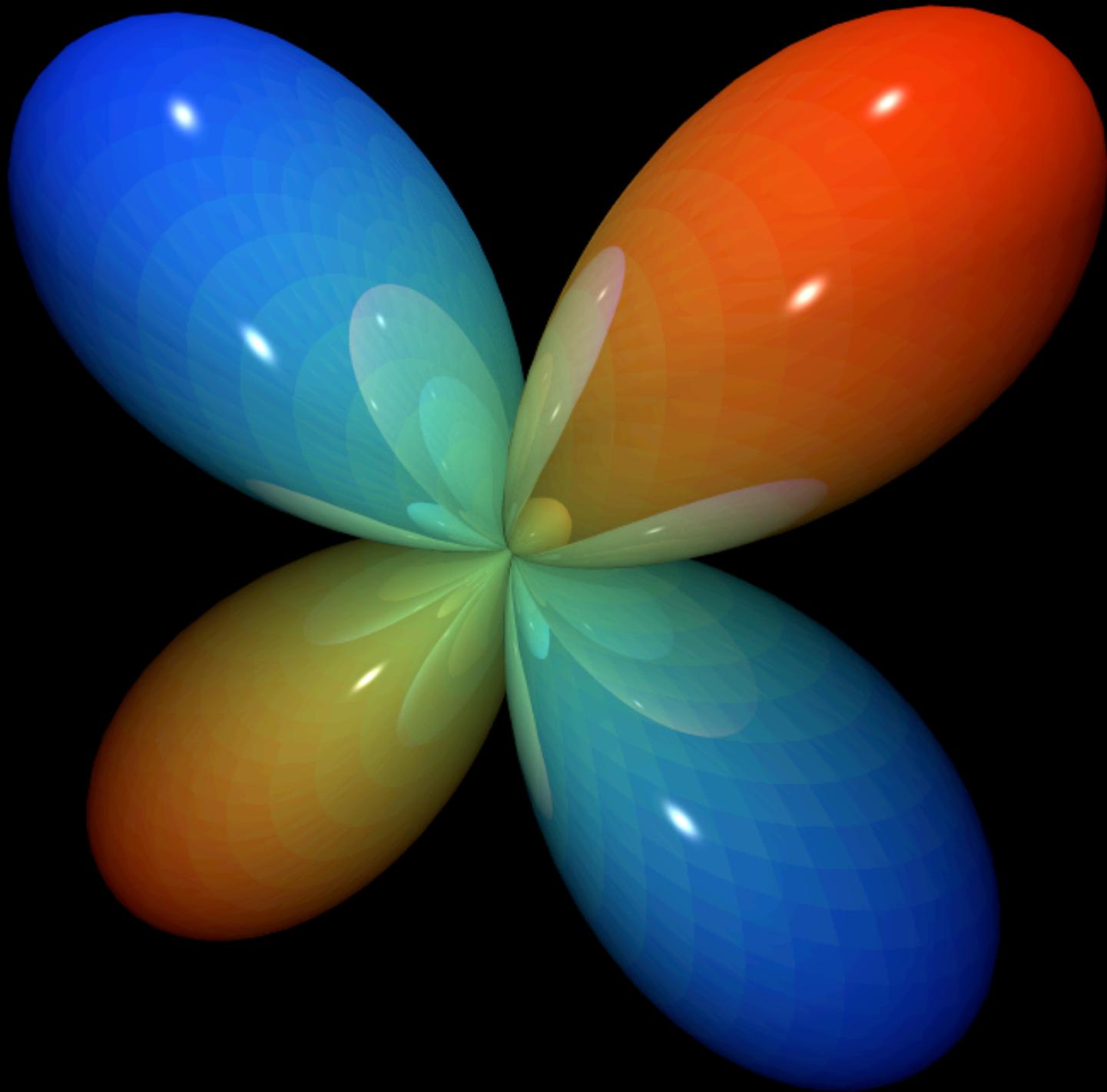


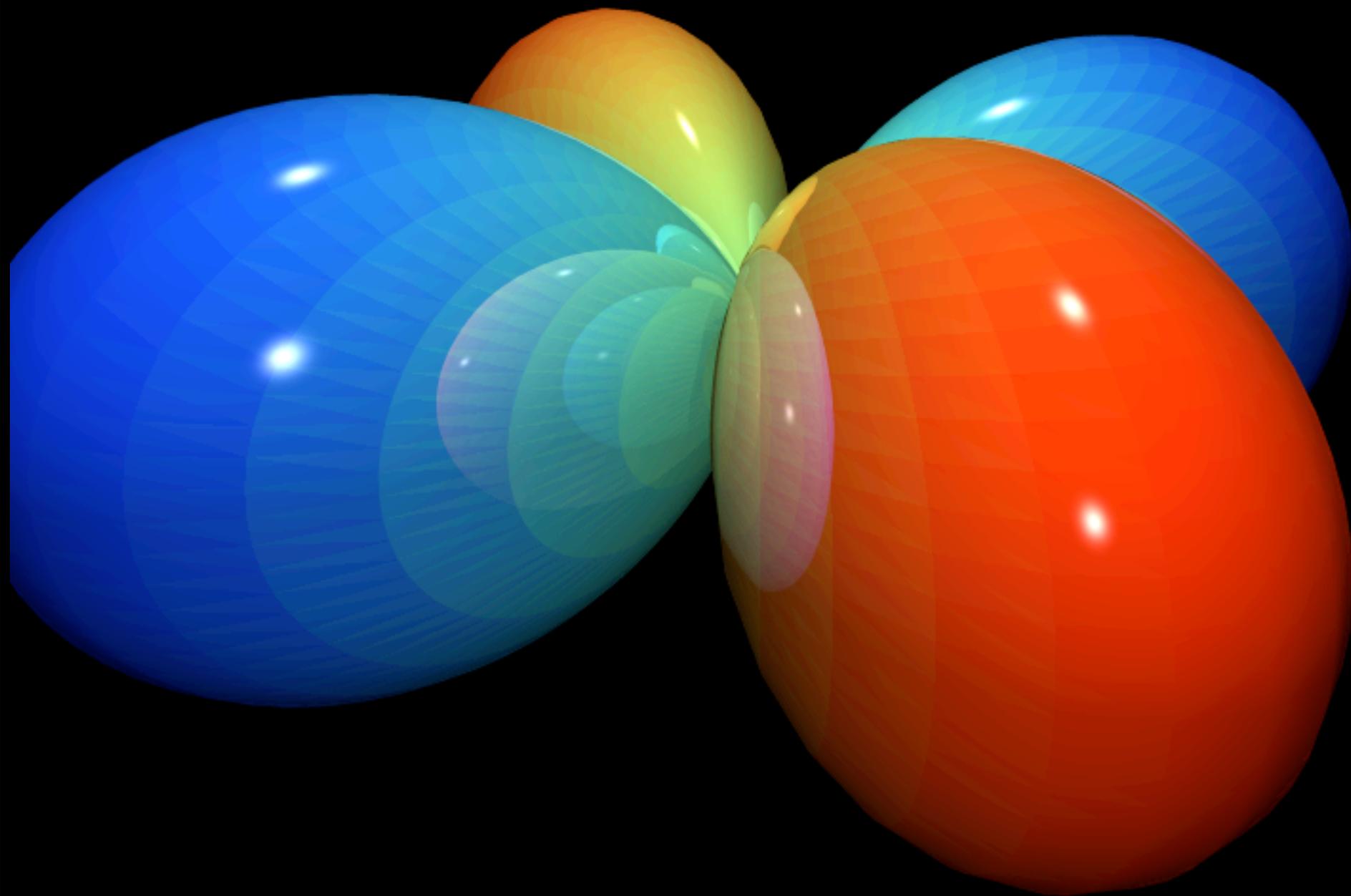
Quantum Computing

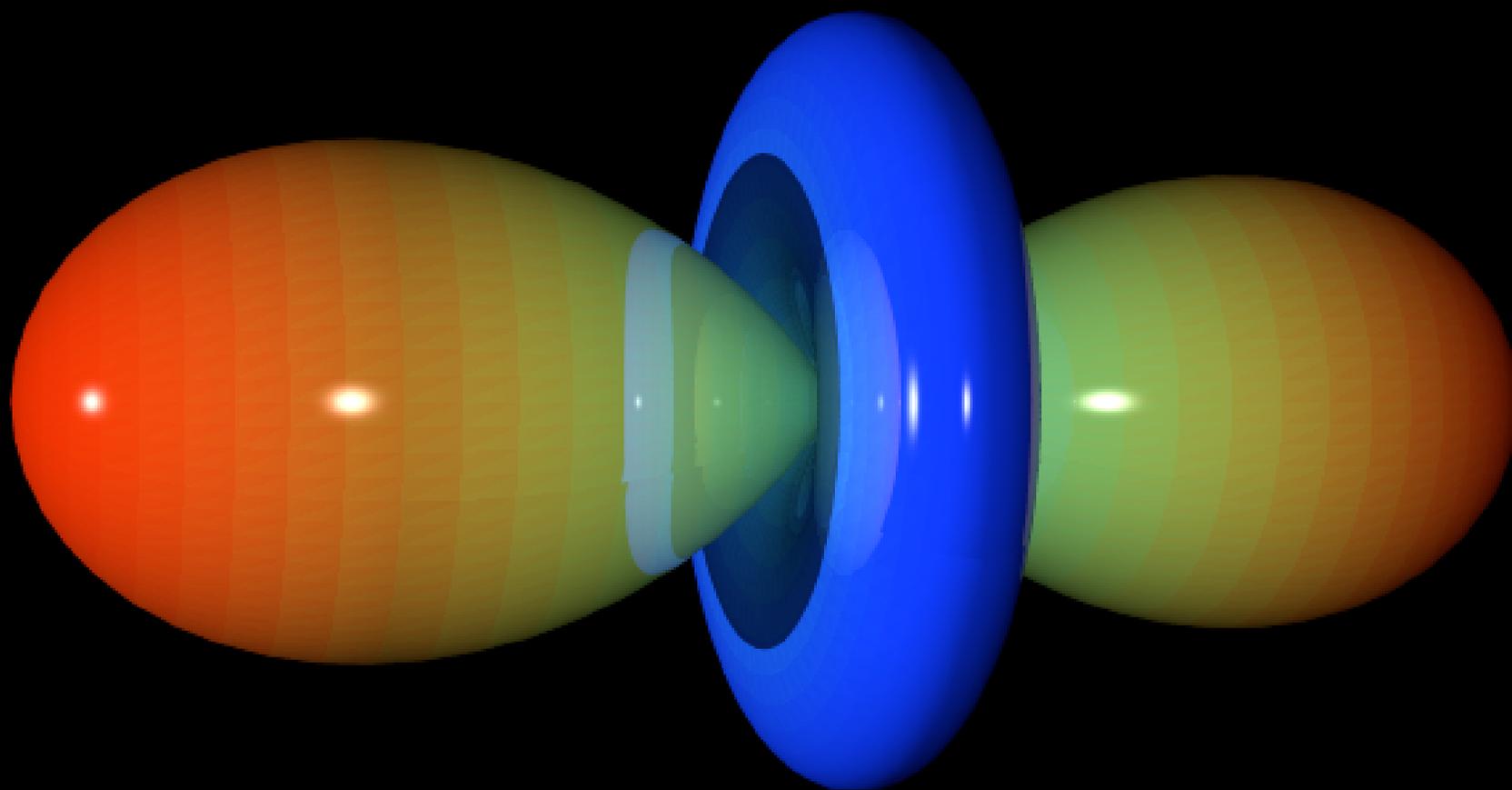


Quantummechanics









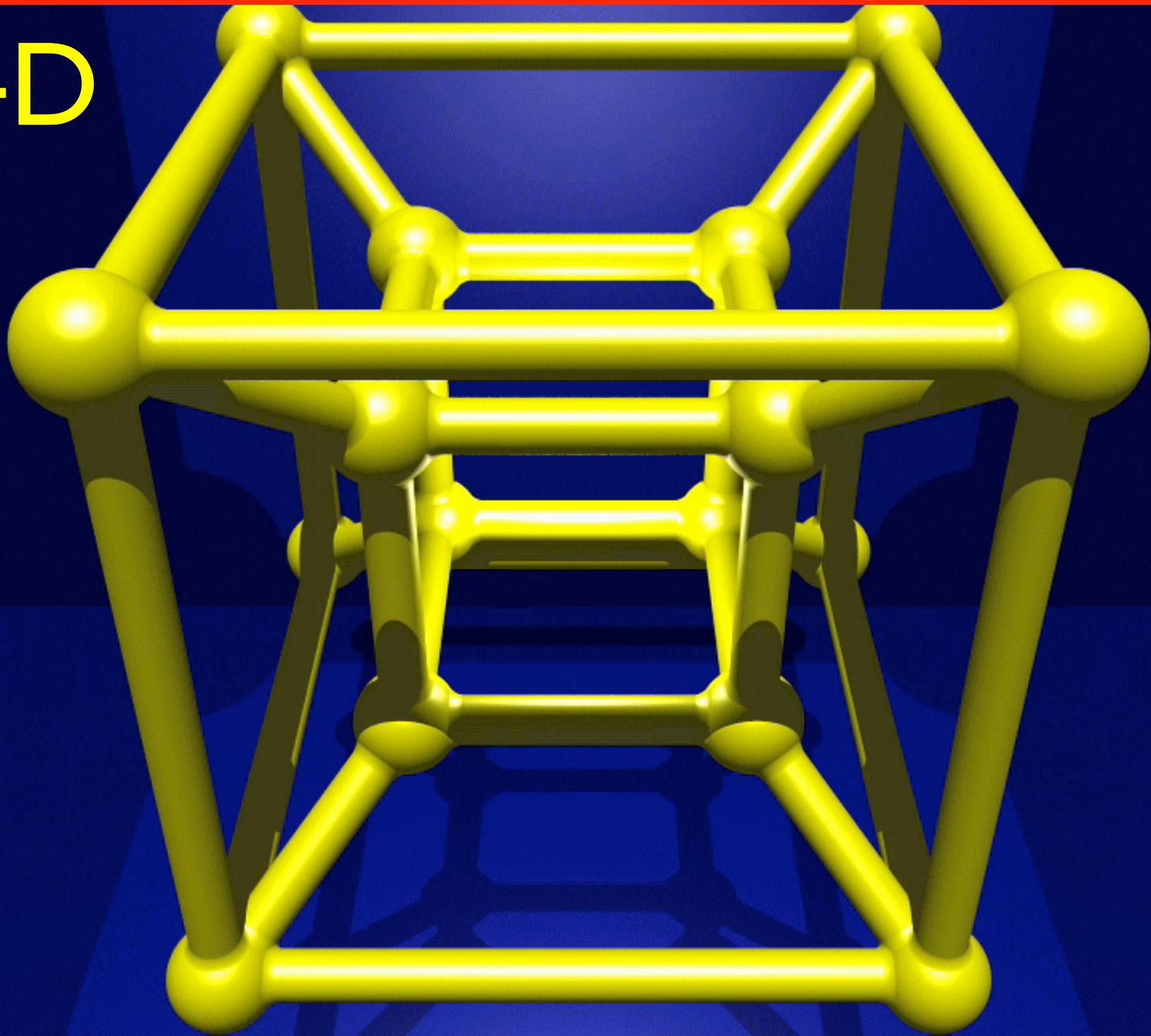
Partial Diff equations



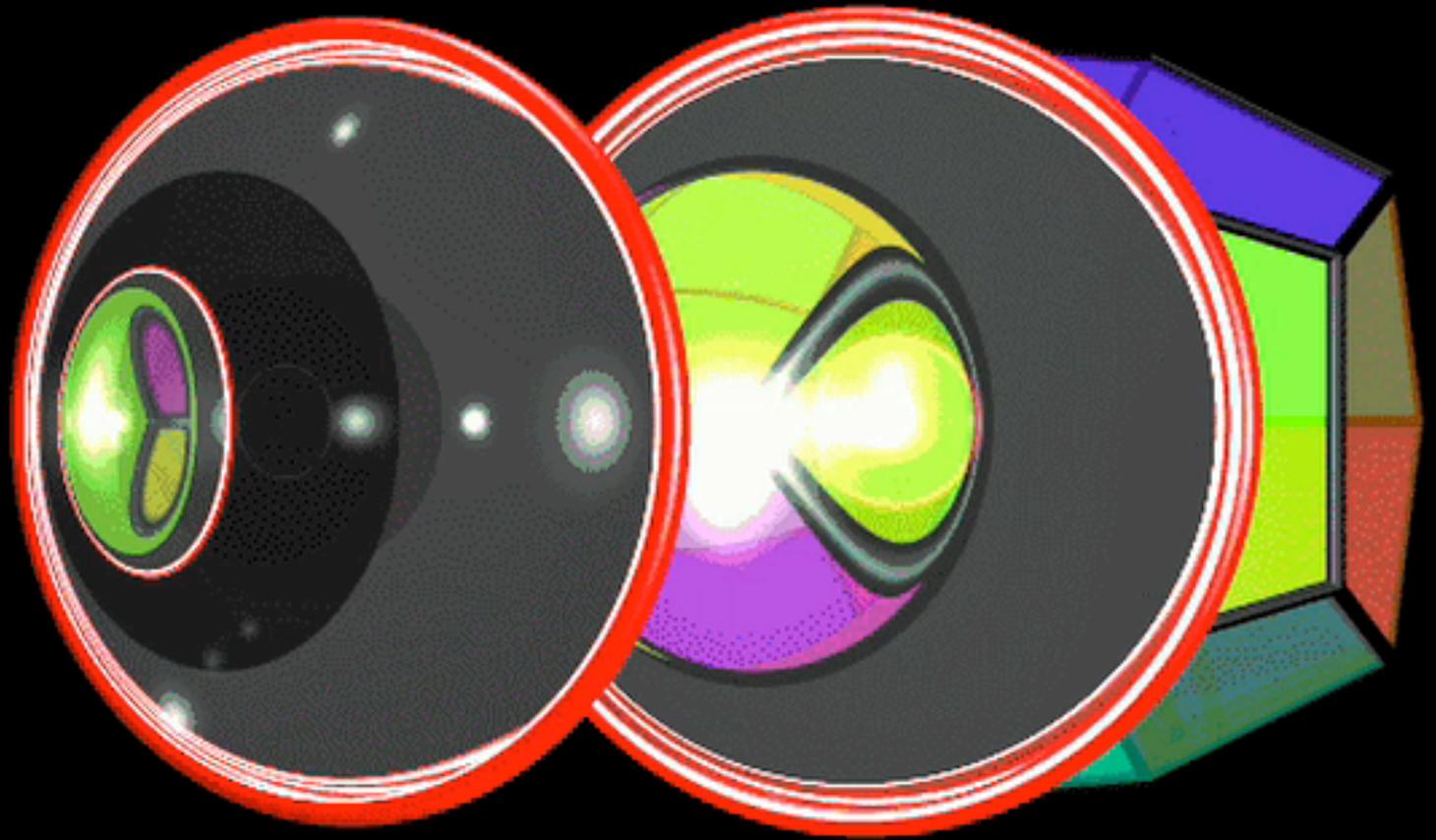
An aerial photograph of a surfer riding a wave in the ocean. The surfer is positioned in the middle-right of the frame, leaving a white wake behind them. The water is a deep blue, and the wave's crest is visible on the left side of the image. The entire scene is framed by a thick orange border.

Wave equation

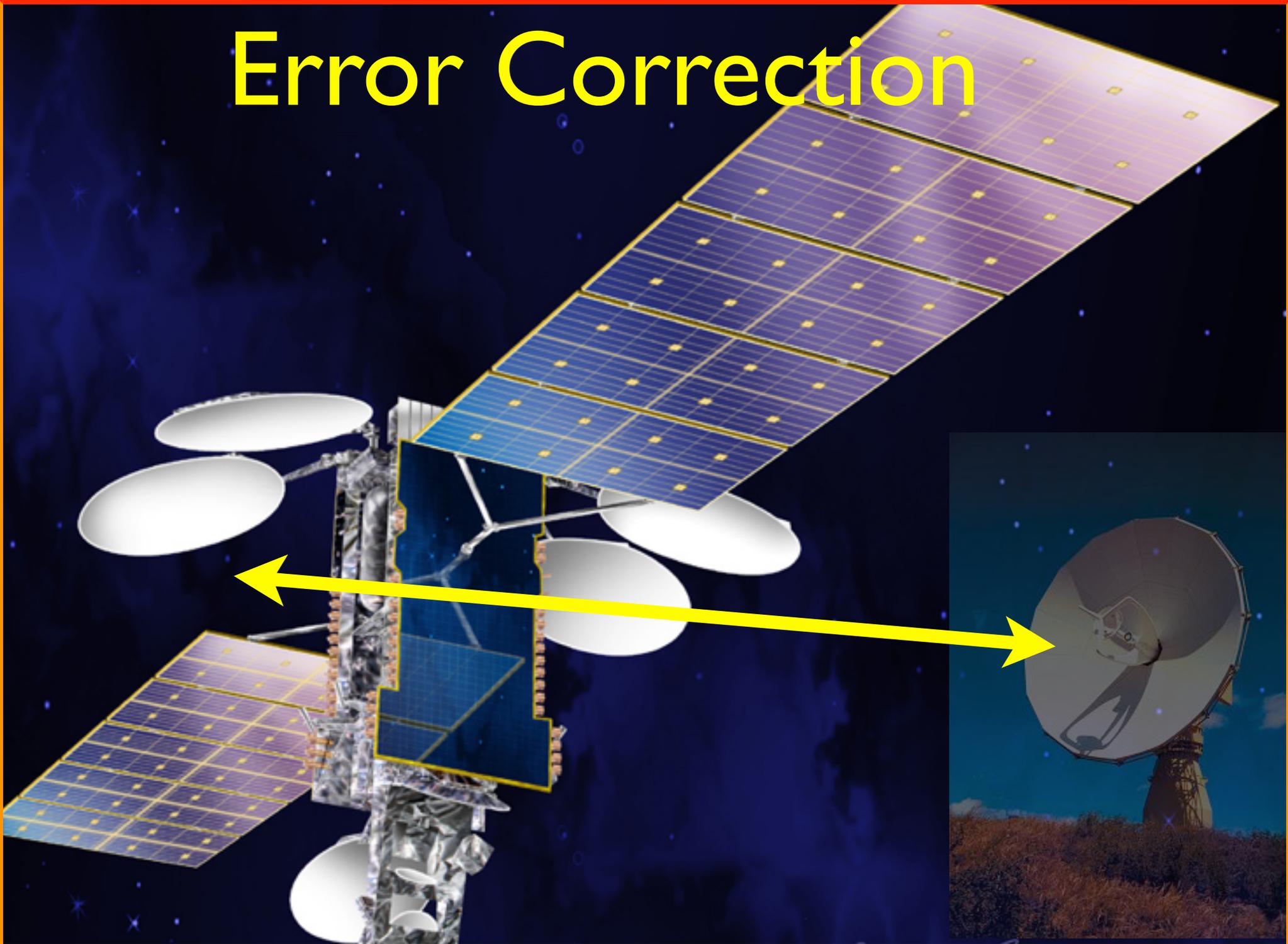
4D



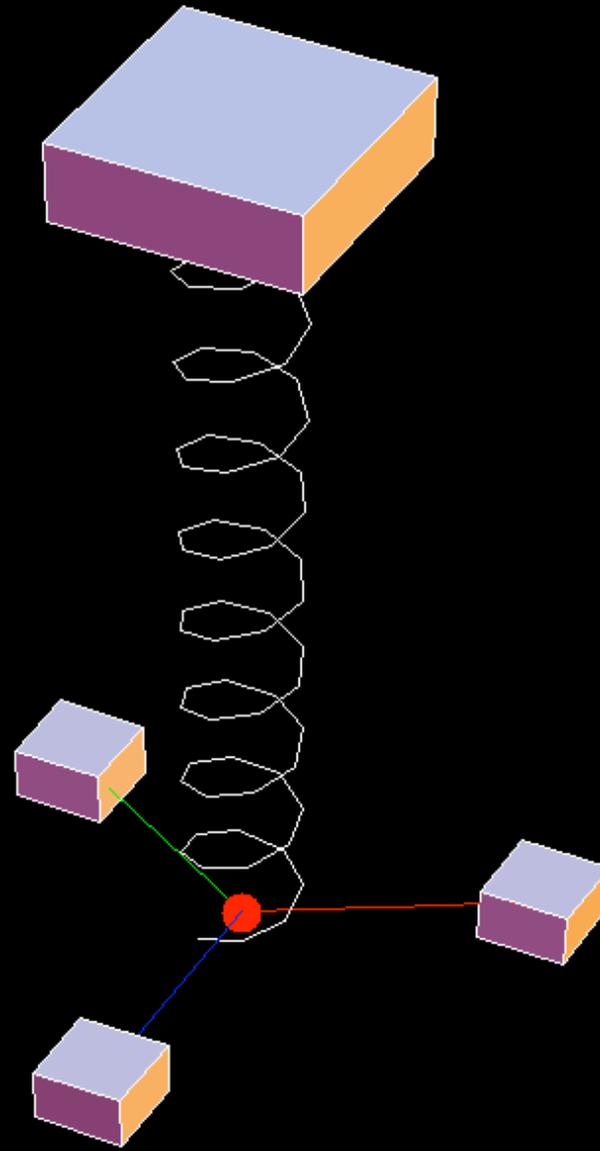
Optics



Error Correction



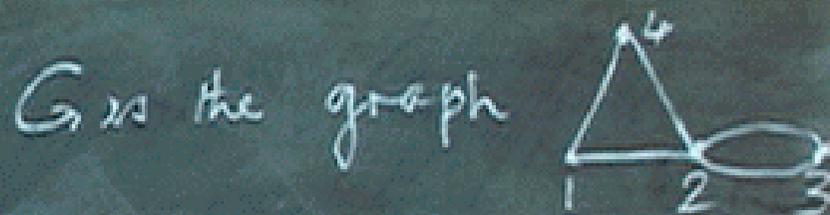
Dynamical Systems



Computer Games



Graphs



Find 1) the adjacency matrix A

2) the matrix giving the number of 3 step walks

3) the generating function for walks from point $i \rightarrow j$

4) the generating function for walks from points $1 \rightarrow 3$

Fourier Theory

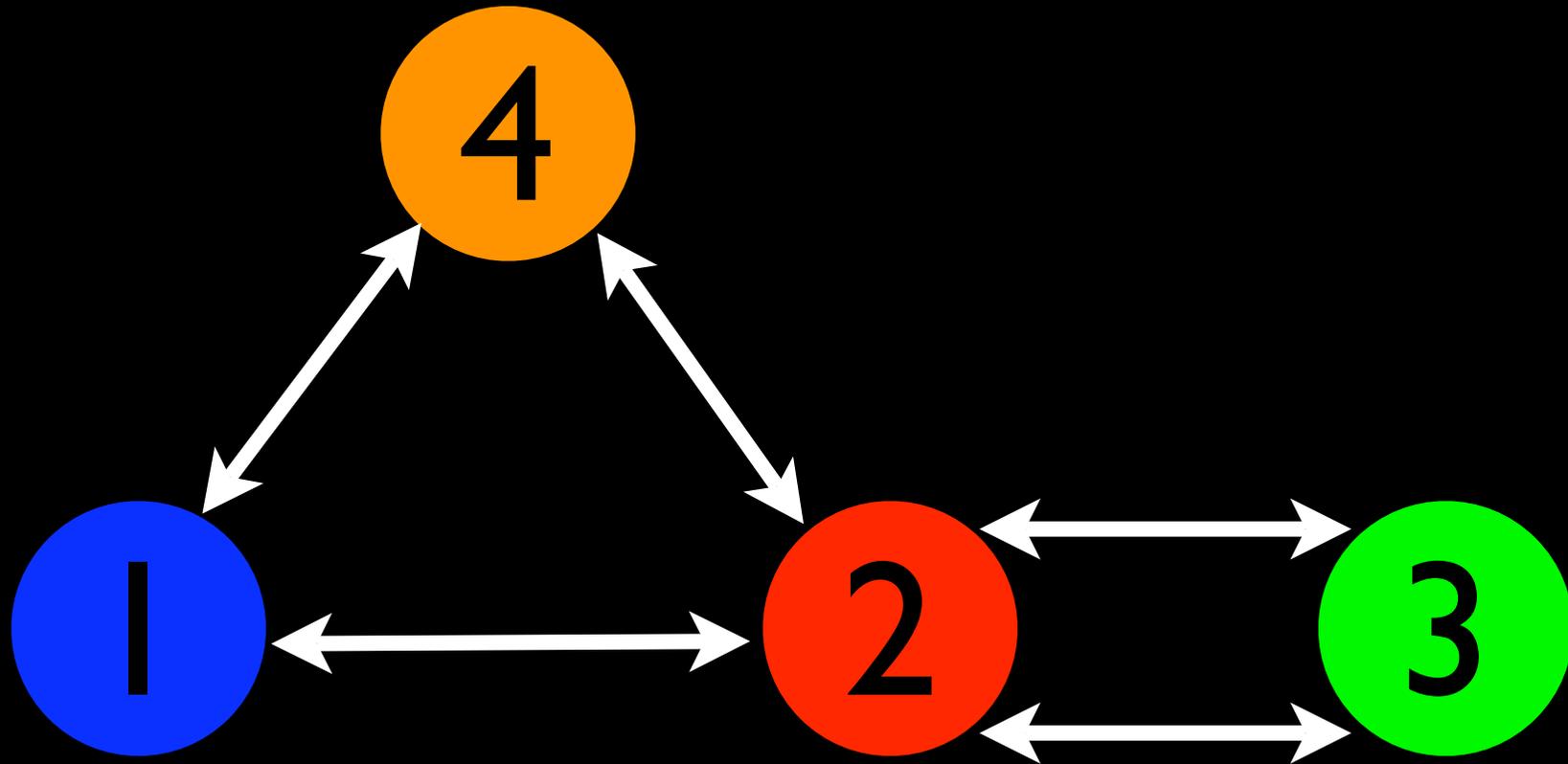


Apropos movies: Fibonacci

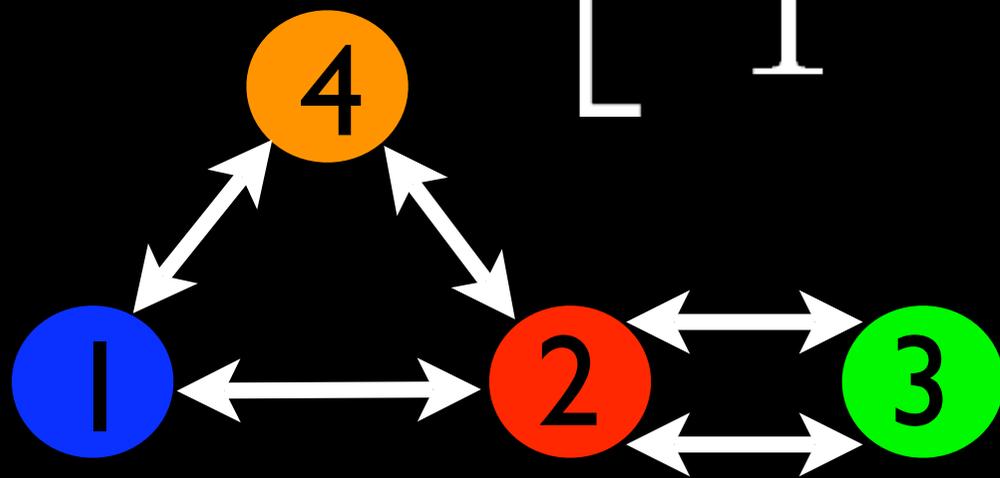


1, 1, 2, 3, 5, 8, 13, 21,

Graphs



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

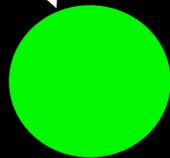
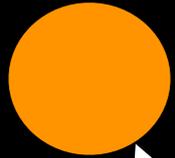


Application: page rank

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

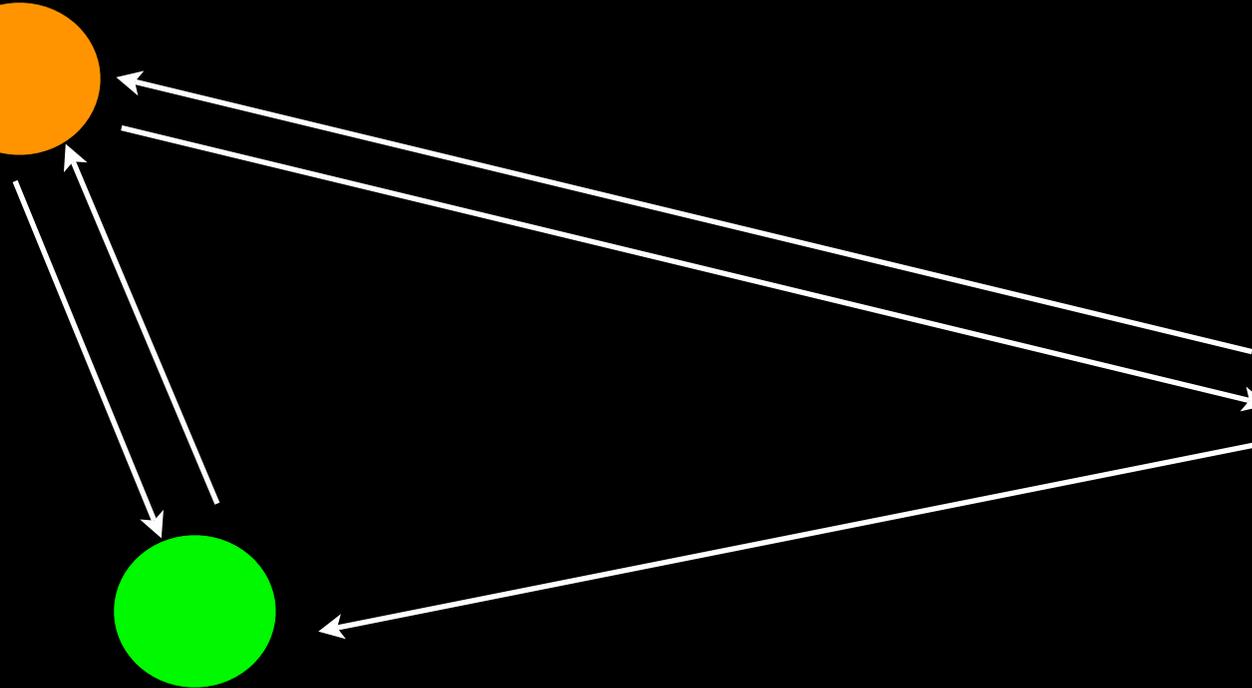
Example:

harvard.edu



mit.edu

courses.fas.harvard.edu/~math21b



Linear algebra kicks in:

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

harvard.edu



mit.edu

courses.fas.harvard.edu/~math21b

$d=0.85$ “damping factor

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

$$(1 - dT)^{-1} \begin{bmatrix} 1 - d \\ 1 - d \\ 1 - d \end{bmatrix} = \begin{bmatrix} 4.3 \\ 3.3 \\ 2.4 \end{bmatrix}$$

This illustrates:



There are many applications



In the page rank case, this was a Markov process from probability theory

Sections

 MWF 10-11, 11-12
9-10 or 12-13 with sufficient
enrollment

 TTh 10:00-11:30, 11:30-13:00

we probably will have 5
sections

How to section

We use a hacker interface:



ssh to [section@ulam.fas.harvard.edu](ssh://section@ulam.fas.harvard.edu)



enter preferences

This can be done in 1 minute

SSH



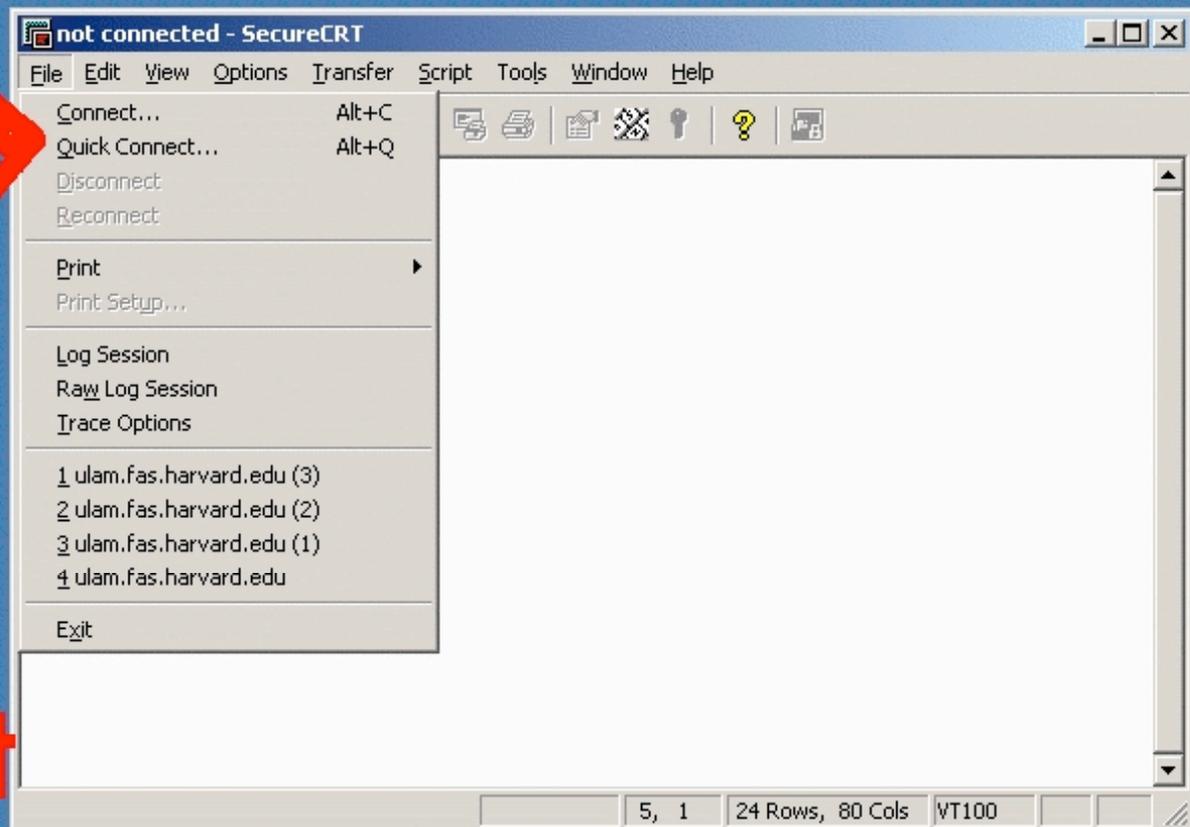
How does it work?

Secure CRT



Quick Connect

Chose
Quick
Connect



Recycle Bin



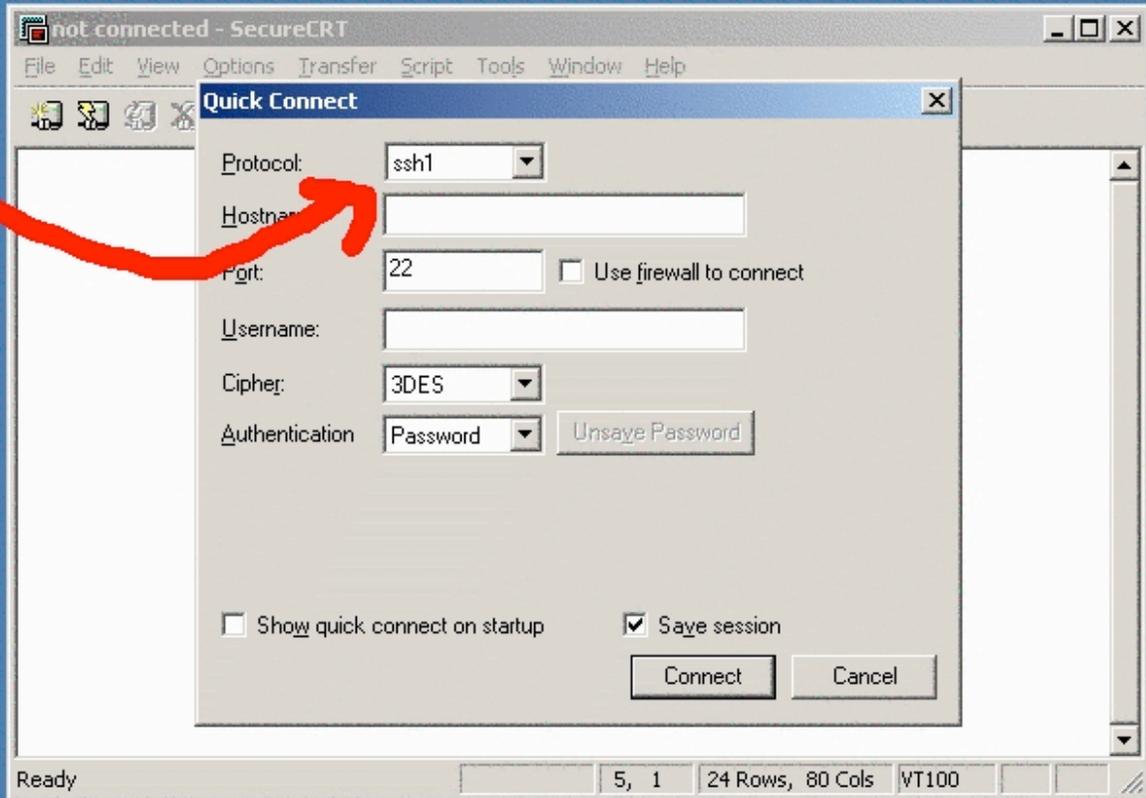
Start



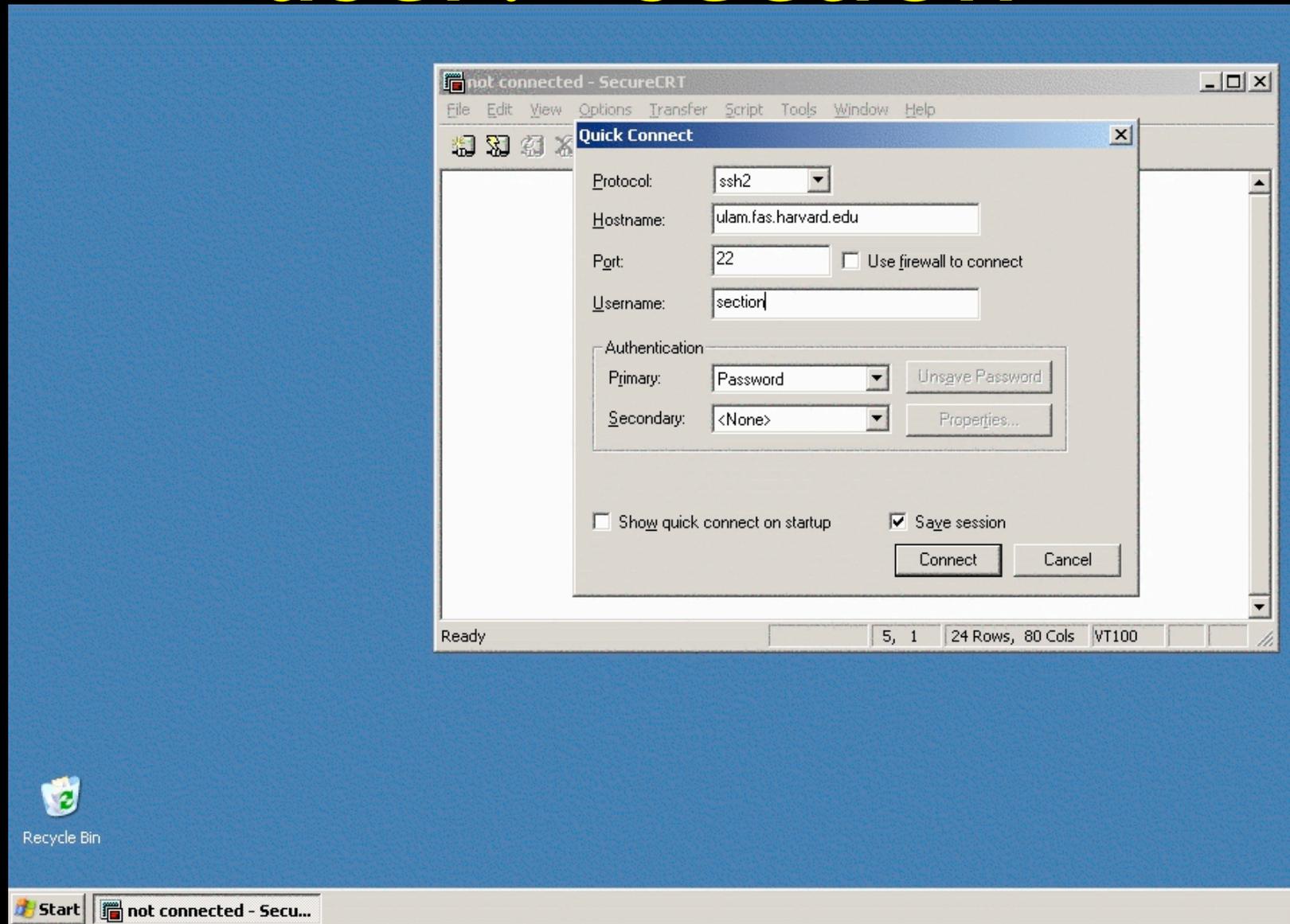
not connected - Secu...

SSH2

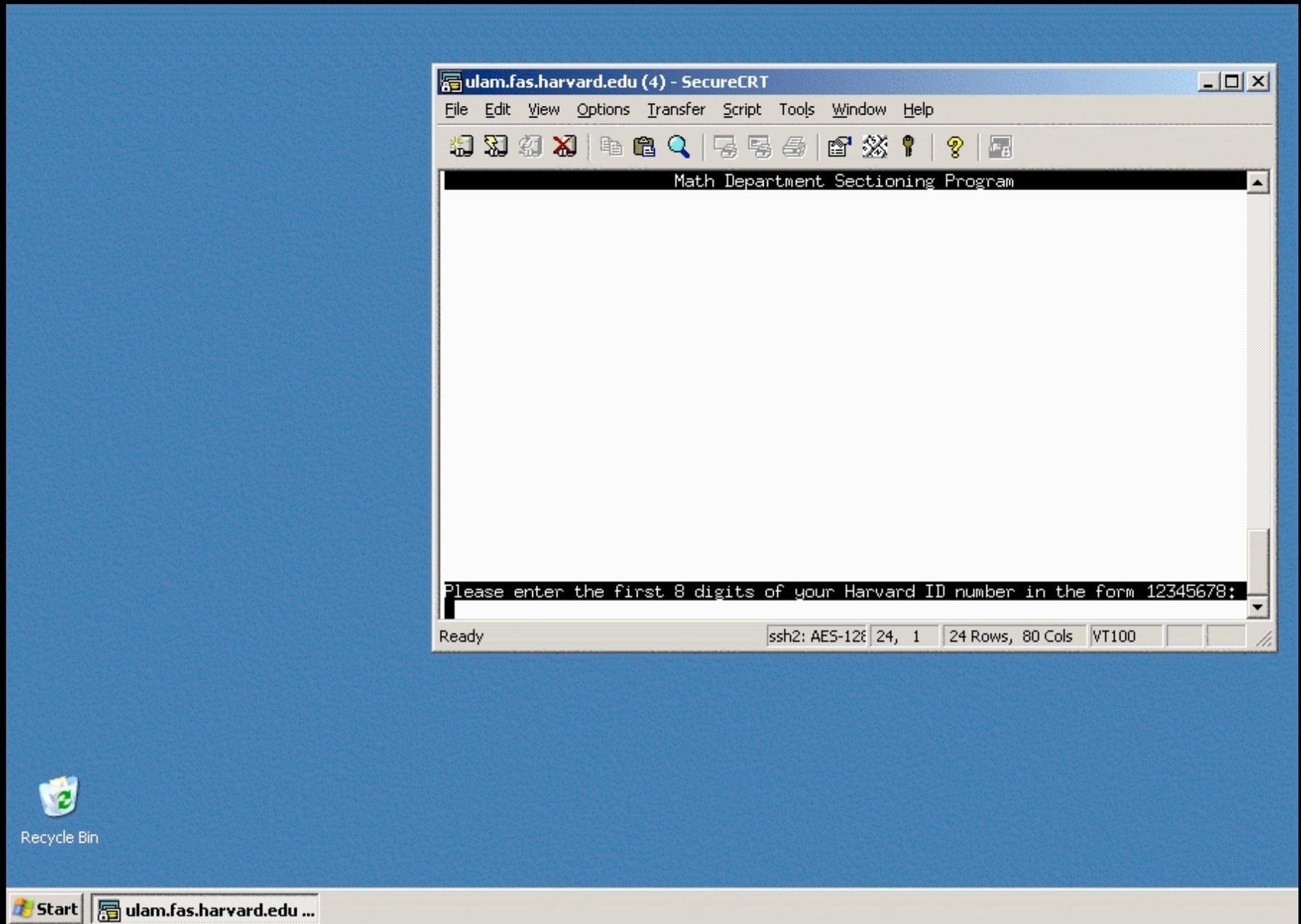
Change
to ssh2



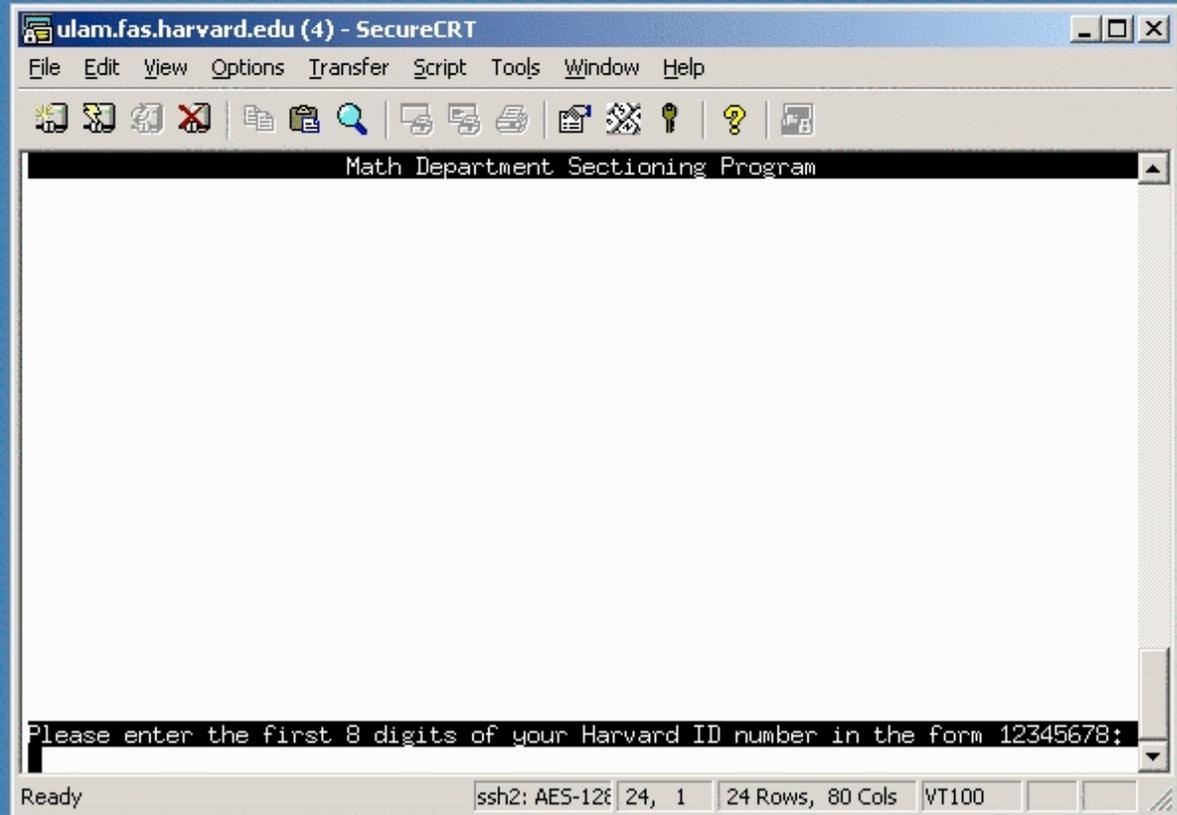
host: ulam.fas.harvard.edu
user: section



Enter HUID



Enter HUD and name



Recycle Bin

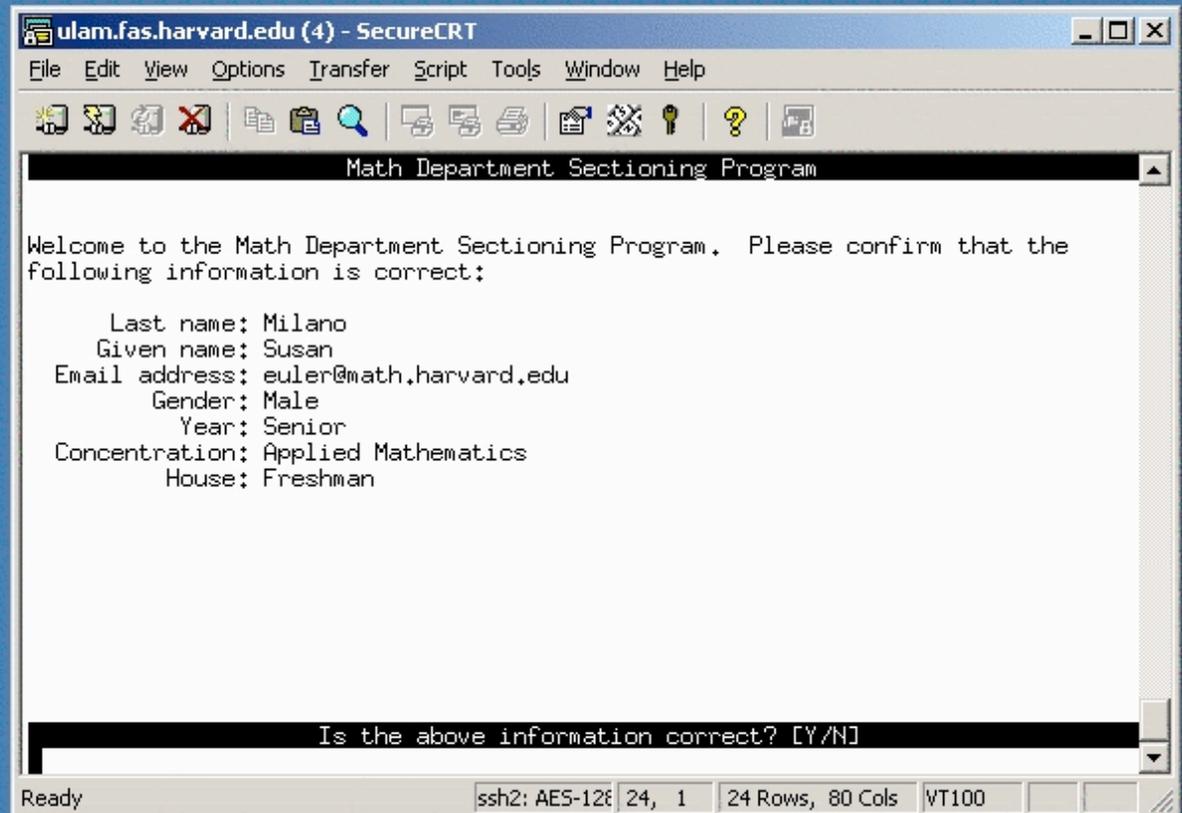


Start



ulam.fas.harvard.edu ...

Confirm



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

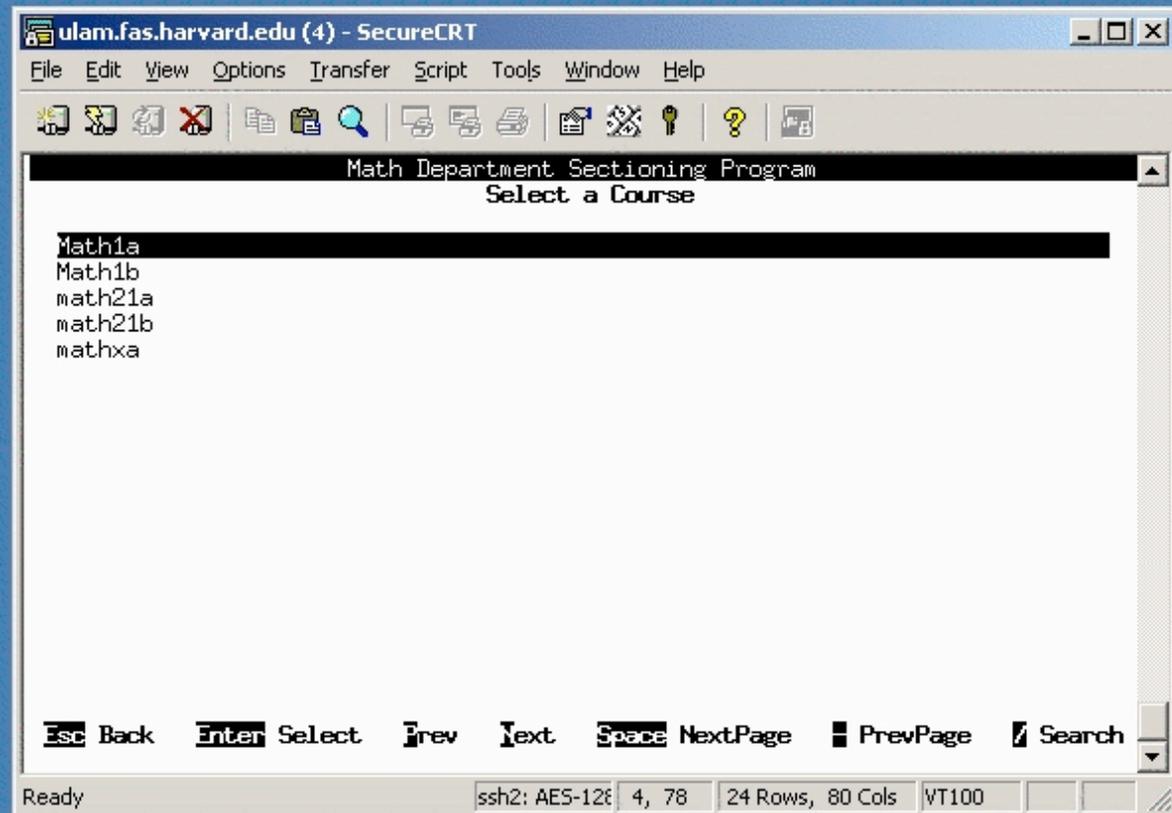


Start



ulam.fas.harvard.edu ...

Chose Math2Ib



Recycle Bin

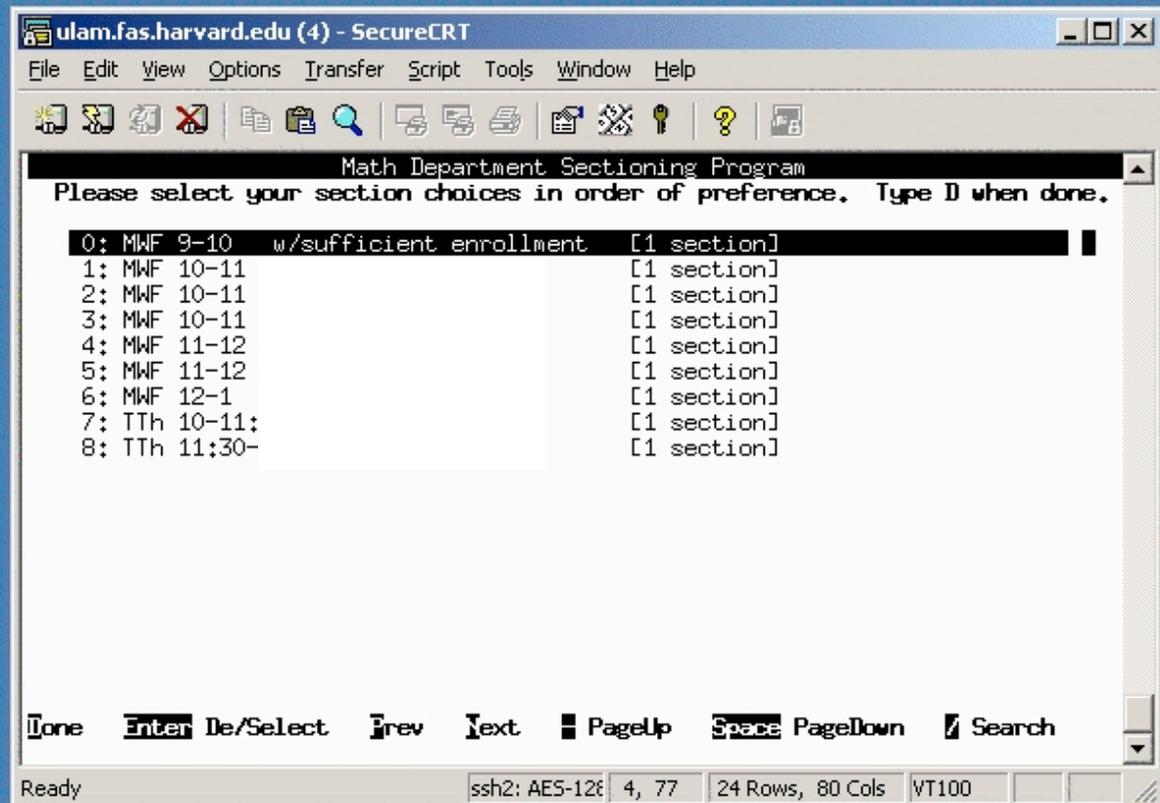


Start



ulam.fas.harvard.edu ...

Chose Section Times

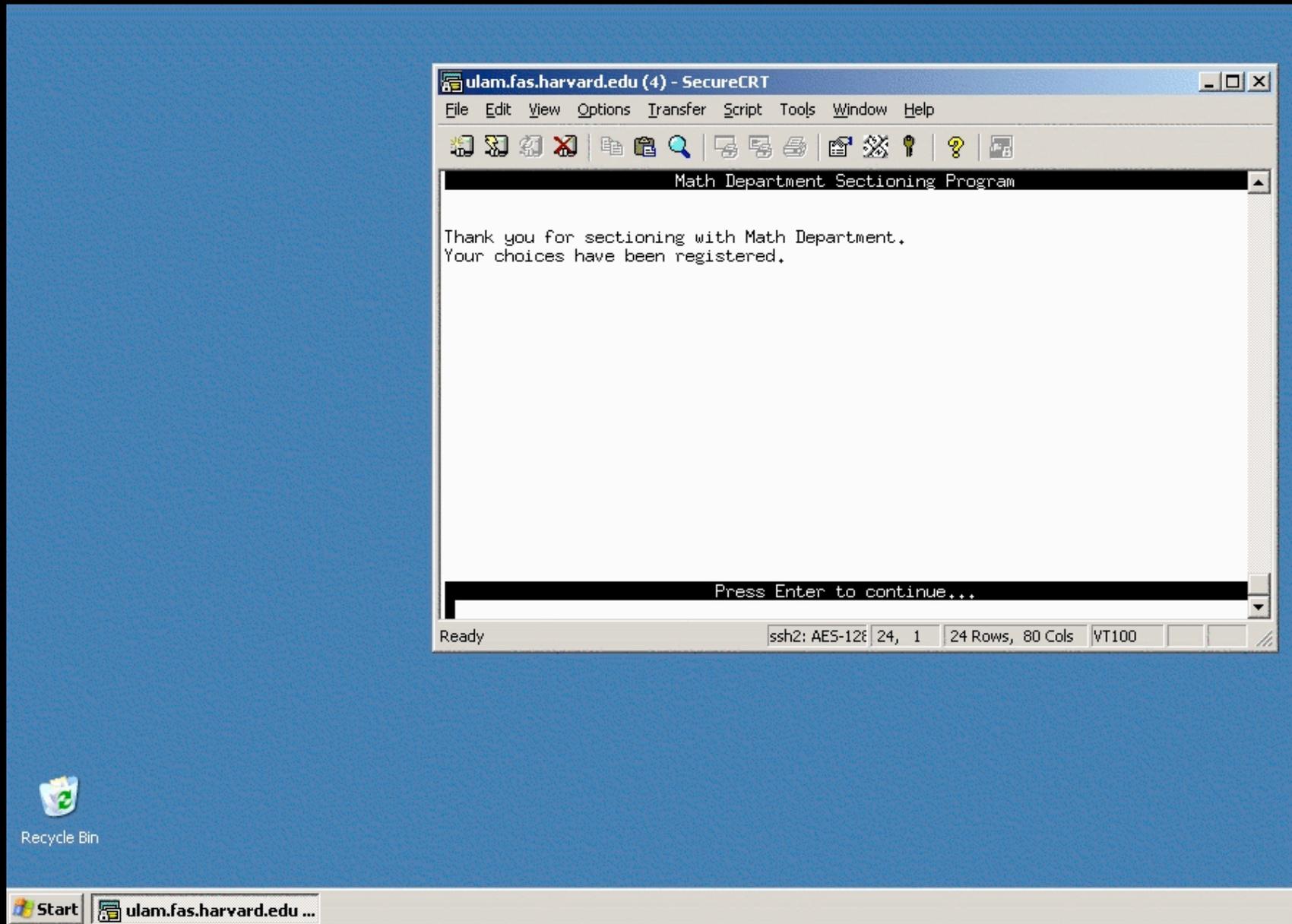


Recycle Bin



ulam.fas.harvard.edu ...

Exit the program



Should I take Math 19b, Math 21b or Applied Math 21b?

- ★ Math 19b: More statistics
- ★ Math 21b: More Differential equations
- ★ AMath 21b: More electrical engineering

You have to decide, ask your friends,
choose the style which fits you

Math 19b, Math 21b or Applied Math 21b?





Do I need to have seen Math21a?



No!



But it can be helpful

Do I have to review anything before starting next week?

- ★ Come with an open mind.
- ★ Later on, we will need some complex numbers.
- ★ A bit of prereading can never hurt.



The end, but every end
is a beginning....