mathematica workshop

(in switzerland , december 6 is santa claus day)

math21a, 12/5/2007.
harvard university
oliver knill


black forest, home of Santa

remarks

- 5 points in grade
- time effort is minimal, but you can show off!
- no late turn ins, no electronic submissions, no drops to mailboxes
- will be graded by Oliver
- is an important part of the course
- gallery of best submissions

plan

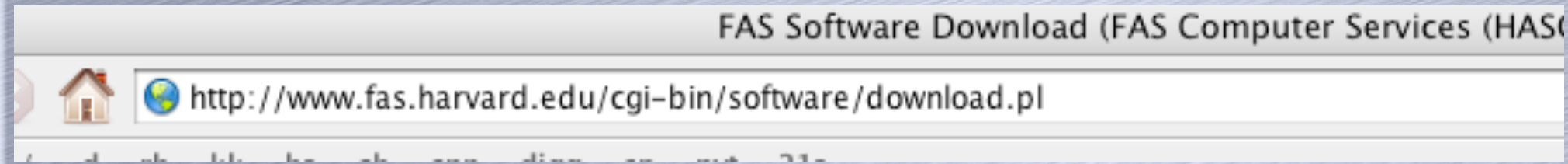
- installation
- the user interface
- getting started
- the assignment
- tips and tricks
- cool stuff

installation

- get the program
- start up and get the id
- submit password request
- enter password

go to the FAS download page

- you need a HUID and pin to access the page
- www.fas.harvard.edu/cgi-bin/software/download.pl

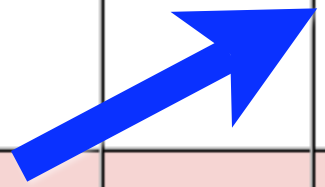


step 1:
get the program

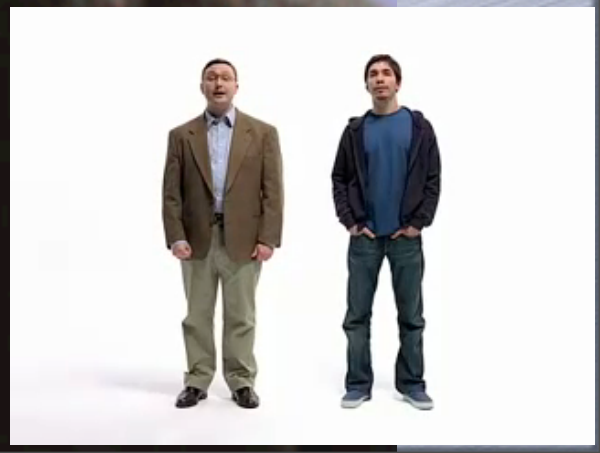
apple users:

download the program for mac OS X

later.					
MacSFTP - Carbon Secure FTP Client for OS 8.6 & higher with CarbonLib.	1.0.6		5.0 Mb	MacOS X	Download
Mail.app Configurer Use this script to configure Apple's OS X Mail.app for servers using SSL.	3.1		0.5 Mb	MacOS X	Download
Maple Mathematic software. Requires OSX, v10.3.9 or later.	11.0	Keyed	367.9 Mb	MacOS X	Download
Mathematica Mathematic software. Please follow on-screen instructions to request a password and complete the installation. Harvard's License Number: L2482-2405. Requires OSX, v10.3.9 or later.	6.0		451.4 Mb	MacOS X	Download
Matlab Mathematic software. Please					

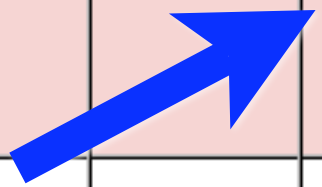


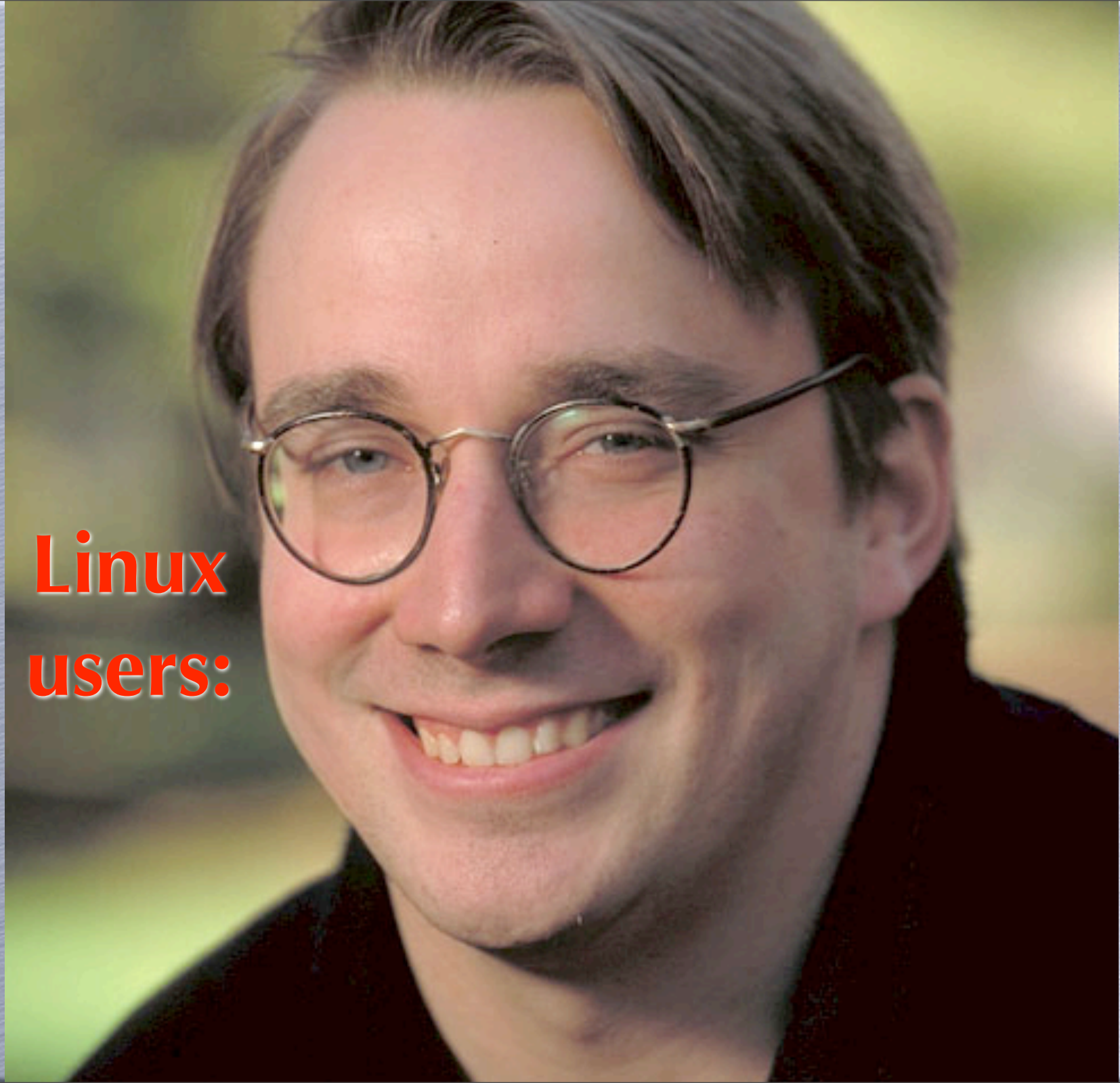
PC users:



download it for windows XP

Data-collection and analysis software. Requires Windows 2000/XP/Vista.	3.5.0		95.7 Mb	Windows	Download
Maple Mathematic modeling and simulation software. Requires Windows 2000/XP/Vista.	11.01	Keyed	219.5 Mb	Windows	Download
Mathematica Harvard's License Number: L2482-2405. To complete the installation process, follow on-screen instructions to request a password from Wolfram's registration site.	6.0		454.2 Mb	Windows	Download
Matlab Mathematic software. Requires Windows 2000/XP/Vista and an	R2007a		636.1 Mb	Windows	Download

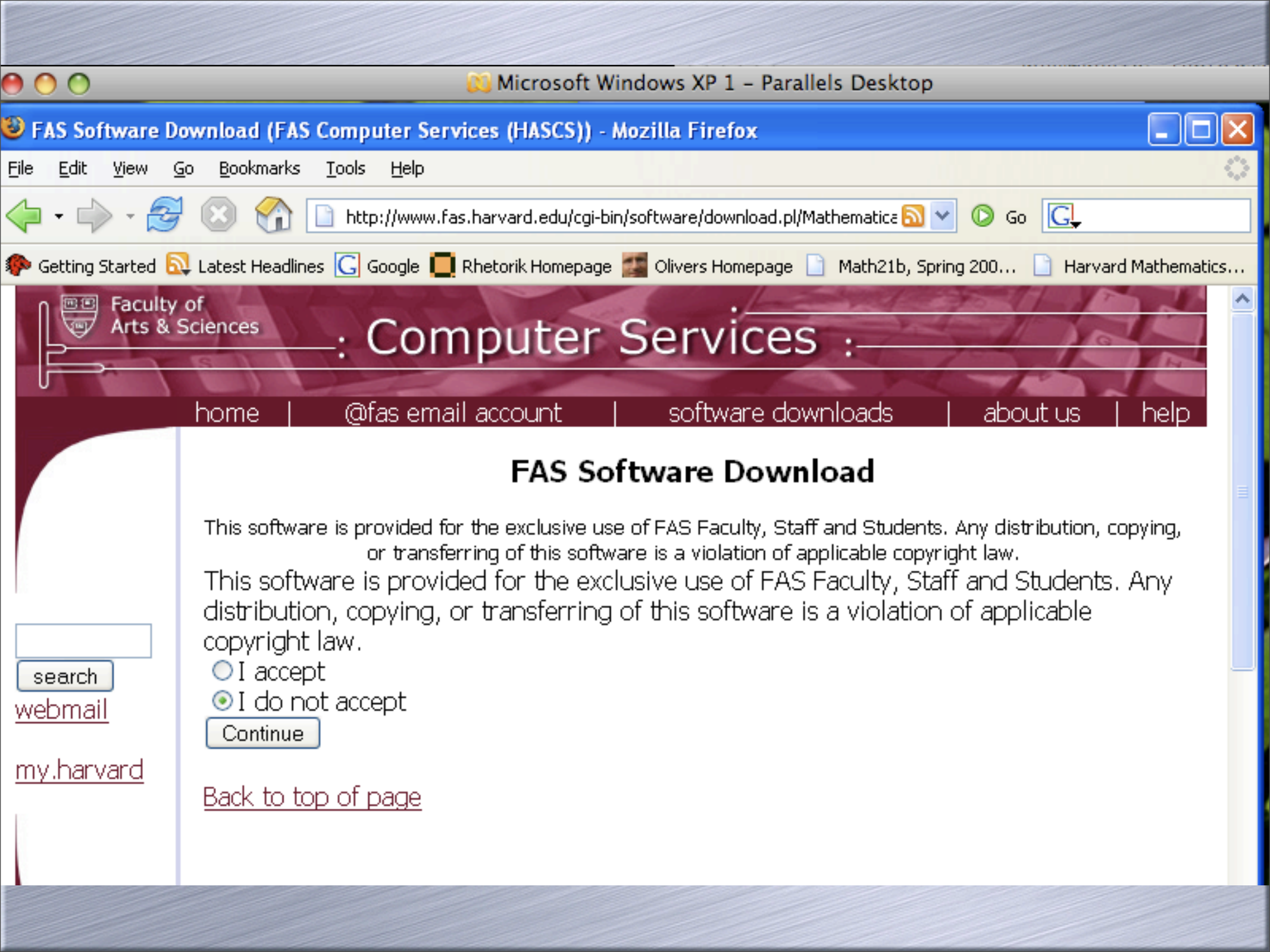



Linux
users:

for Linux, contact me

- we can provide you with a CD image
- or a tar ball with the program

tar ball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I do not accept
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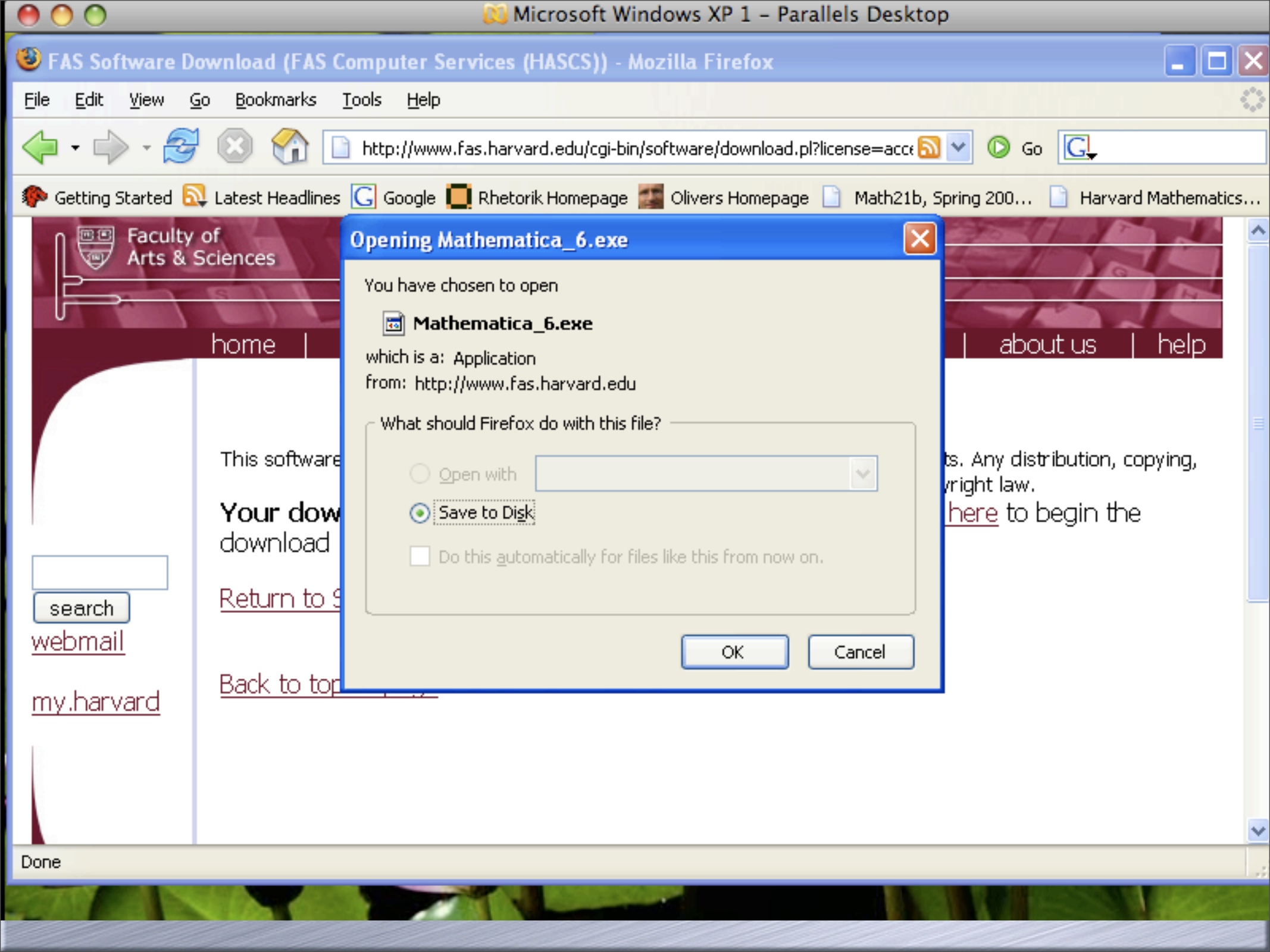
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You have chosen to open
Mathematica_6.exe
which is a: Application
from: http://www.fas.harvard.edu
What should Firefox do with this file?
Open with
Save to Disk
Do this automatically for files like this from now on.
OK
Cancel
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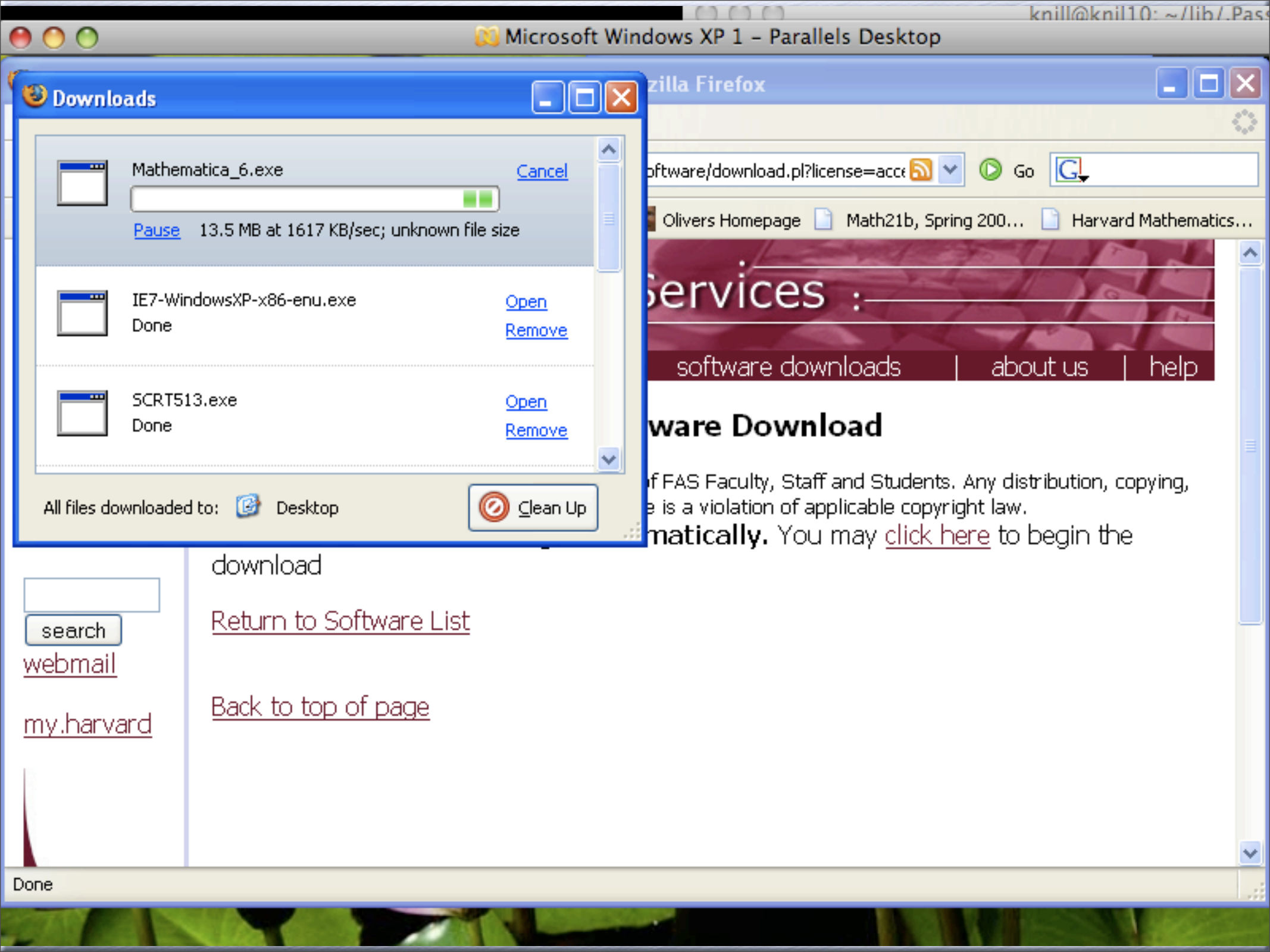
knill@knil10: ~/lib/.Pas
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Downloads
Mathematica_6.exe
Cancel
Pause
13.5 MB at 1617 KB/sec; unknown file size
IE7-WindowsXP-x86-enu.exe
Done
Open
Remove
SCRT513.exe
Done
Open
Remove
All files downloaded to:
Desktop
Clean Up
zilla Firefox
oftware/download.pl?license=acce
Go
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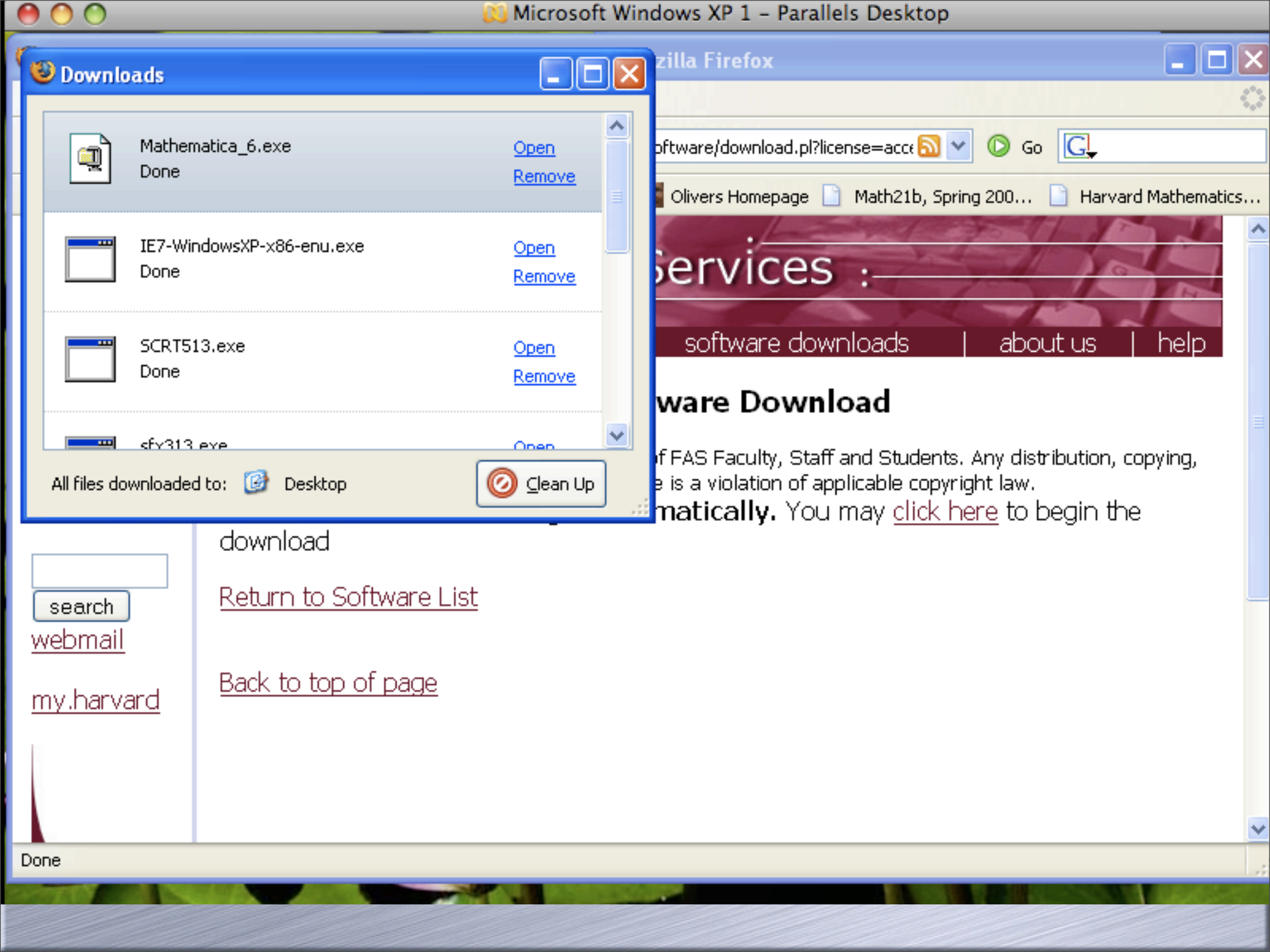
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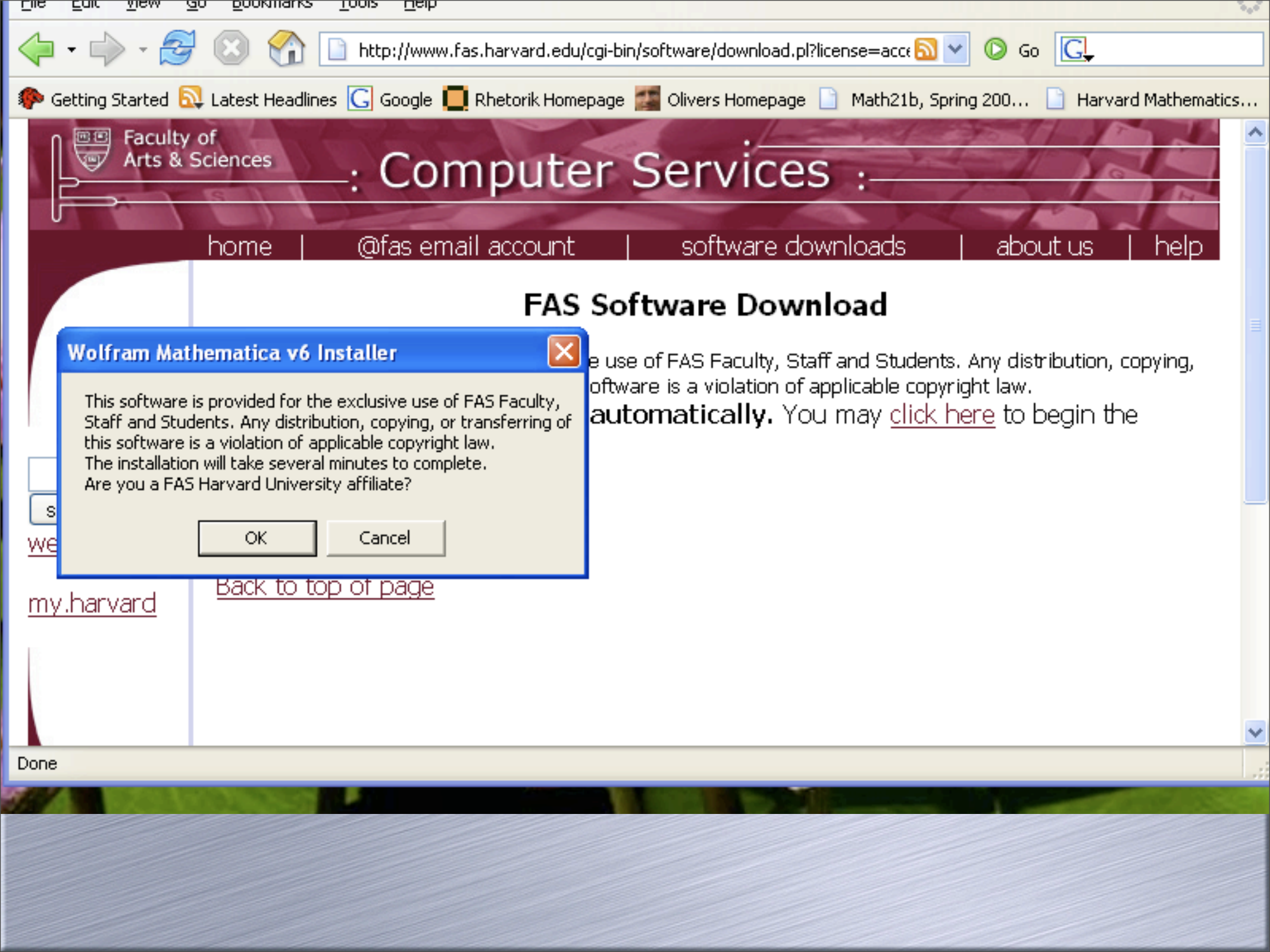
step 2: install the program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The installation will take several minutes to complete.
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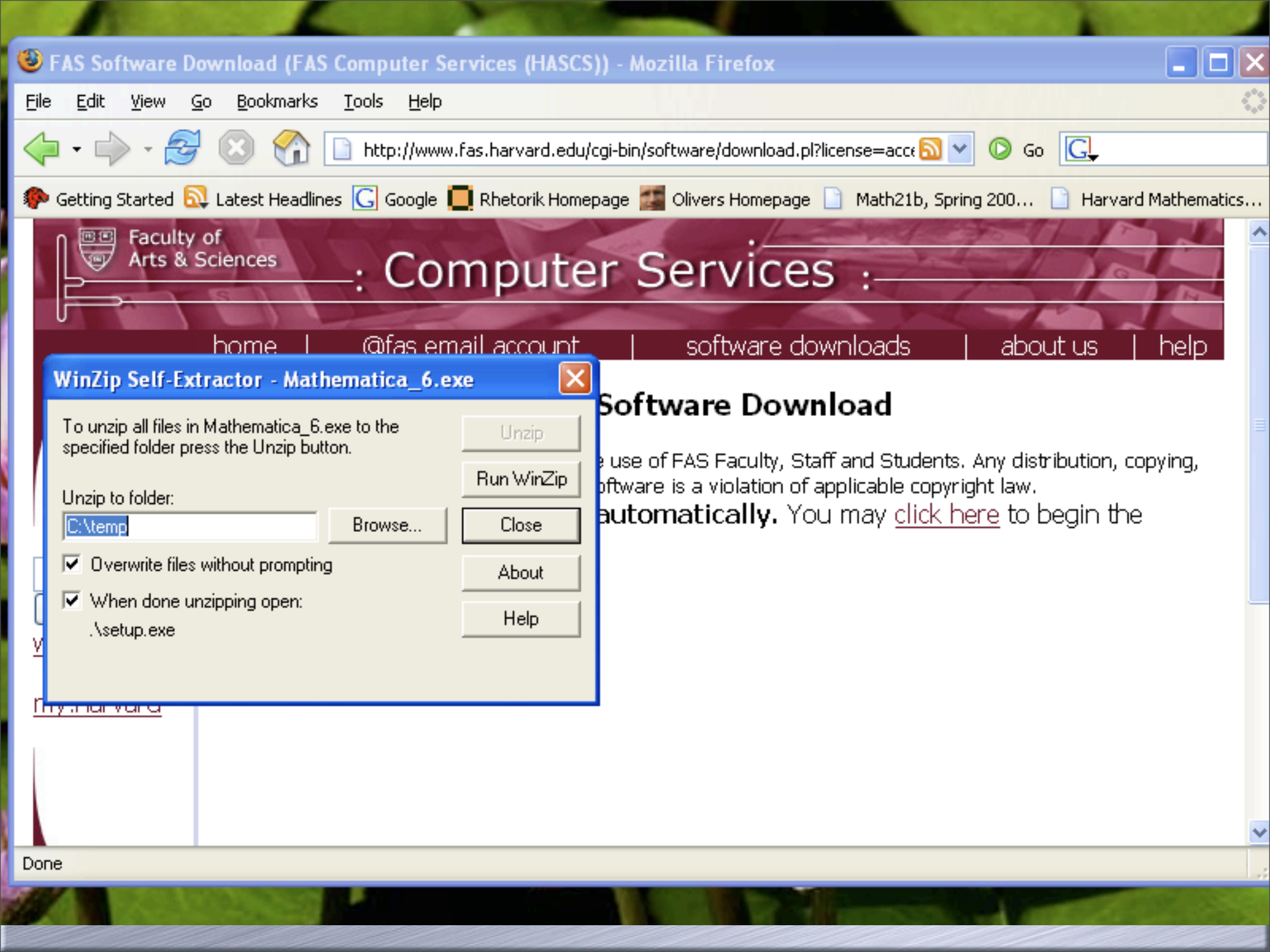
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WinZip Self-Extractor - Mathematica_6.exe
To unzip all files in Mathematica_6.exe to the specified folder press the Unzip button.
Unzip
Run WinZip
Unzip to folder:
C:\temp
Browse...
Close
Overwrite files without prompting
About
When done unzipping open:
.\setup.exe
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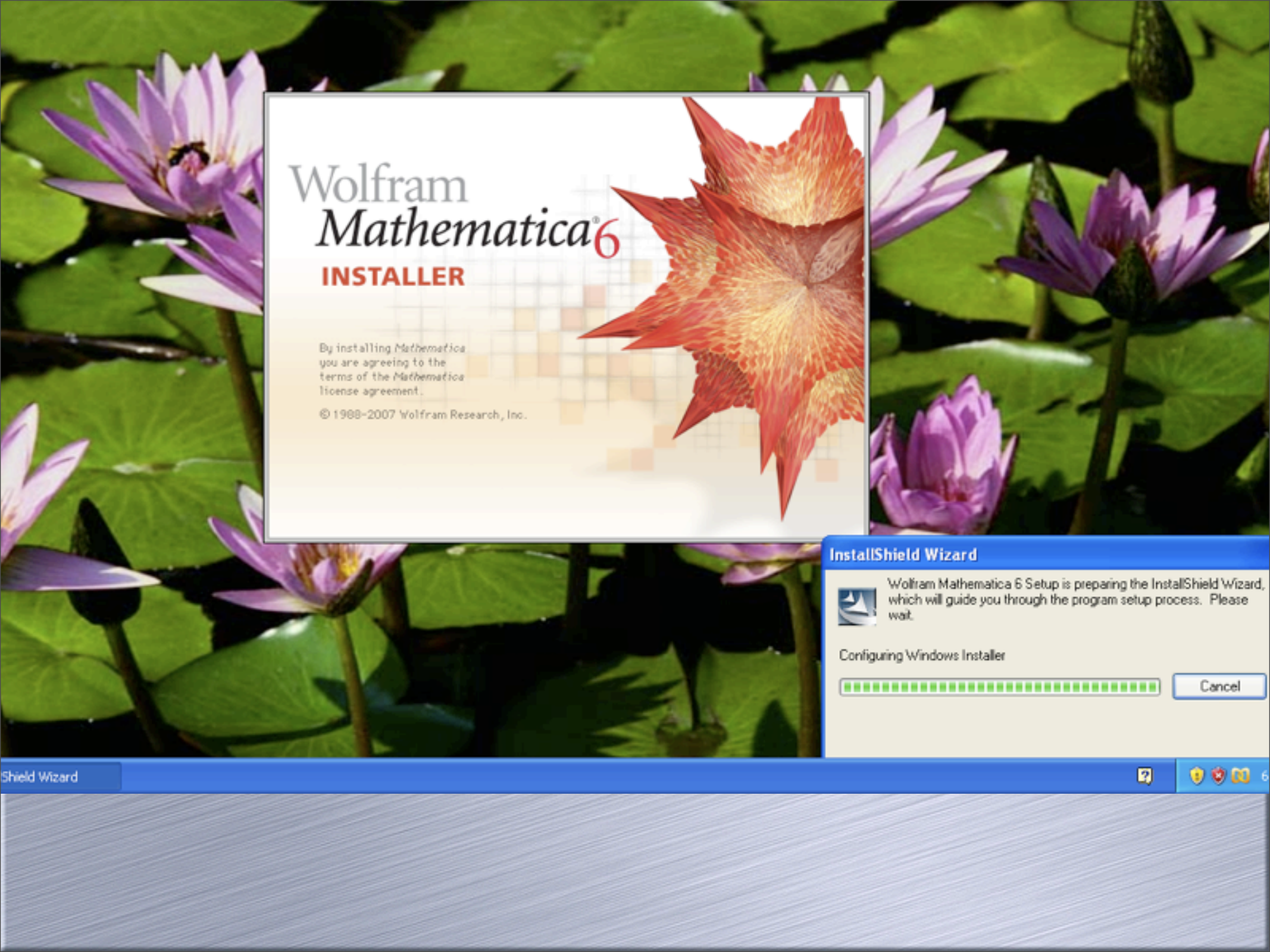
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INSTALLER
By installing Mathematica you are agreeing to the terms of the Mathematica license agreement.
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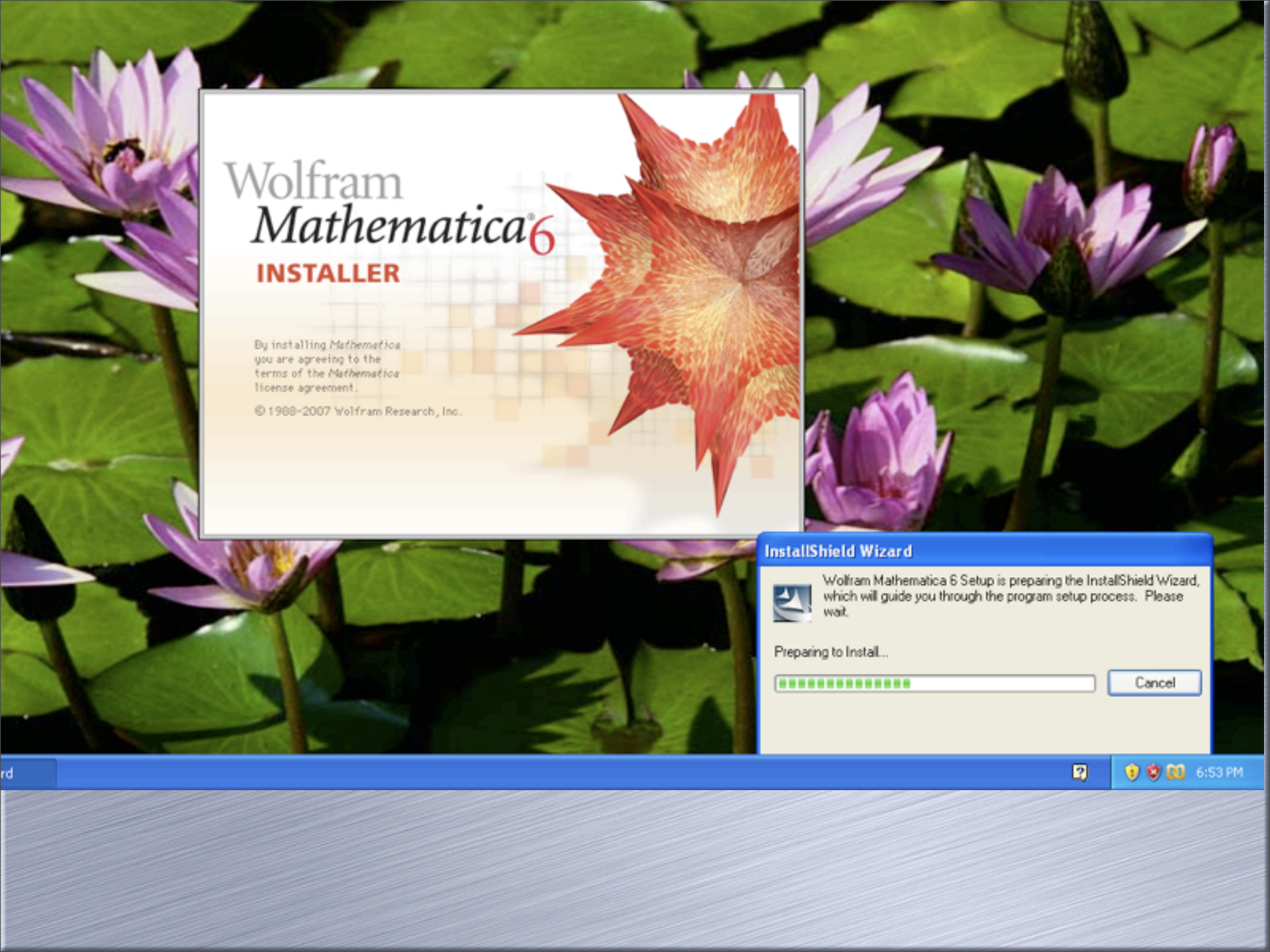
InstallShield Wizard
Wolfram Mathematica 6 Setup is preparing the InstallShield Wizard, which will guide you through the program setup process. Please wait.
Configuring Windows Installer
Cancel
Shield Wizard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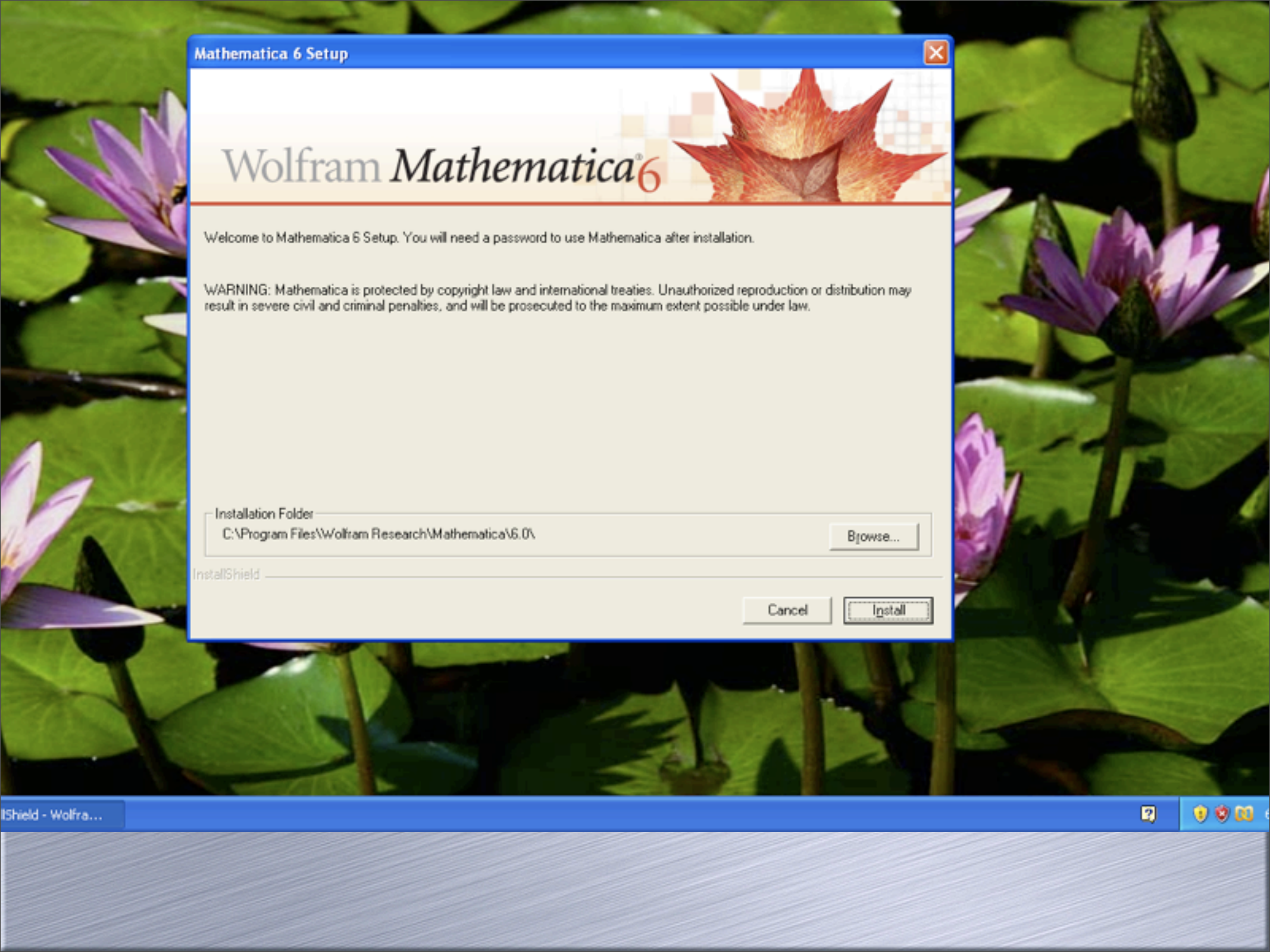
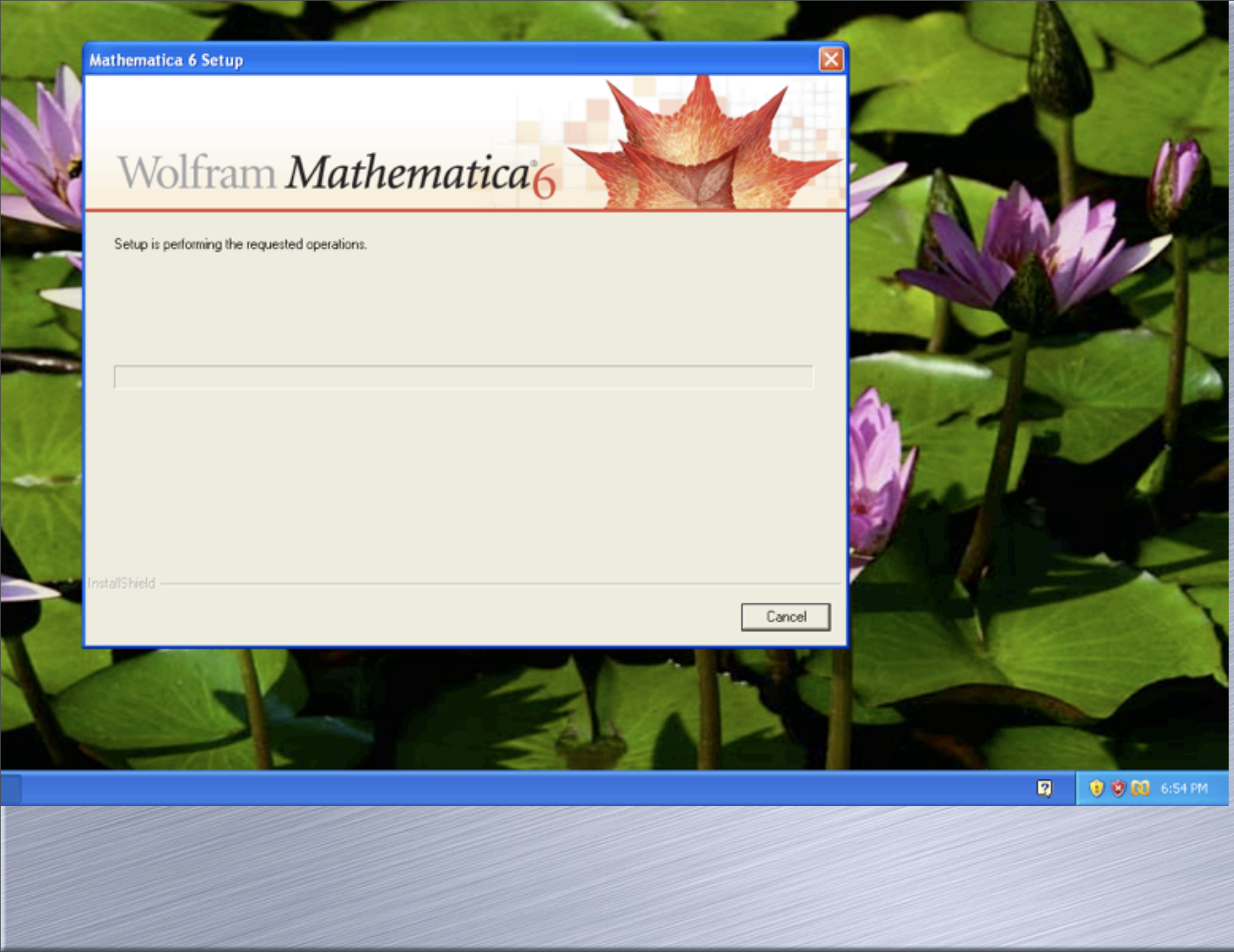
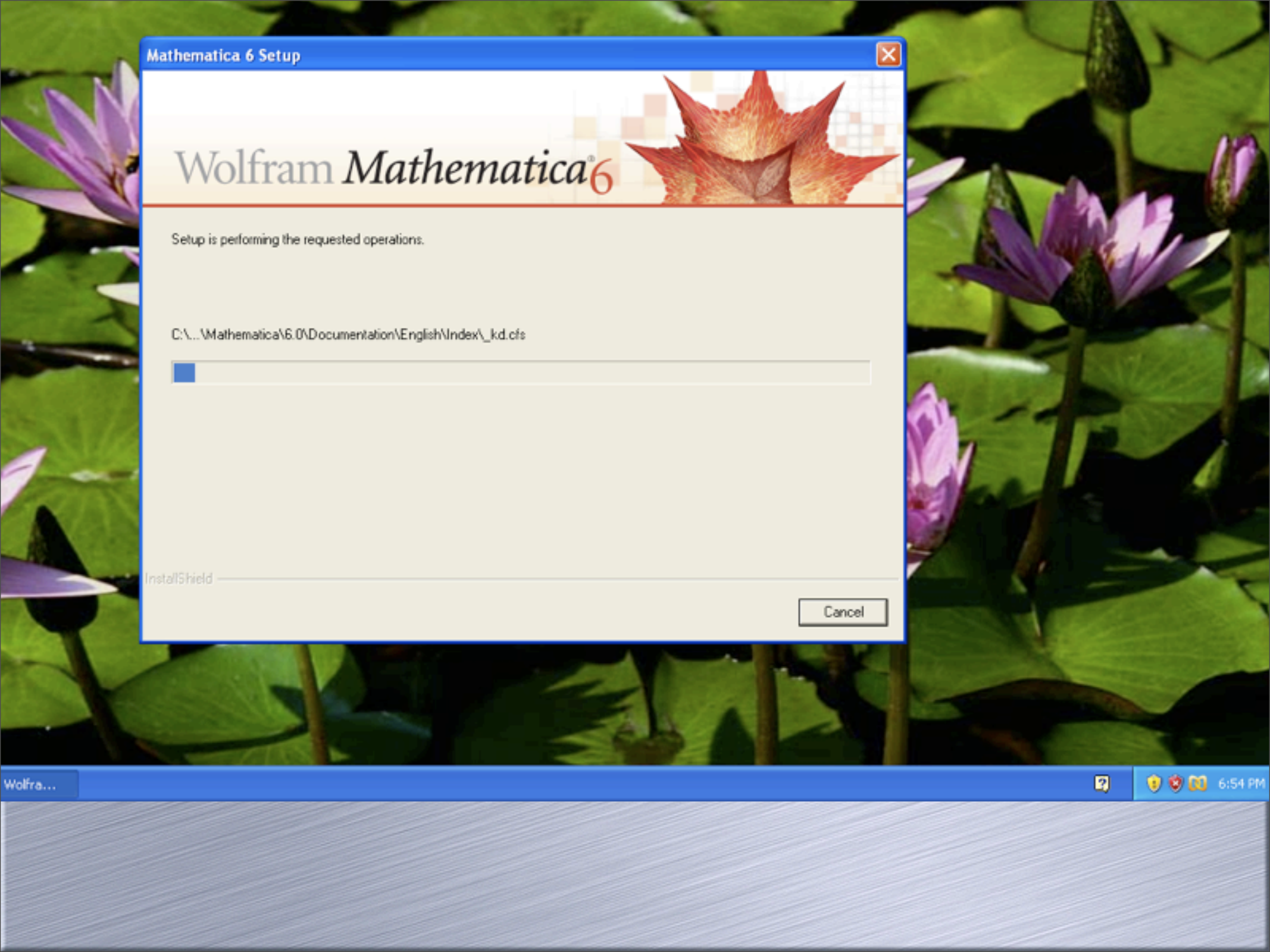
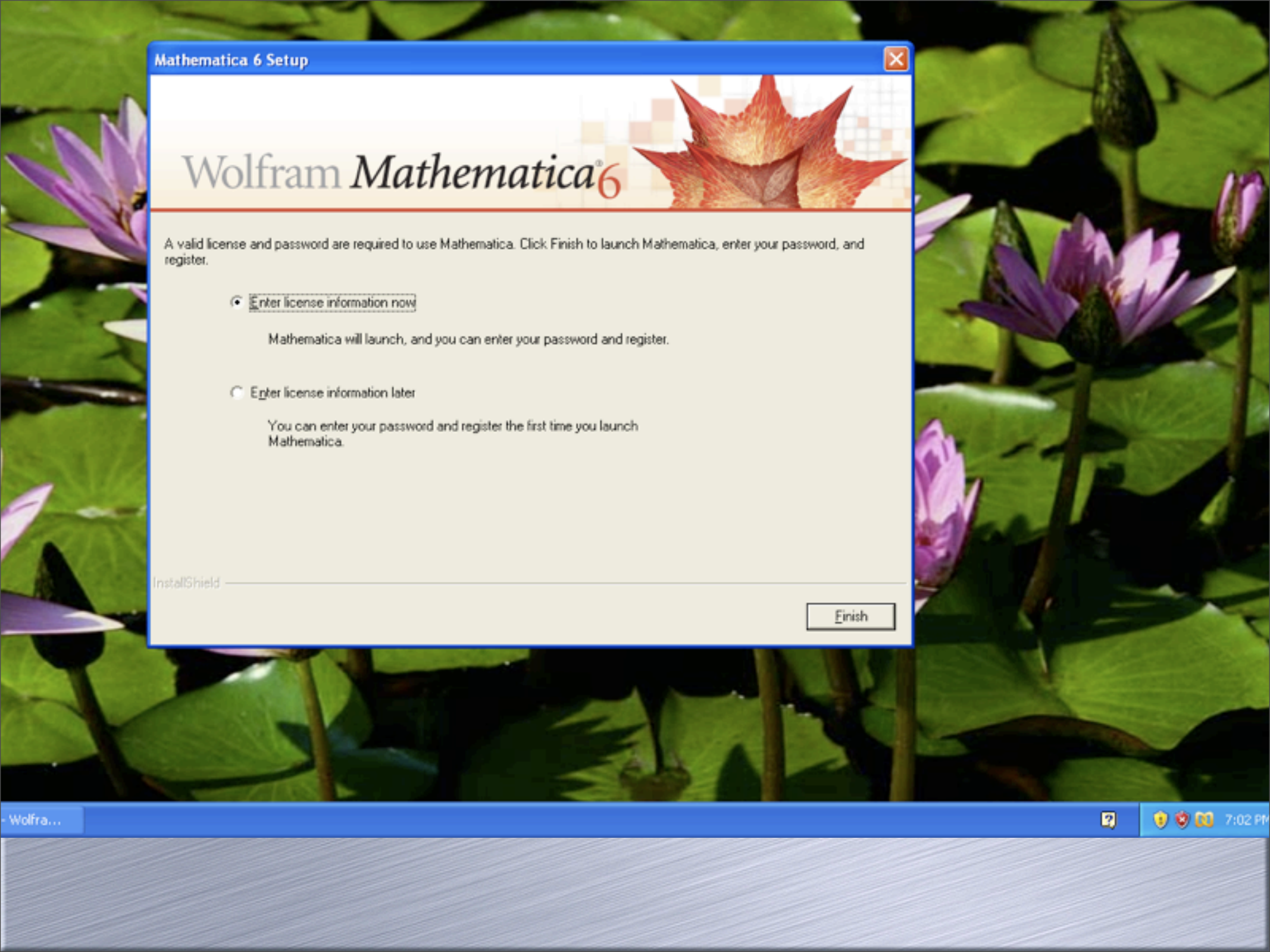
InstallShield Wizard
Wolfram Mathematica 6 Setup is preparing the InstallShield Wizard, which will guide you through the program setup process. Please wait.
Preparing to Install...
Cancel
6:53 PM

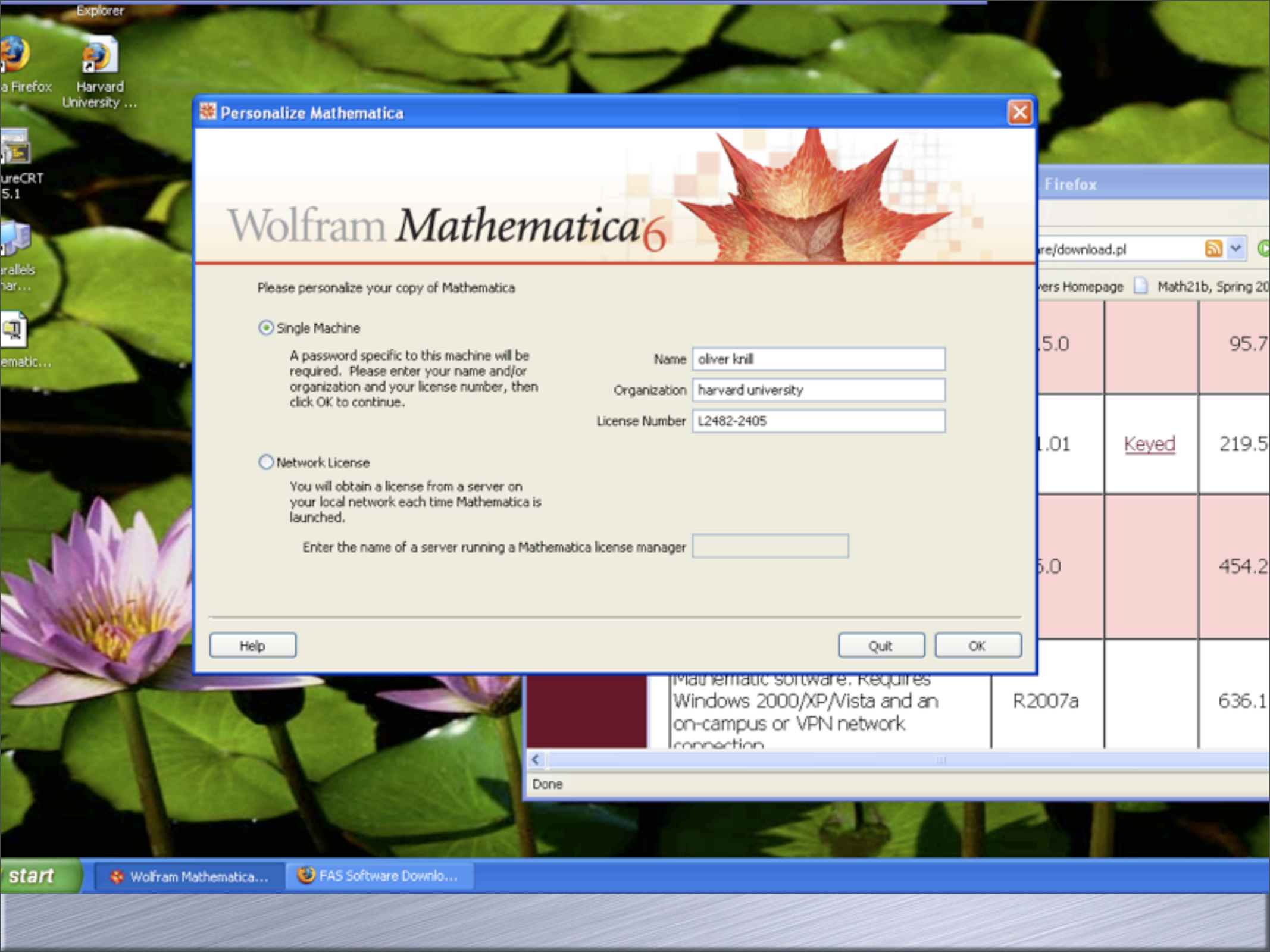

Mathematica 6 Setup
Wolfram Mathematica 6
Welcome to Mathematica 6 Setup. You will need a password to use Mathematica after installation.
WARNING: Mathematica is protected by copyright law and international treaties. Unauthorized reproduction or distribution may result in severe civil and criminal penalties, and will be prosecuted to the maximum extent possible under law.
Installation Folder
C:\Program Files\Wolfram Research\Mathematica\6.0\
Browse...
InstallShield
Cancel
Install


Mathematica 6 Setup
Wolfram Mathematica 6
Setup is performing the requested operations.
InstallShield
Cancel
6:54 PM


Mathematica 6 Setup
Wolfram Mathematica 6
Setup is performing the requested operations.
C:\...\Mathematica\6.0\Documentation\English\Index_kd.cfs
InstallShield
Cancel
Wolfra...
6:54 PM


Mathematica 6 Setup
Wolfram Mathematica 6
A valid license and password are required to use Mathematica. Click Finish to launch Mathematica, enter your password, and register.
Enter license information now
Mathematica will launch, and you can enter your password and register.
Enter license information later
You can enter your password and register the first time you launch Mathematica.
InstallShield
Finish
- Wolfra...
7:02 PM

step 3: request a password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Please personalize your copy of Mathematica
Single Machine
A password specific to this machine will be required. Please enter your name and/or organization and your license number, then click OK to continue.
Name
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License Number
L2482-2405
Network License
You will obtain a license from a server on your local network each time Mathematica is launched.
Enter the name of a server running a Mathematica license manager
Help
Quit
OK
Firefox
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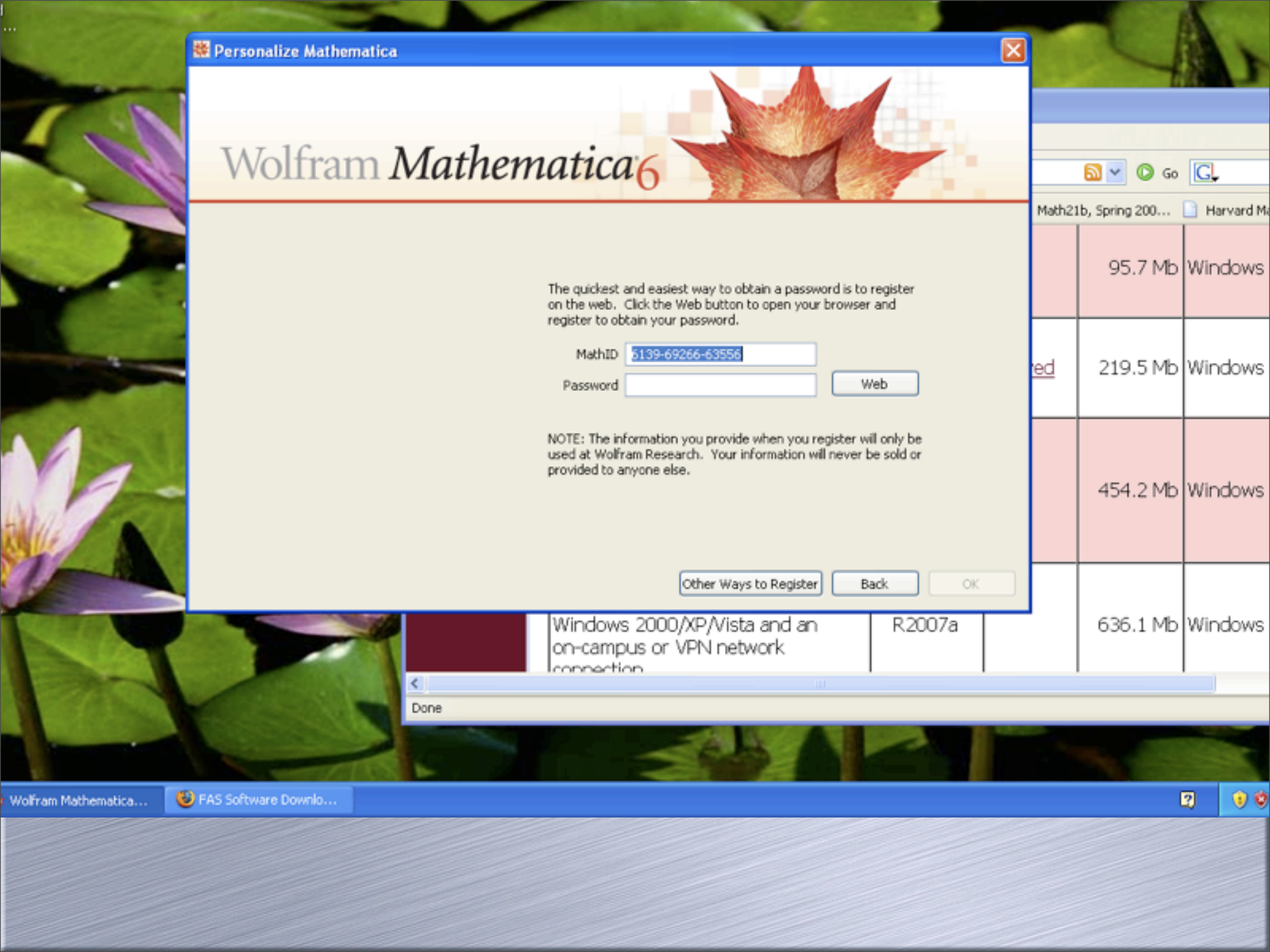
Windows 2000/XP/Vista and an on-campus or VPN network
R2007a
Done
start
Wolfram Mathematica...
FAS Software Downlo...


Personalize Mathematica
Wolfram Mathematica 6
The quickest and easiest way to obtain a password is to register on the web. Click the Web button to open your browser and register to obtain your password.
MathID
6139-69266-63556
Password
Web
NOTE: The information you provide when you register will only be used at Wolfram Research. Your information will never be sold or provided to anyone else.
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636.1 Mb
Windows
Windows 2000/XP/Vista and an on-campus or VPN network
R2007a
Done
Wolfram Mathematica...
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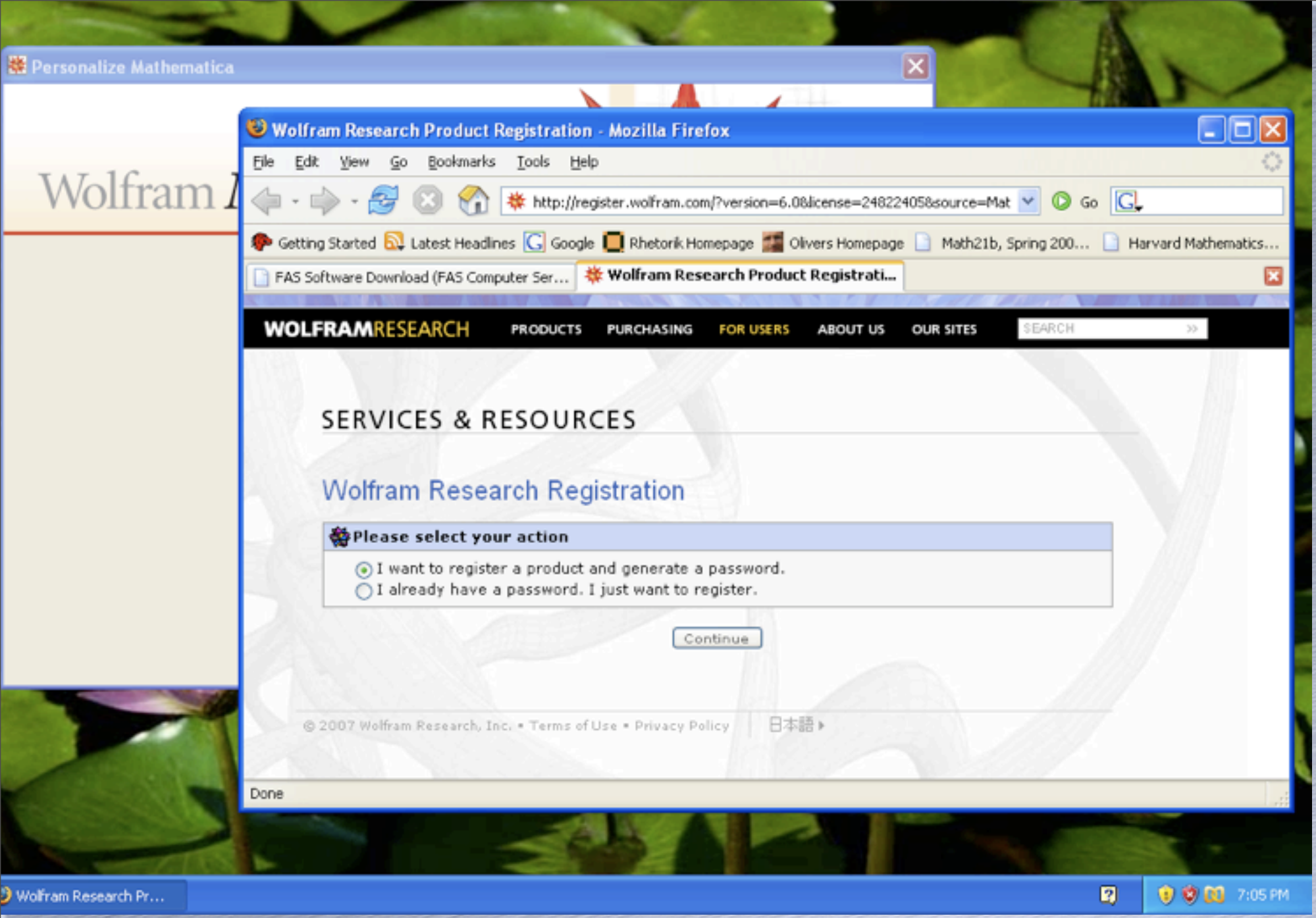
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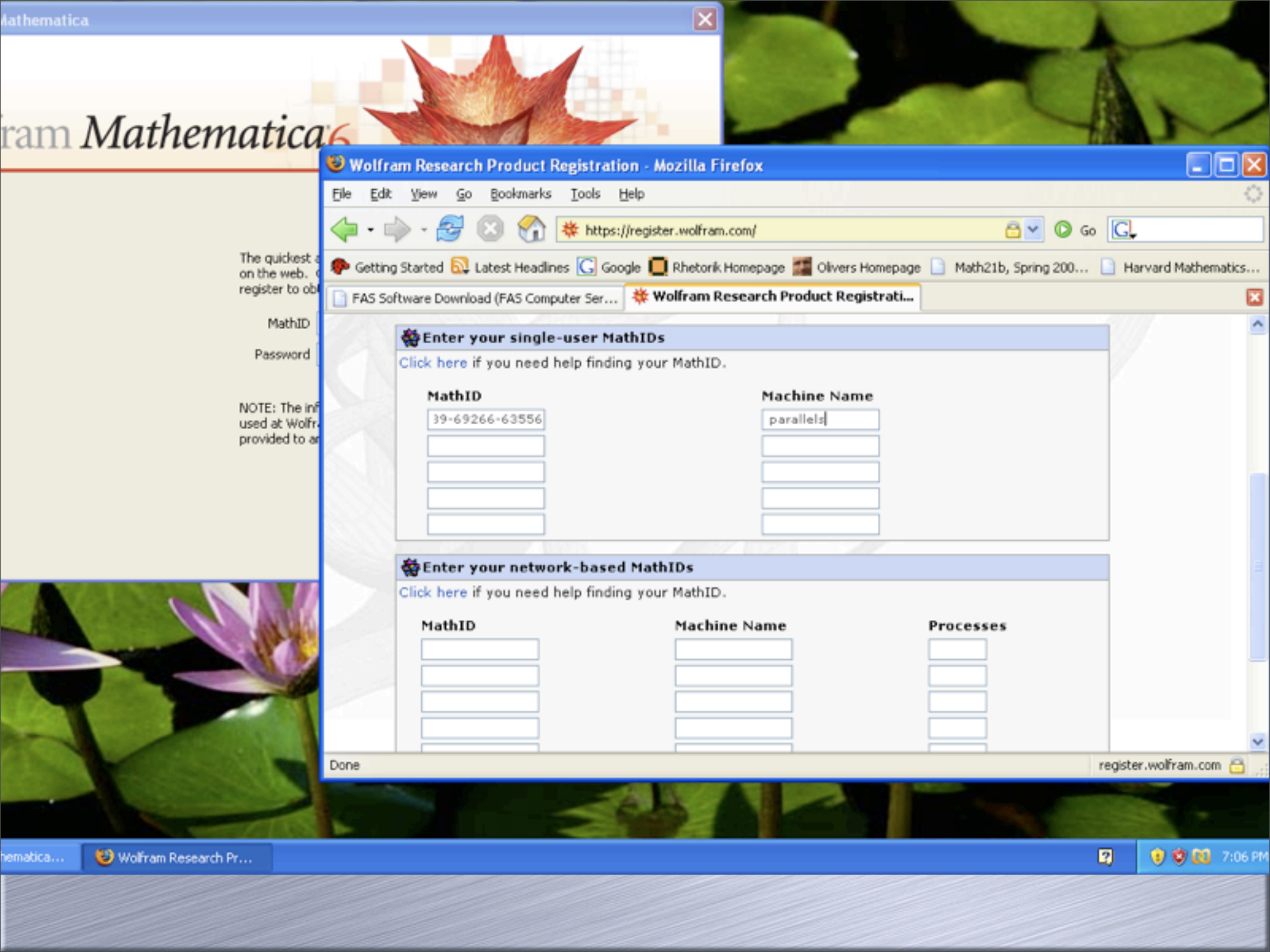
7:05 PM


Mathematica
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The quickest
on the web.
register to ob
MathID
Password
NOTE: The inf
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provided to a
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Done
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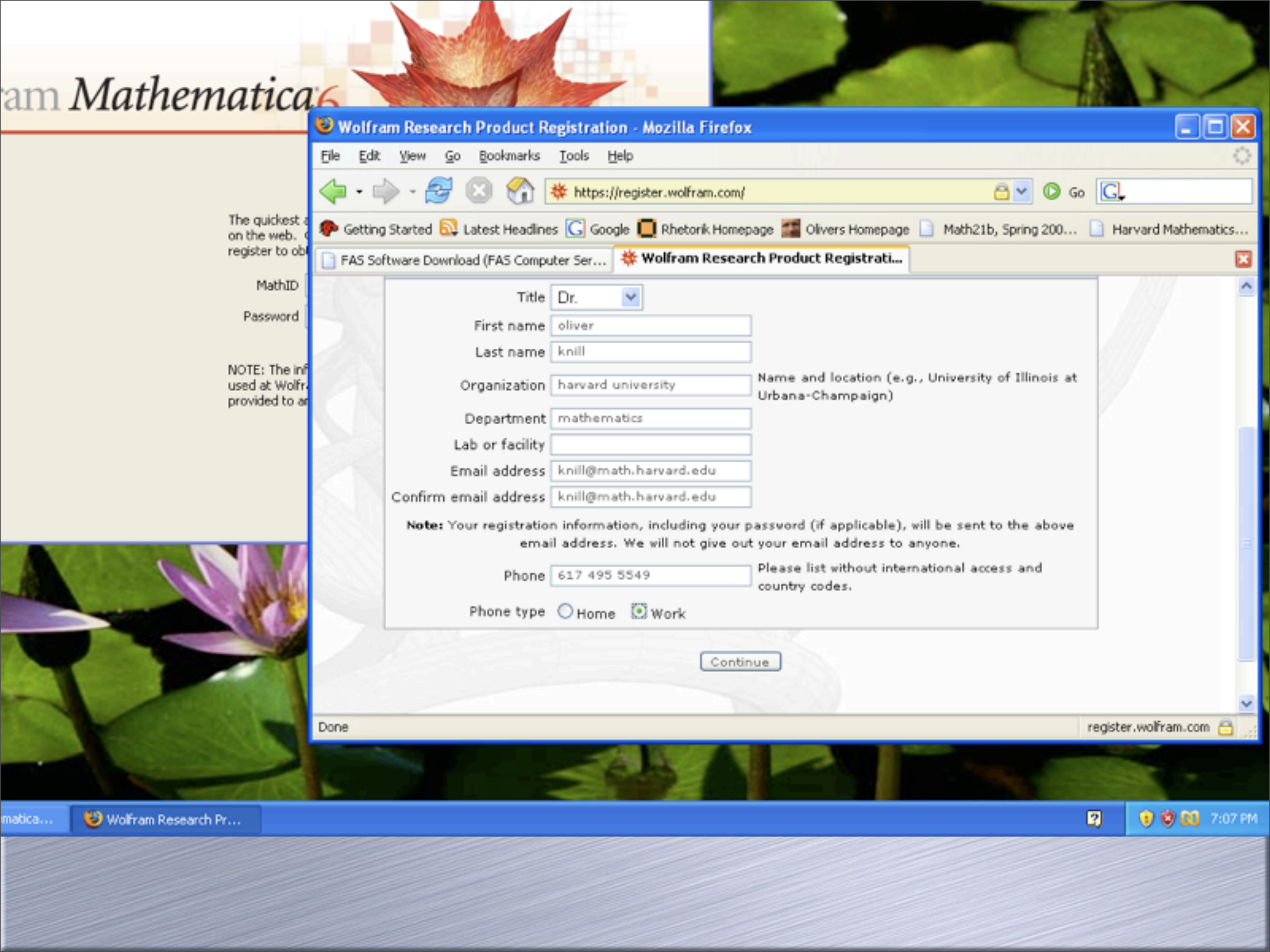
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The quickest
on the web.
register to ob
MathID
Password
NOTE: The inf
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Title Dr.
First name oliver
Last name knill
Organization harvard university
Name and location (e.g., University of Illinois at Urbana-Champaign)
Department mathematics
Lab or facility
Email address knill@math.harvard.edu
Confirm email address knill@math.harvard.edu
Note: Your registration information, including your password (if applicable), will be sent to the above email address. We will not give out your email address to anyone.
Phone 617 495 5549
Please list without international access and country codes.
Phone type Home Work
Continue
Done
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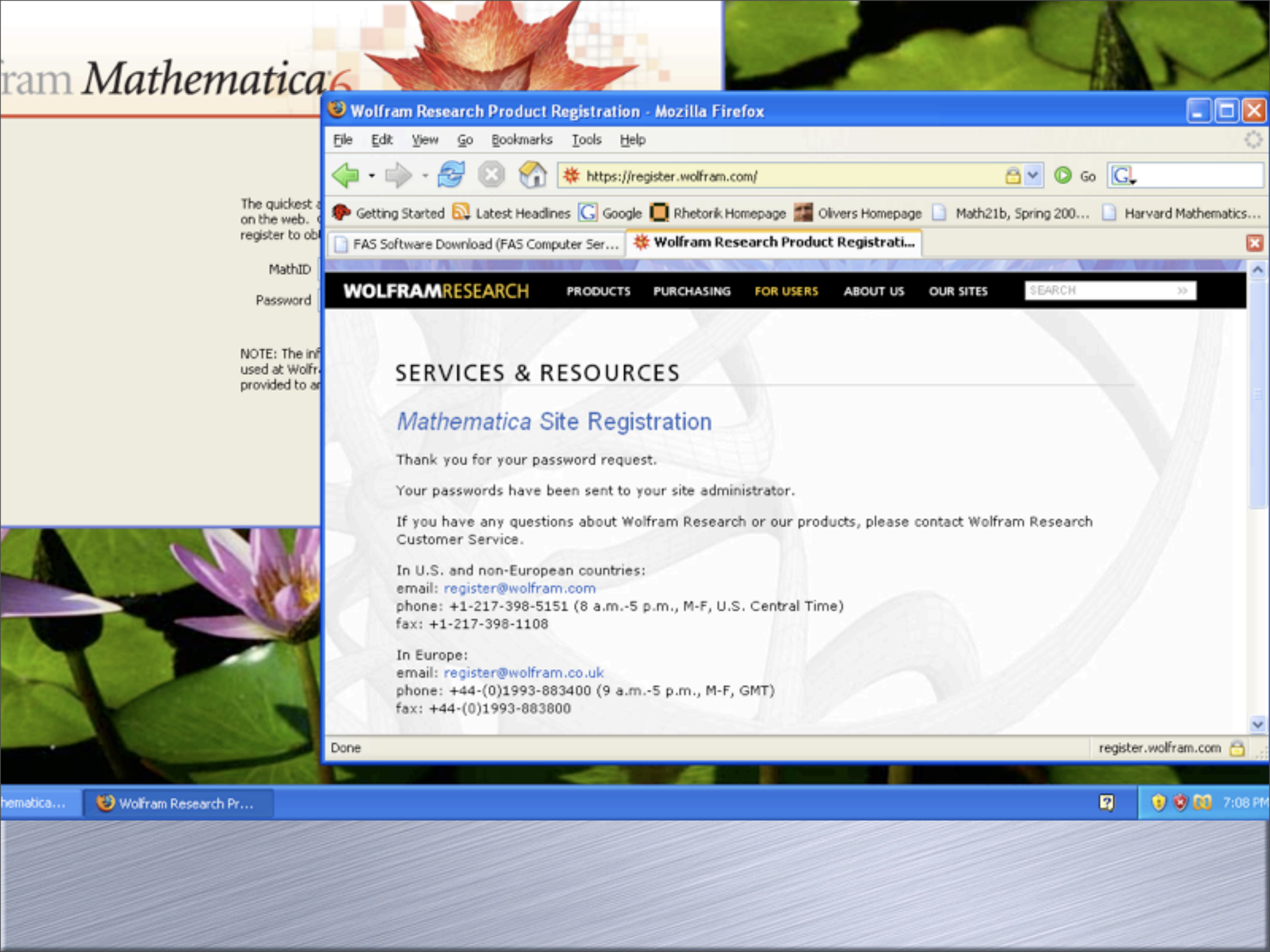
ram Mathematica 6
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NOTE: The inf
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fax: +44-(0)1993-883800
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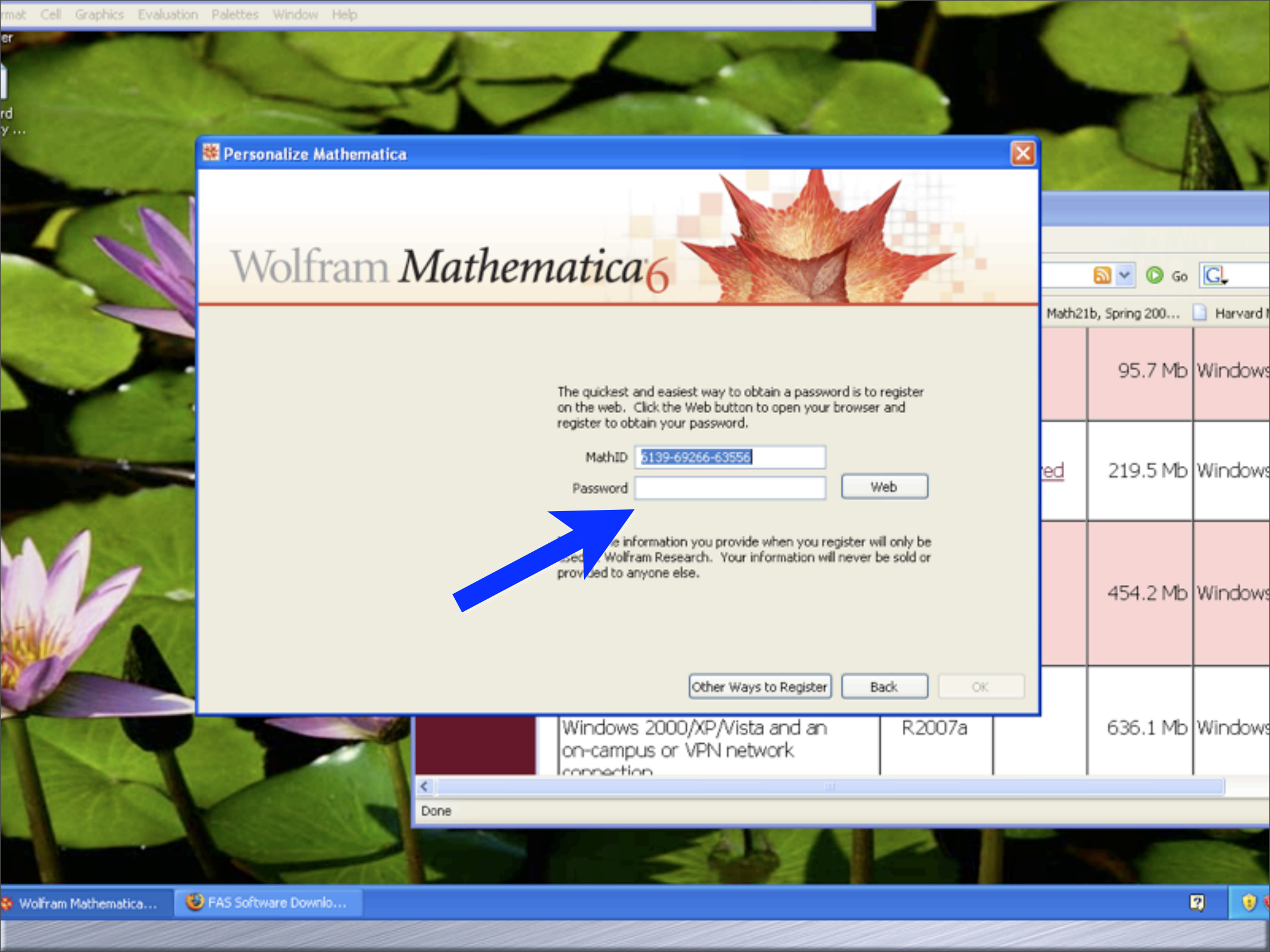
Wolfram Research Pr...
7:08 PM

step 4:
enter the password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The quickest and easiest way to obtain a password is to register on the web. Click the Web button to open your browser and register to obtain your password.
MathID
6139-69266-63556
Password
Web
Other Ways to Register
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OK
Windows 2000/XP/Vista and an on-campus or VPN network
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636.1 Mb
Done
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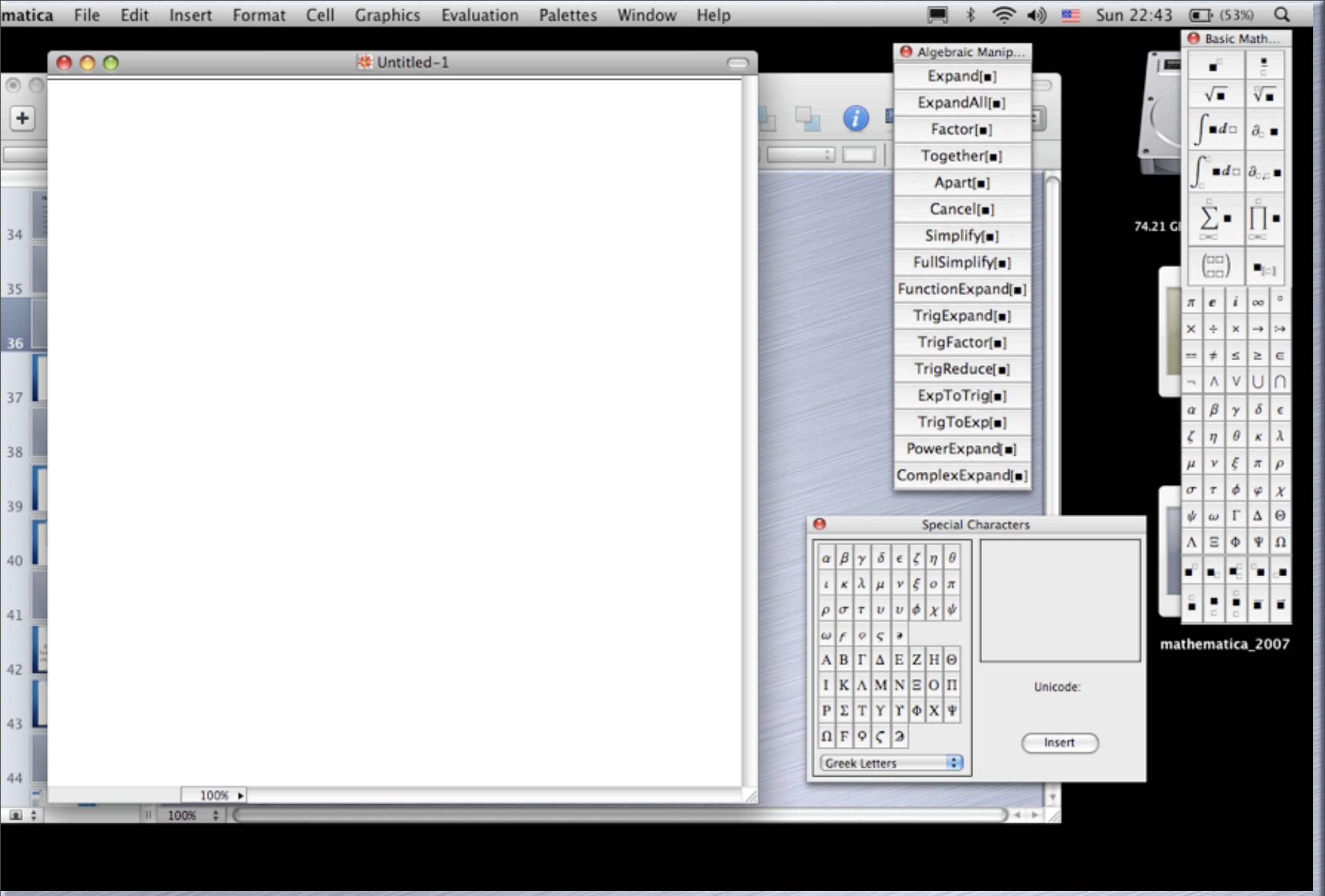
FAS Software Downlo...

the user interface

- notebooks
- cells
- submitting commands
- the menu
- stopping the kernel
- saving the notebook

notebooks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(53%)
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Expand[■]
ExpandAll[■]
Factor[■]
Together[■]
Apart[■]
Cancel[■]
Simplify[■]
FullSimplify[■]
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TrigExpand[■]
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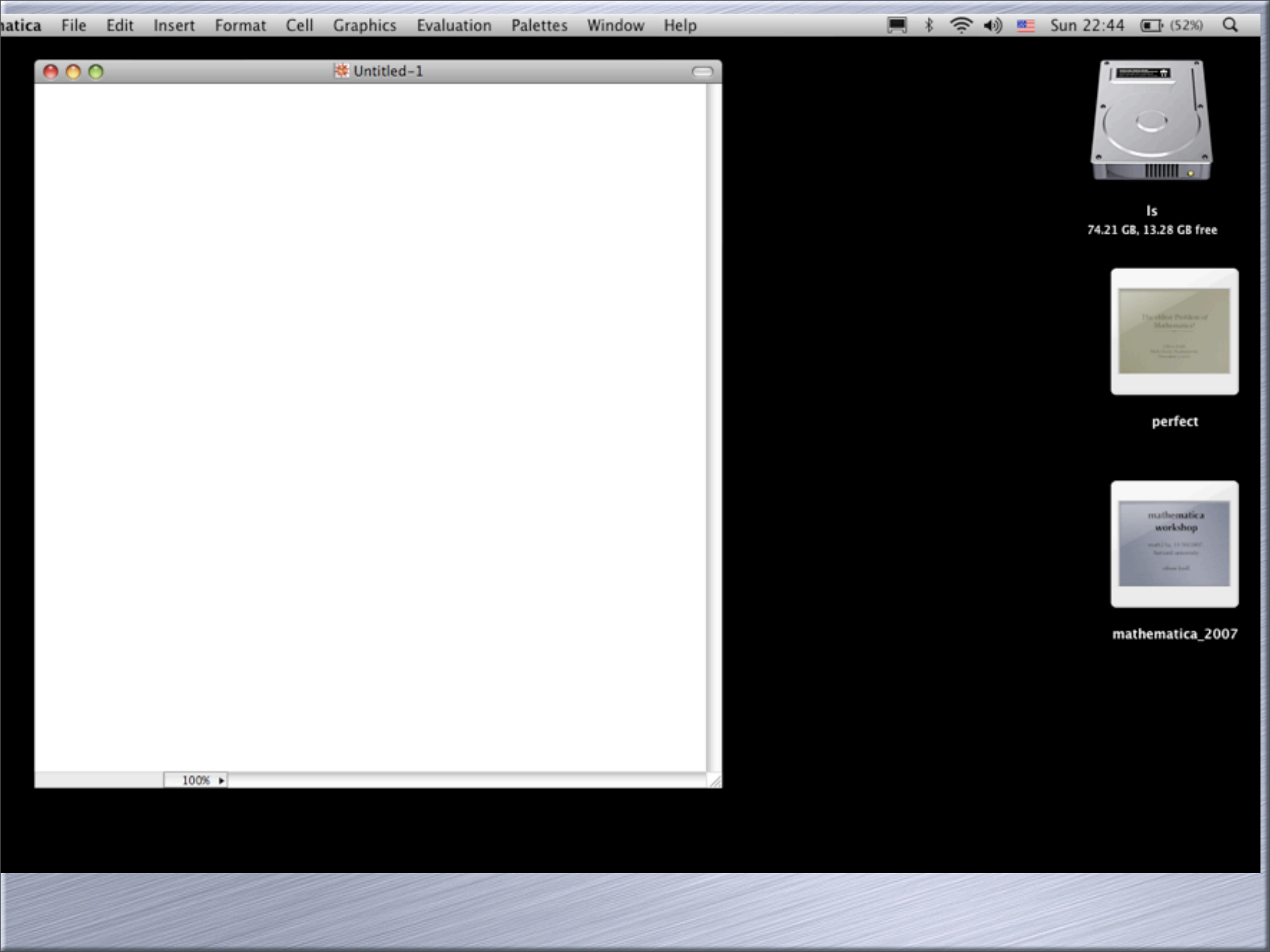
100%
mathematica_2007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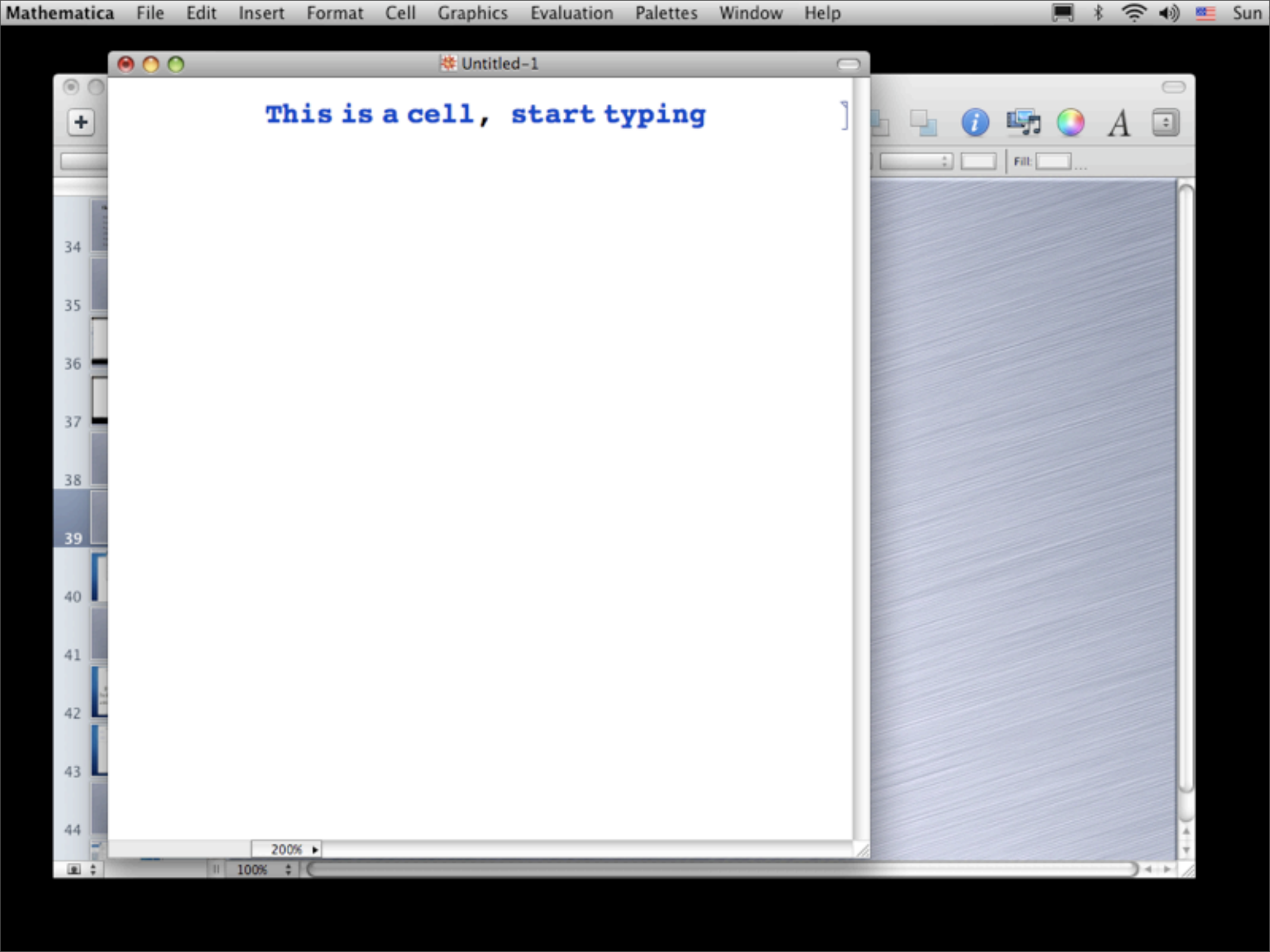
mathematica workshop
mathematica_2007

cells


Mathematica File Edit Insert Format Cell Graphics Evaluation Palettes Window Help
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Untitled-1
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34
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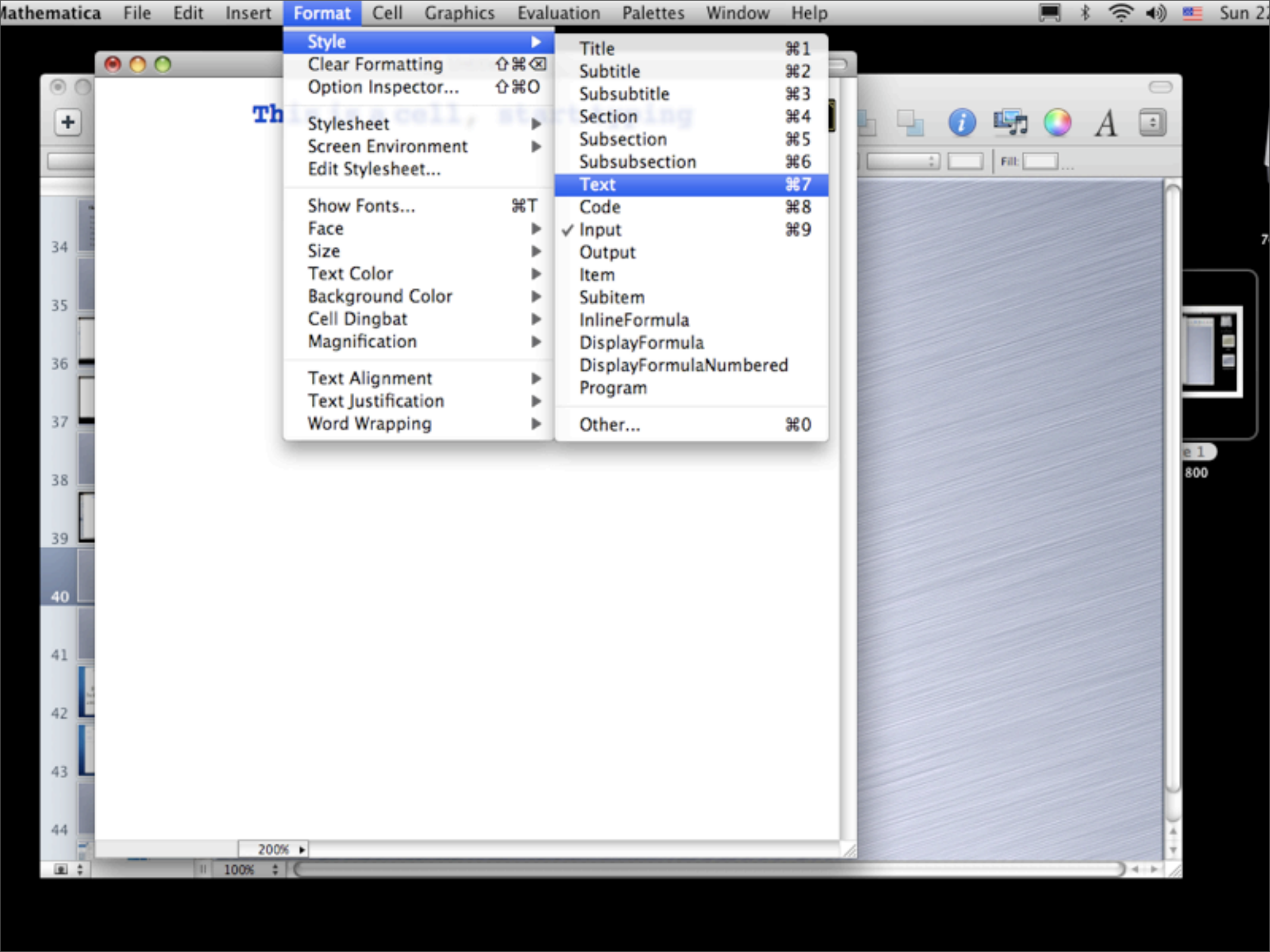
Mathematica File Edit Insert Format Cell Graphics Evaluation Palettes Window Help
Style
Clear Formatting ⇧⌘⌫
Option Inspector... ⇧⌘O
Stylesheet
Screen Environment
Edit Stylesheet...
Show Fonts... ⌘T
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Background Color
Cell Dingbat
Magnification
Text Alignment
Text Justification
Word Wrapping
Title ⌘1
Subtitle ⌘2
Subsubtitle ⌘3
Section ⌘4
Subsection ⌘5
Subsubsection ⌘6
Text ⌘7
Code ⌘8
Input ⌘9
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200%
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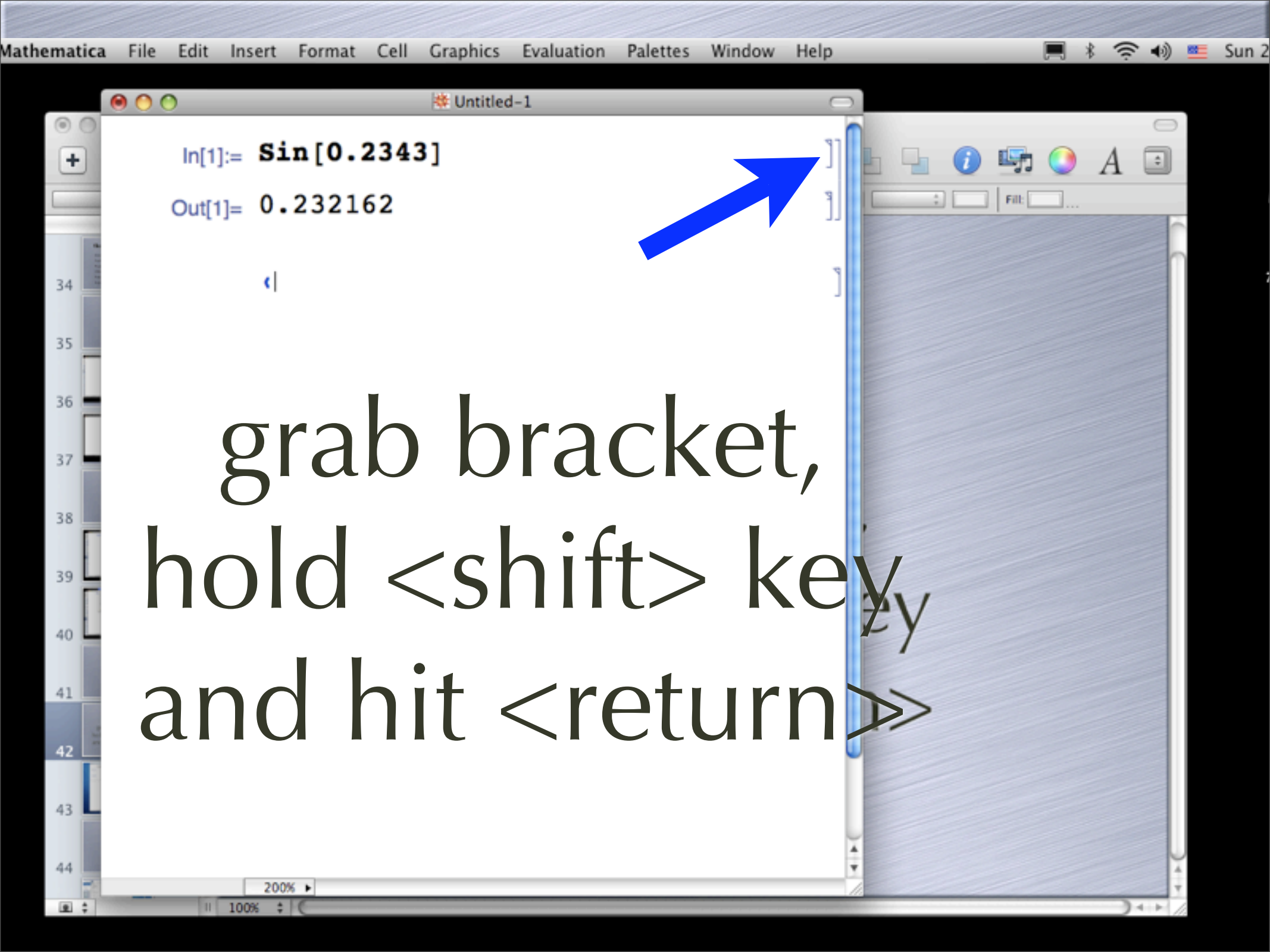
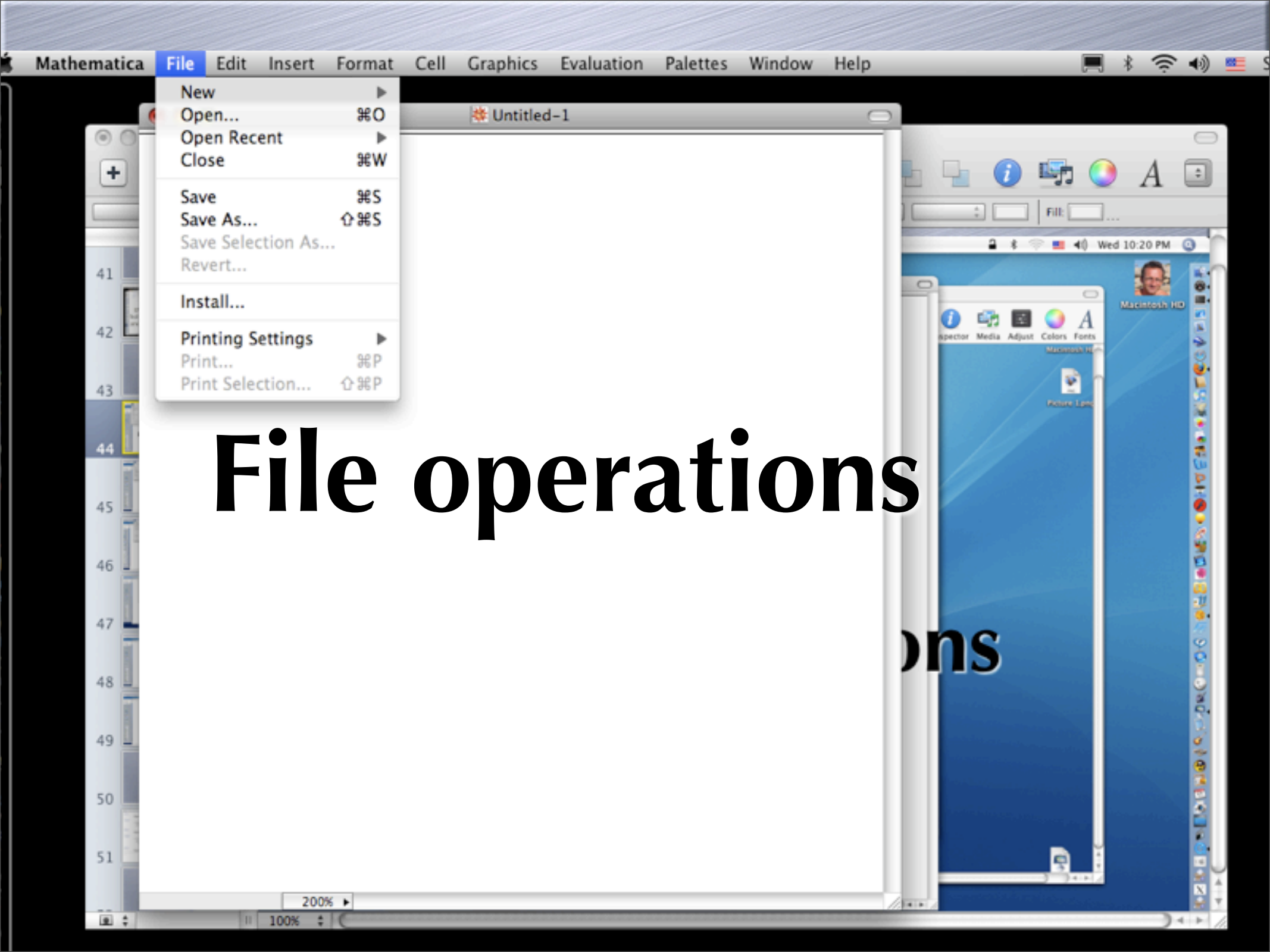
submitting commands


Mathematica File Edit Insert Format Cell Graphics Evaluation Palettes Window Help
Untitled-1
In[1]:= Sin[0.2343]
Out[1]= 0.232162
grab bracket,
hold <shift> key
and hit <return>
200%
100%

the menu


Mathematica
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Save As... ⇧⌘S
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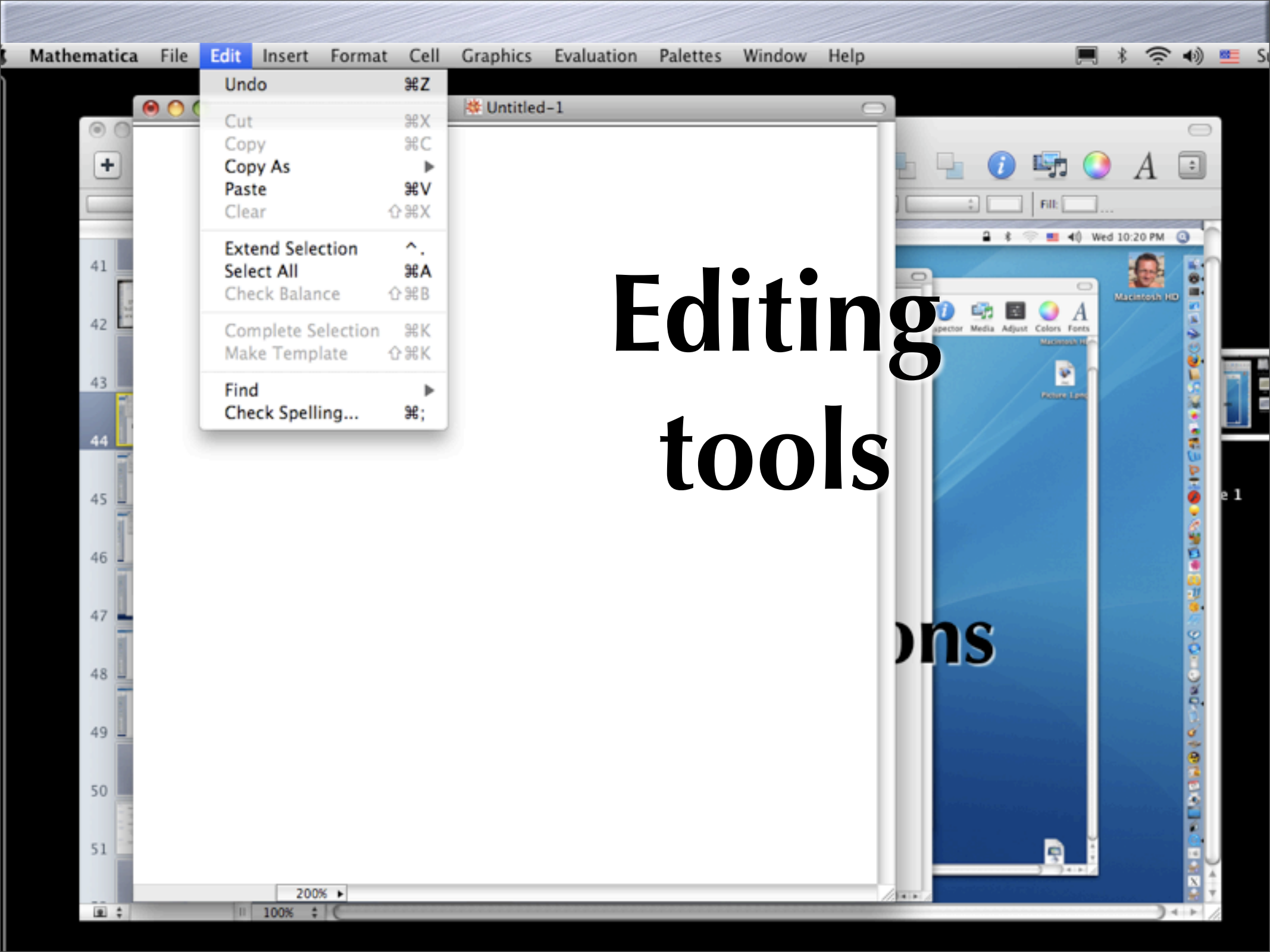
Mathematica File Edit Insert Format Cell Graphics Evaluation Palettes Window Help
Undo ⌘Z
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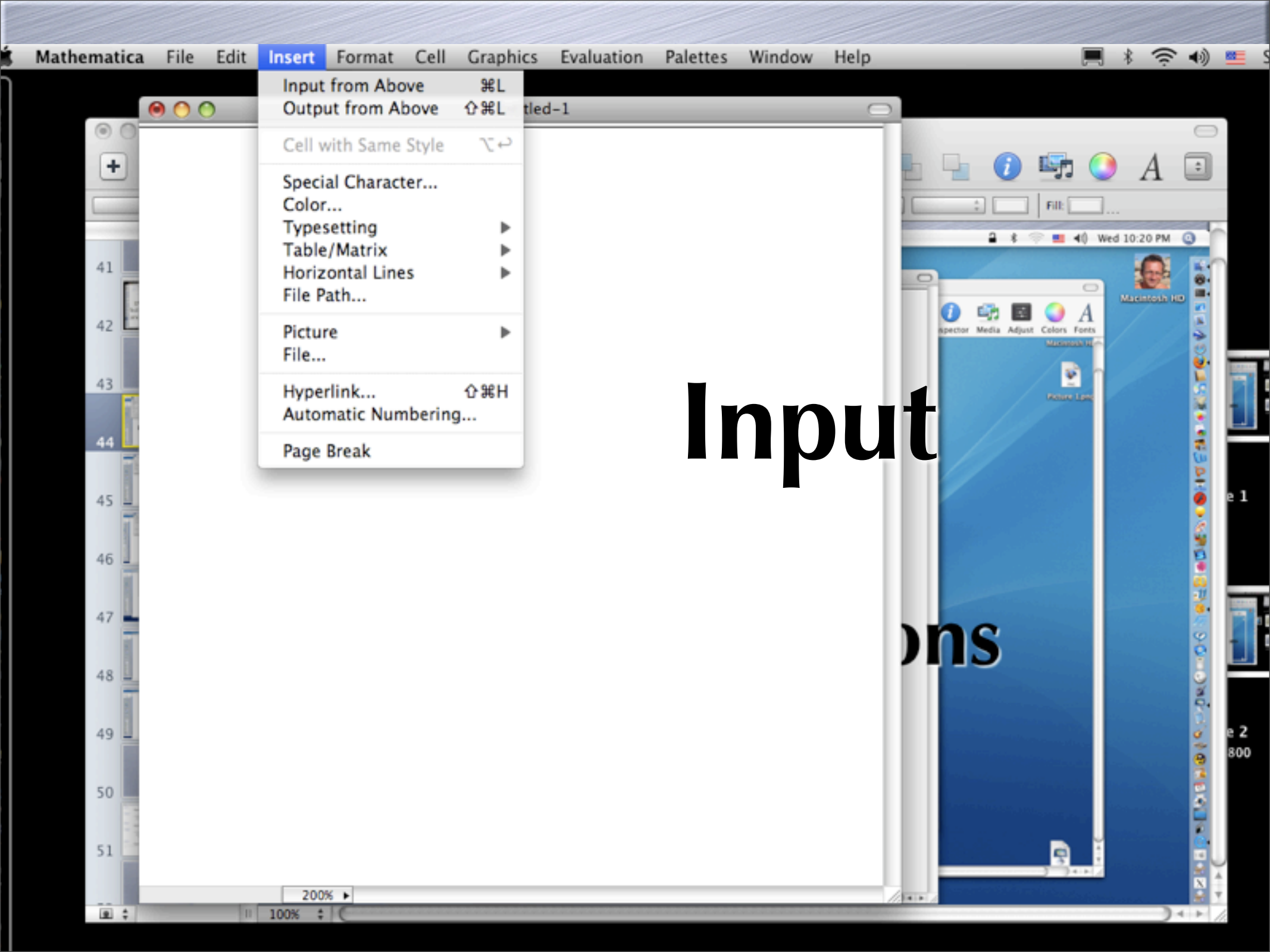
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Output from Above ⇧⌘L
Cell with Same Style ⌥↩
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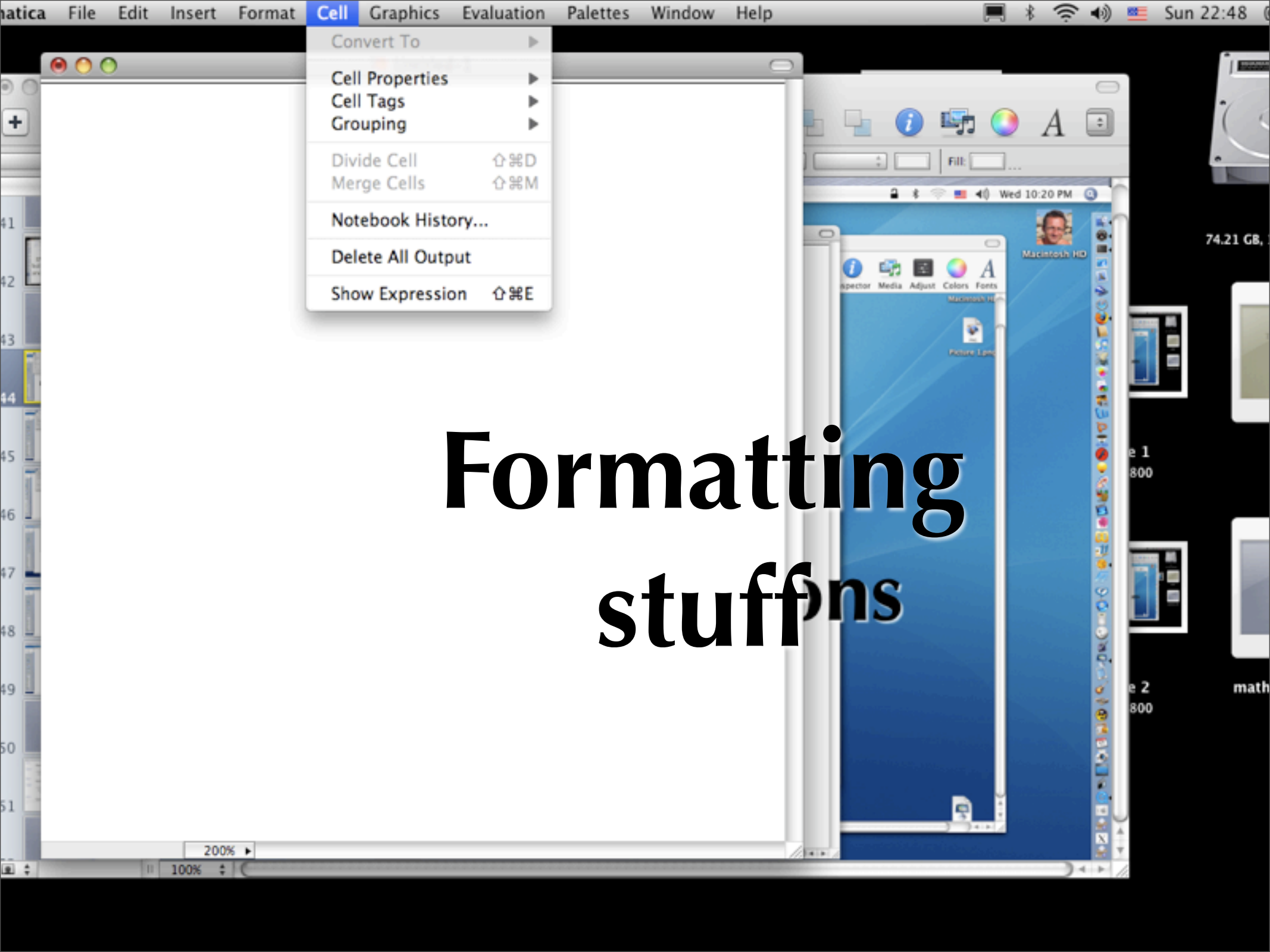
File Edit Insert Format Cell Graphics Evaluation Palettes Window Help
Sun 22:48
Convert To
Cell Properties
Cell Tags
Grouping
Divide Cell ⇧⌘D
Merge Cells ⇧⌘M
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Delete All Output
Show Expression ⇧⌘E
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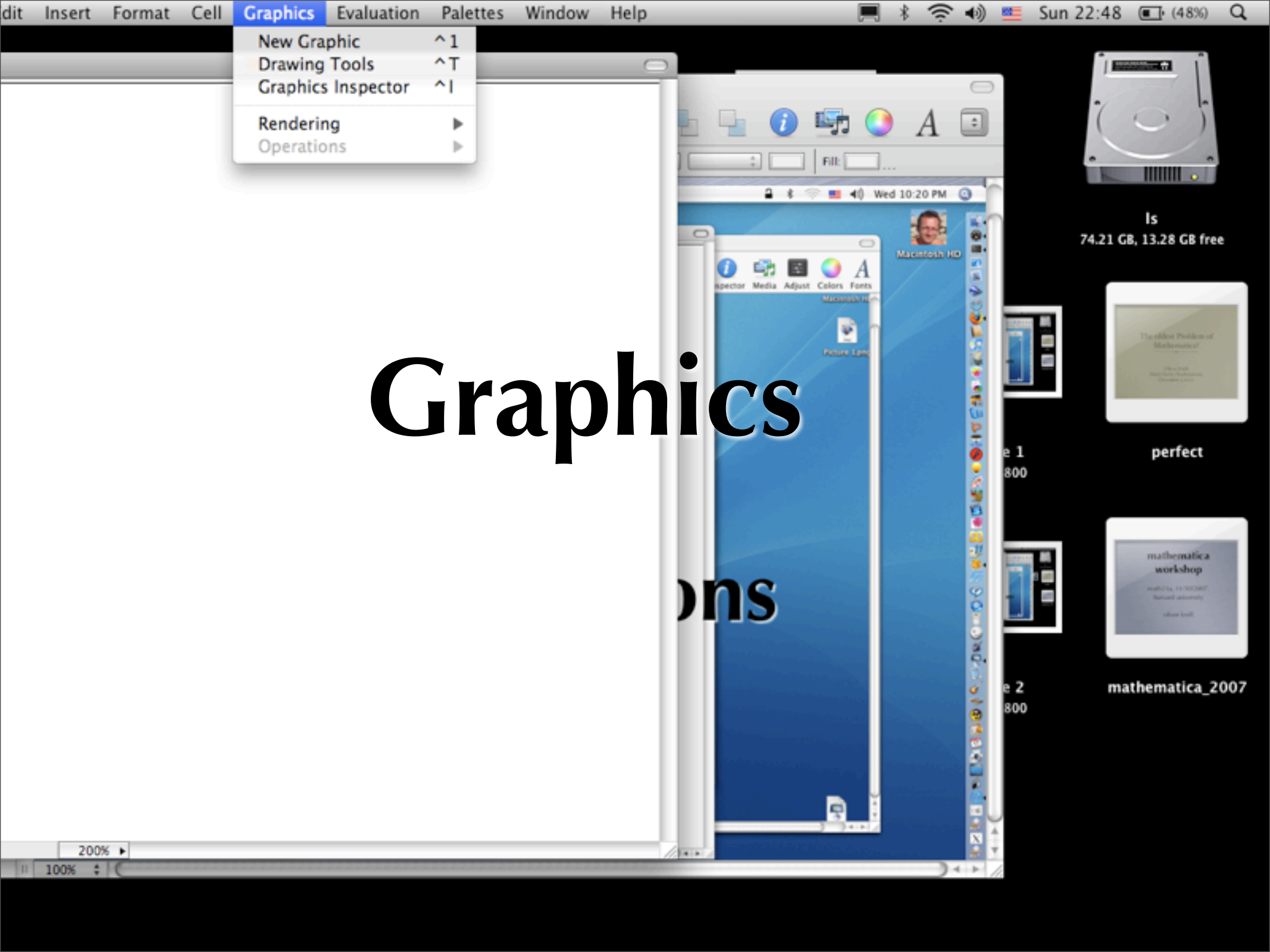
dit Insert Format Cell Graphics Evaluation Palettes Window Help
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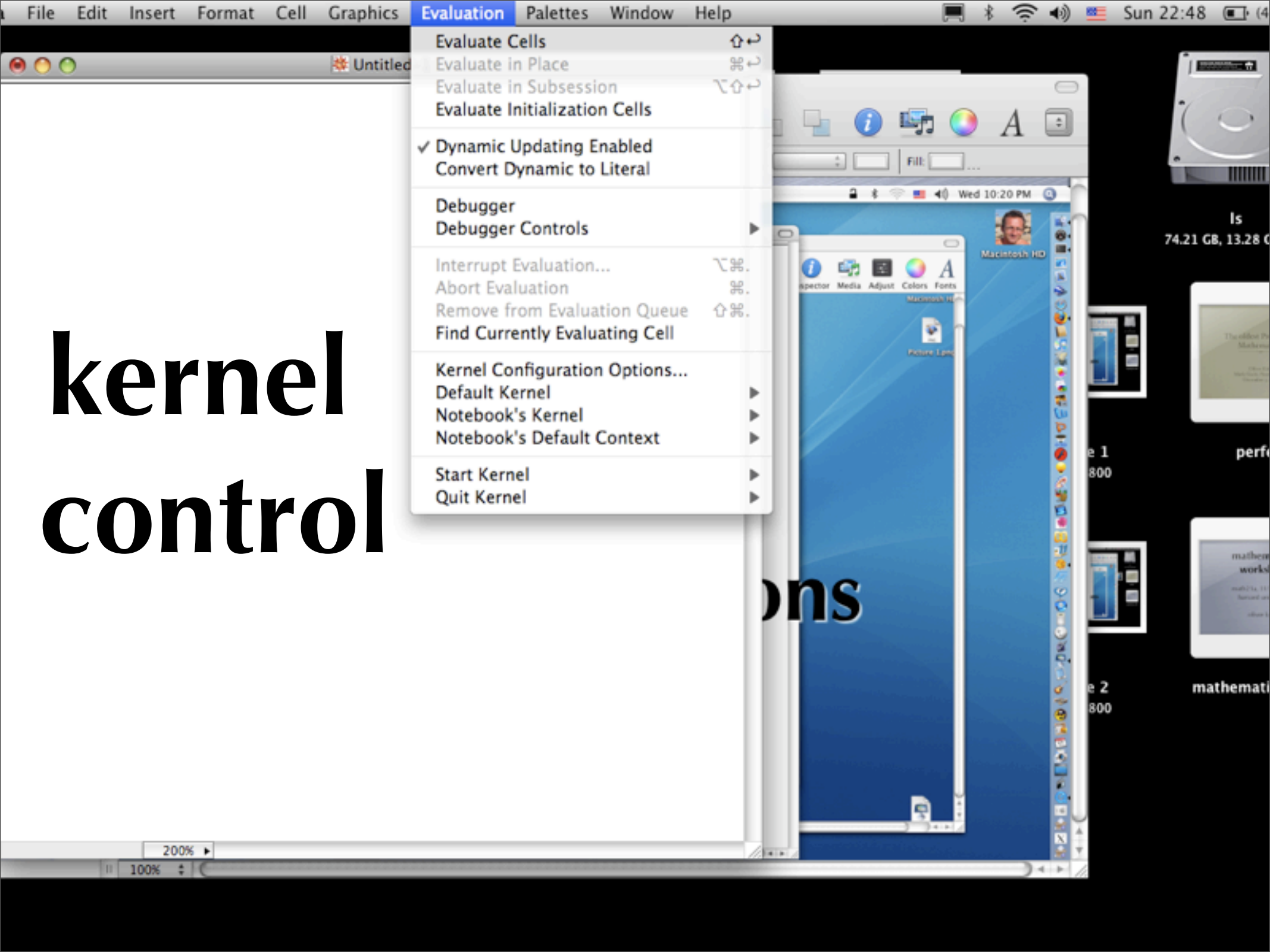
kernel
control
File Edit Insert Format Cell Graphics Evaluation Palettes Window Help
Sun 22:48
Evaluate Cells
Evaluate in Place
Evaluate in Subsession
Evaluate Initialization Cells
Dynamic Updating Enabled
Convert Dynamic to Literal
Debugger
Debugger Controls
Interrupt Evaluation...
Abort Evaluation
Remove from Evaluation Queue
Find Currently Evaluating Cell
Kernel Configuration Options...
Default Kernel
Notebook's Kernel
Notebook's Default Context
Start Kernel
Quit Kernel
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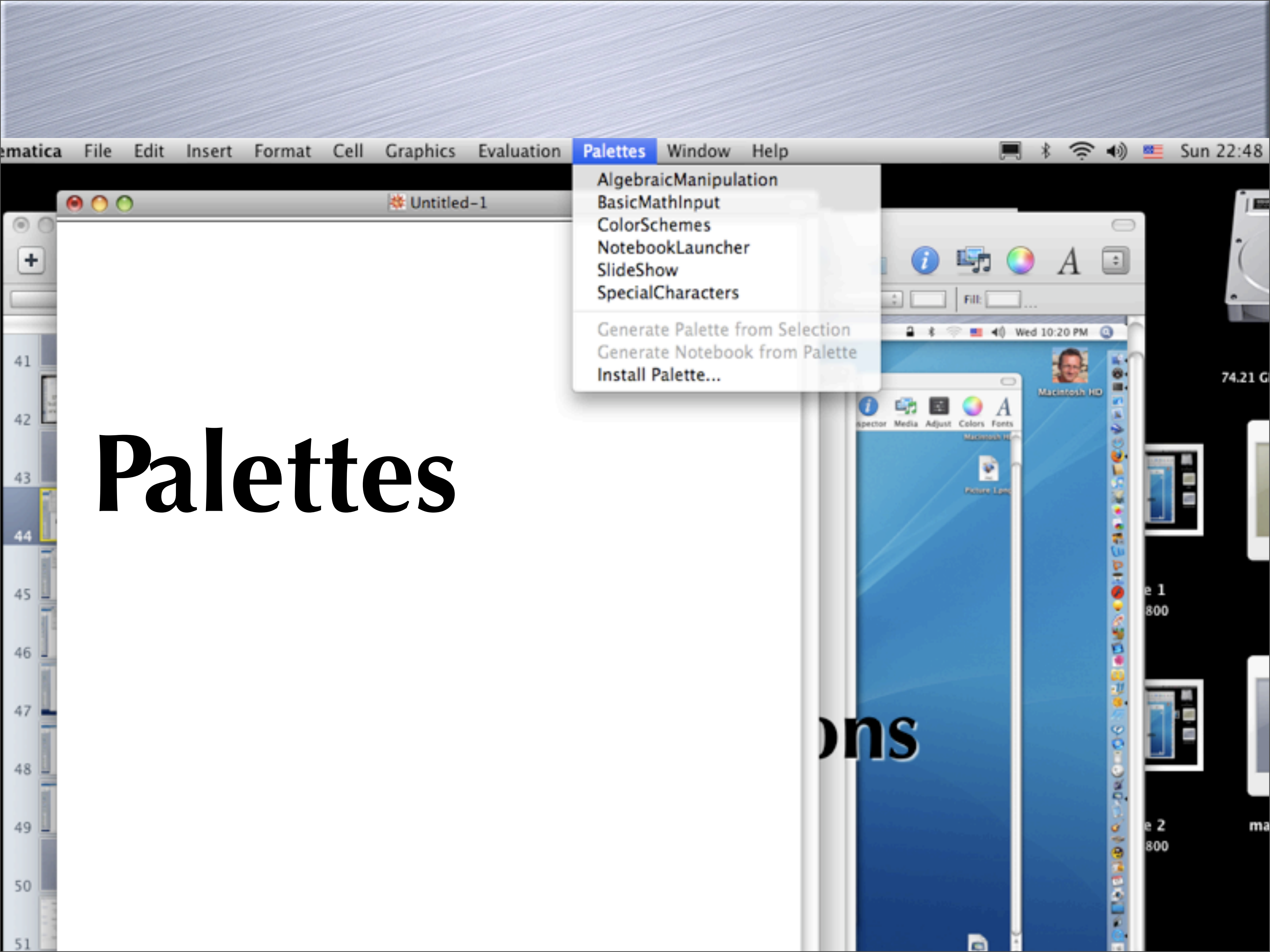

Palettes
ematica File Edit Insert Format Cell Graphics Evaluation Palettes Window Help
Sun 22:48
AlgebraicManipulation
BasicMathInput
ColorSchemes
NotebookLauncher
SlideShow
SpecialCharacters
Generate Palette from Selection
Generate Notebook from Palette
Install Palette...
Untitled-1
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Colors
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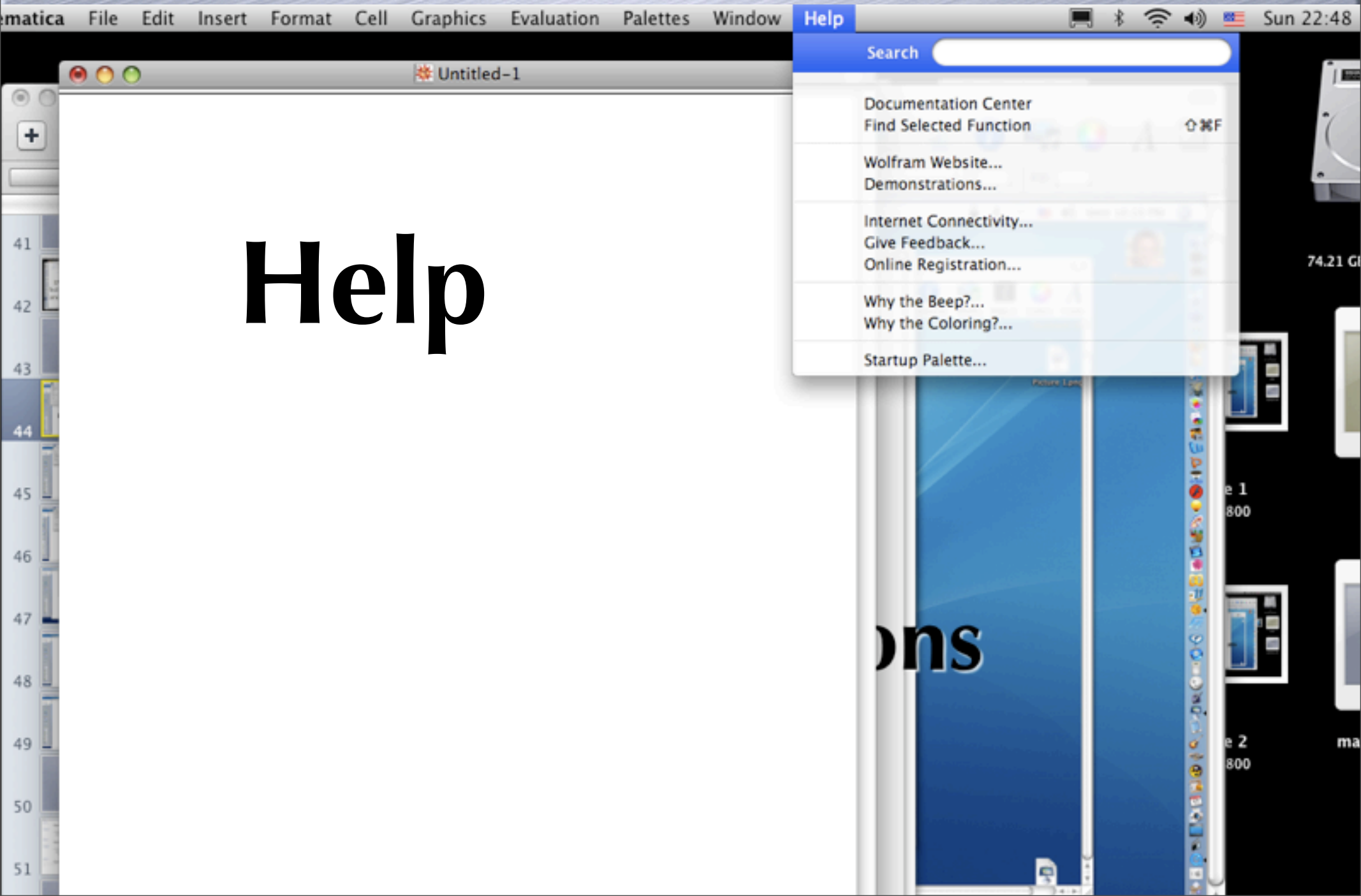
matica File Edit Insert Format Cell Graphics Evaluation Palettes Window Help Sun 22:48
Untitled-1
Help
Search
Documentation Center
Find Selected Function ⇧⌘F
Wolfram Website...
Demonstrations...
Internet Connectivity...
Give Feedback...
Online Registration...
Why the Beep?...
Why the Coloring?...
Startup Palette...
41
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51

stopping the kernel

In[1]:=

```
FactorInteger[2^(2^7) + 1]
```

Out[1]=

```
{{59649589127497217, 1},
 {5704689200685129054721, 1}}
```

In[2]:=

```
FactorInteger[2^(2^8) + 1]
```

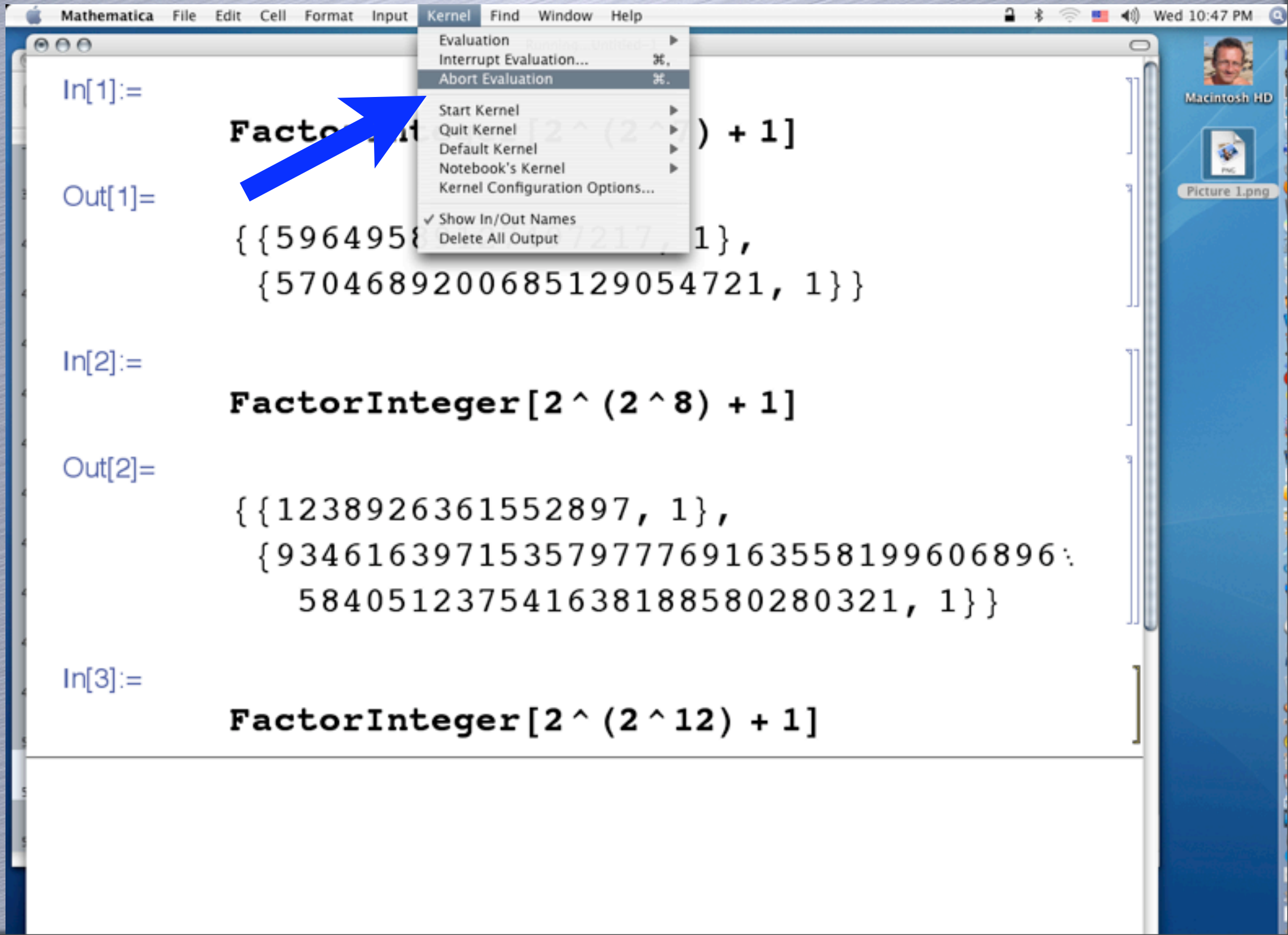
Out[2]=

```
{{1238926361552897, 1},
 {93461639715357977769163558199606896
   584051237541638188580280321, 1}}
```

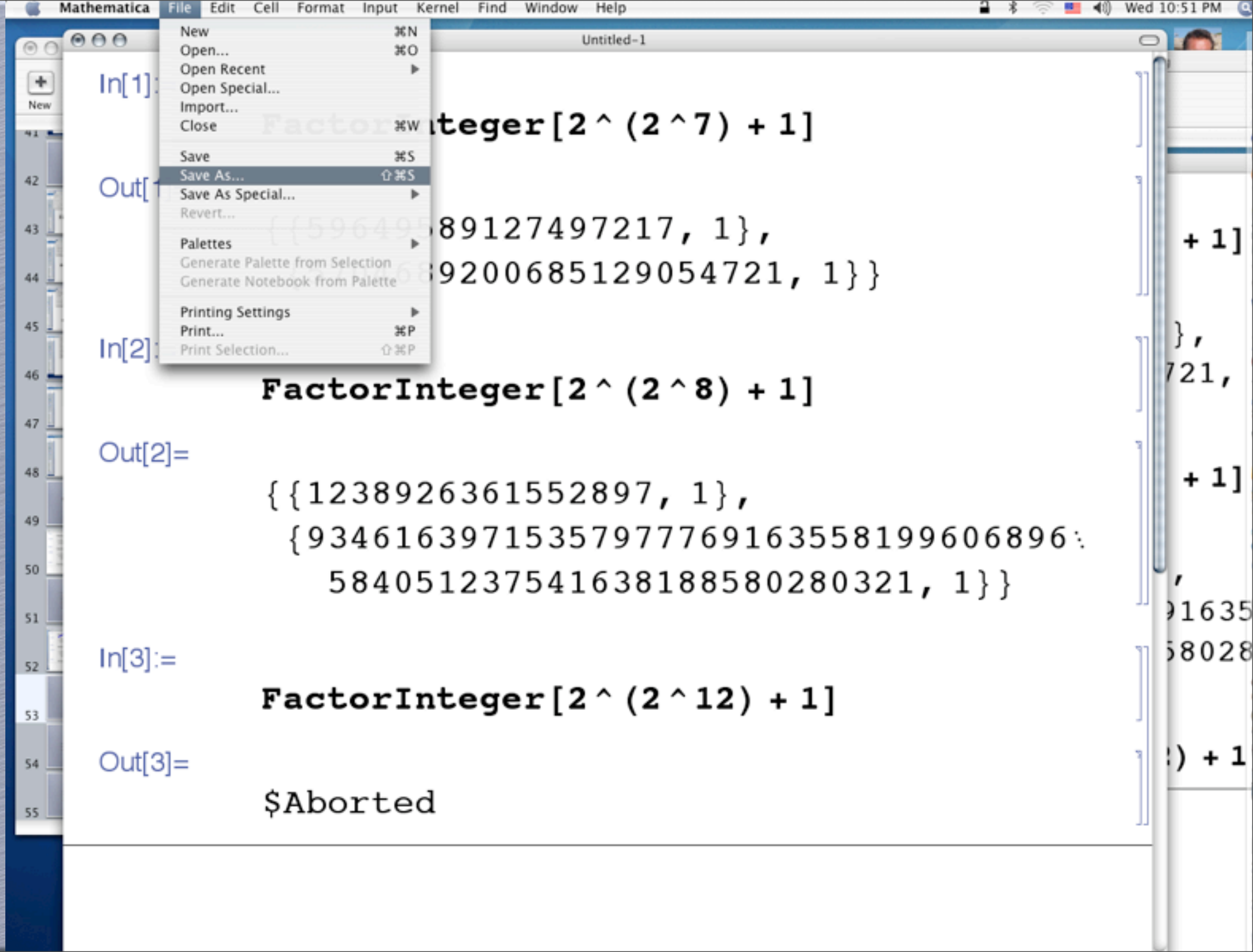
In[3]:=

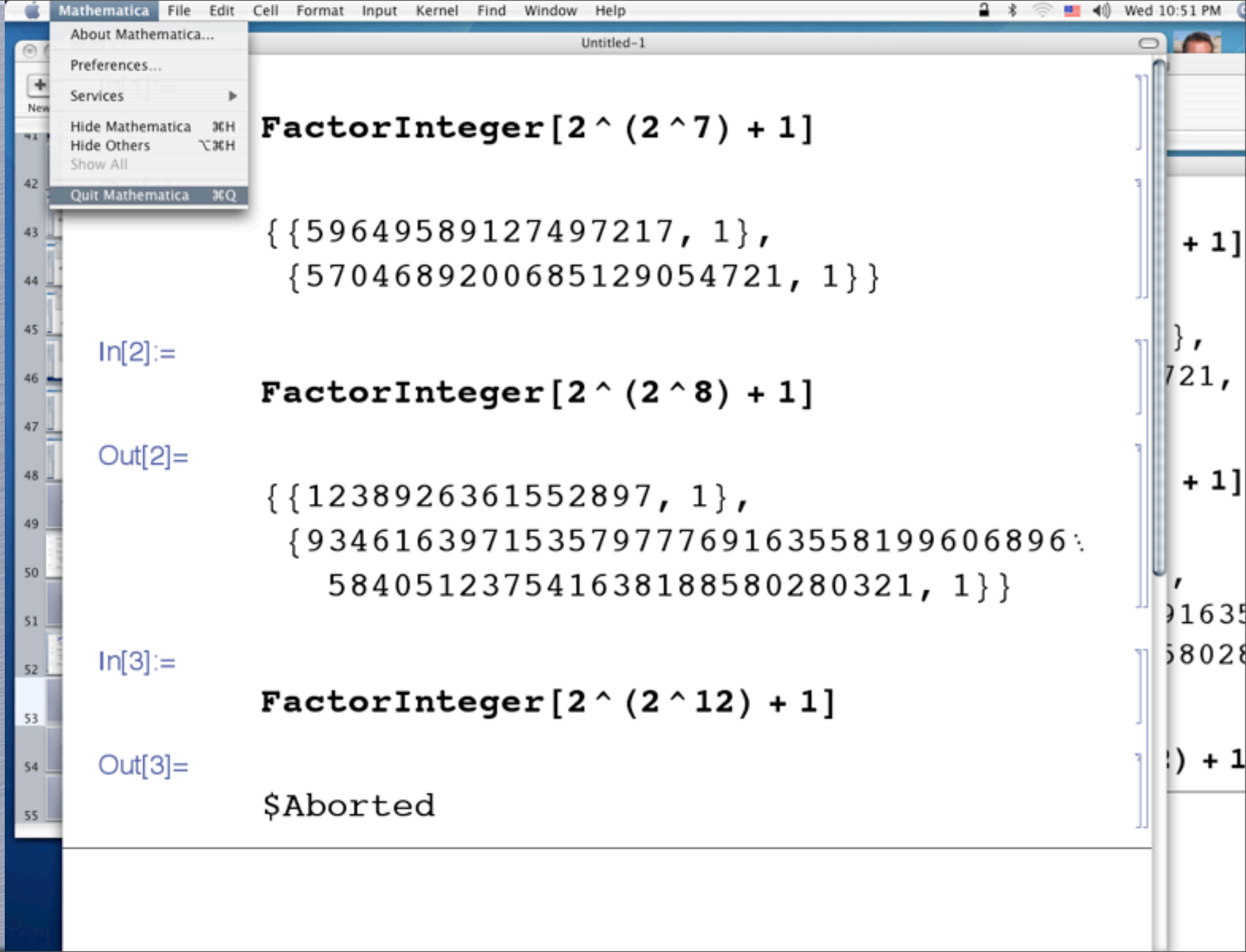
```
FactorInteger[2^(2^12) + 1]
```

- we are stuck
- the 12′th Fermat number has not yet been factored completely. Mathematica could try for years to factor it.
- We have to stop the kernel.


Mathematica File Edit Cell Format Input Kernel Find Window Help
Wed 10:47 PM
Evaluation
Interrupt Evaluation... ⌘,
Abort Evaluation ⌘.
Start Kernel
Quit Kernel
Default Kernel
Notebook's Kernel
Kernel Configuration Options...
✓ Show In/Out Names
Delete All Output
In[1]:=
Out[1]=
{{5704689200685129054721, 1}}
In[2]:=
FactorInteger[2^(2^8) + 1]
Out[2]=
{{1238926361552897, 1},
{93461639715357977769163558199606896
584051237541638188580280321, 1}}
In[3]:=
FactorInteger[2^(2^12) + 1]
Macintosh HD
Picture 1.png

saving the notebook

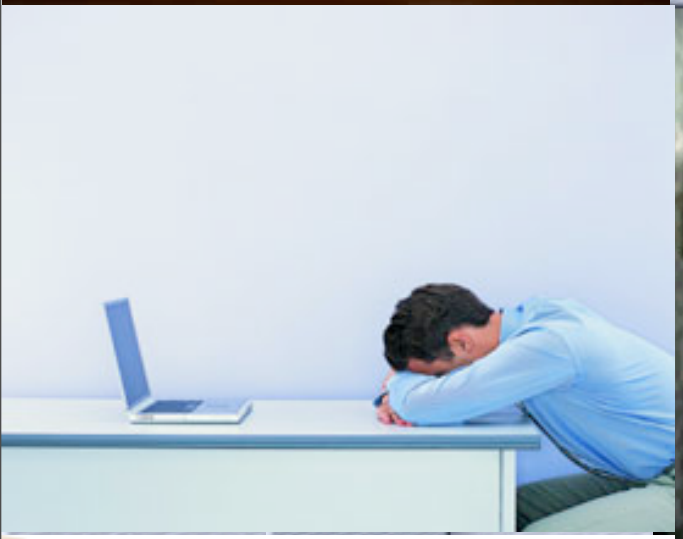

Mathematica File Edit Cell Format Input Kernel Find Window Help
Wed 10:51 PM
New ⌘N
Open... ⌘O
Open Recent
Open Special...
Import...
Close ⌘W
Save ⌘S
Save As... ⇧⌘S
Save As Special...
Revert...
Palettes
Generate Palette from Selection
Generate Notebook from Palette
Printing Settings
Print... ⌘P
Print Selection... ⇧⌘P
Untitled-1
New
In[1]:=
teger[2^(2^7) + 1]
Out[1]=
89127497217, 1},
920068512905472l, 1}}
In[2]:=
FactorInteger[2^(2^8) + 1]
Out[2]=
{{1238926361552897, 1},
{93461639715357977769163558199606896
584051237541638188580280321, 1}}
In[3]:=
FactorInteger[2^(2^12) + 1]
Out[3]=
$Aborted

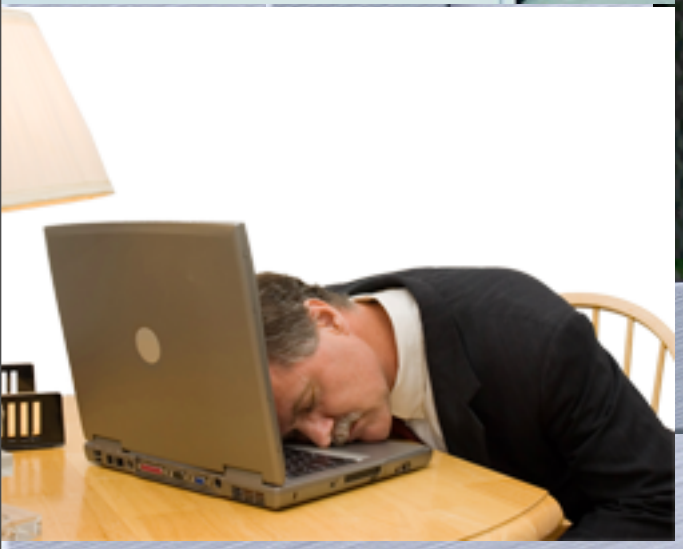

Mathematica File Edit Cell Format Input Kernel Find Window Help
Wed 10:51 PM
About Mathematica...
Preferences...
Services
Hide Mathematica ⌘H
Hide Others ⌥⌘H
Show All
Quit Mathematica ⌘Q
Untitled-1
FactorInteger[2^(2^7) + 1]
{{59649589127497217, 1},
{5704689200685129054721, 1}}
In[2]:=
FactorInteger[2^(2^8) + 1]
Out[2]=
{{1238926361552897, 1},
{93461639715357977769163558199606896
584051237541638188580280321, 1}}
In[3]:=
FactorInteger[2^(2^12) + 1]
Out[3]=
$Aborted

Remember Murphy's law

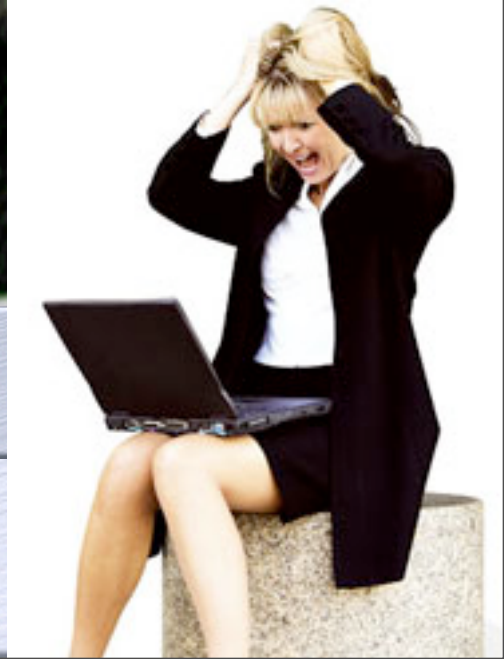
Anything that can go wrong, will.

Murphy was an optimist!





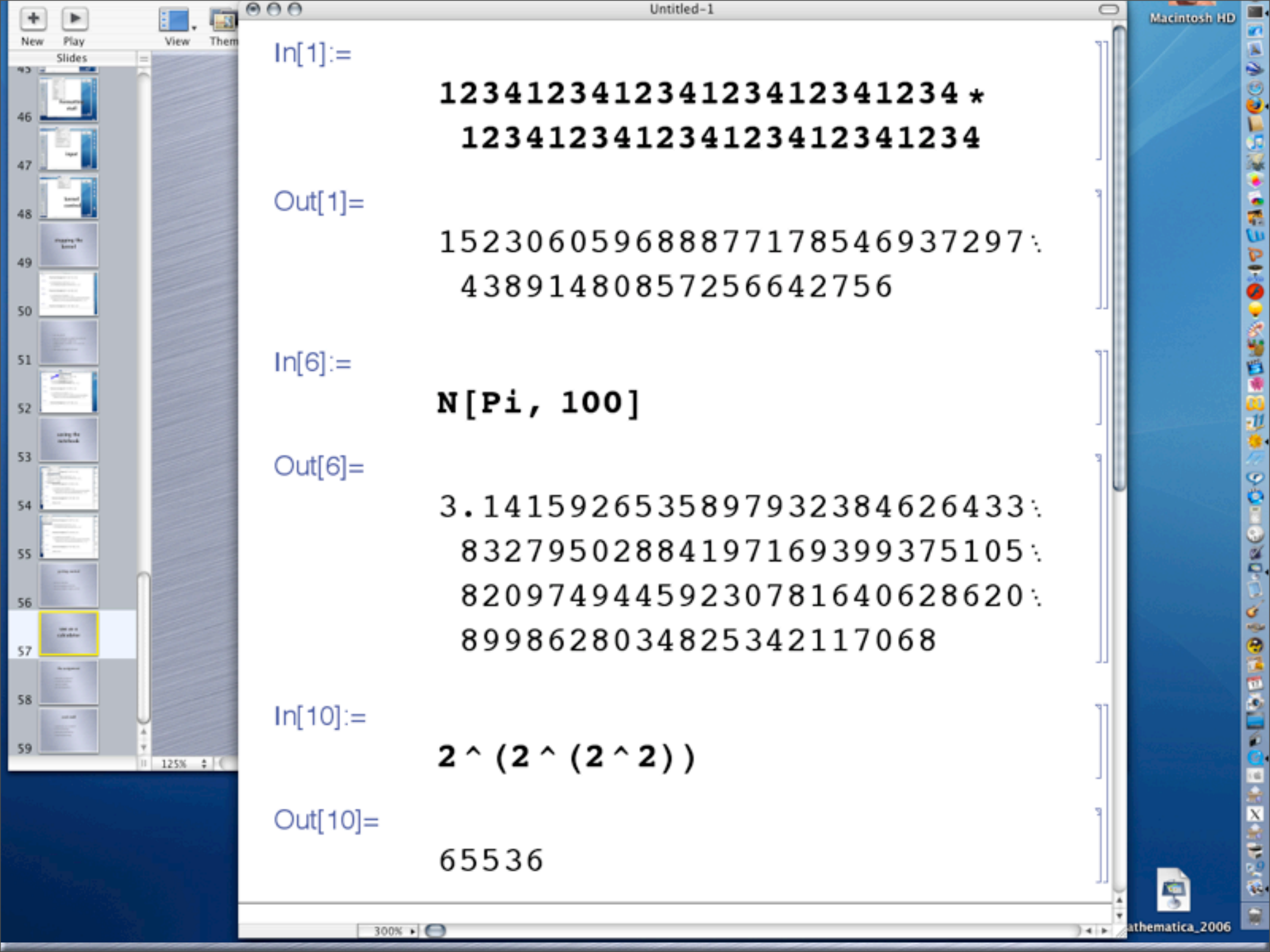
Movie source: ABCD group Harvard



getting started

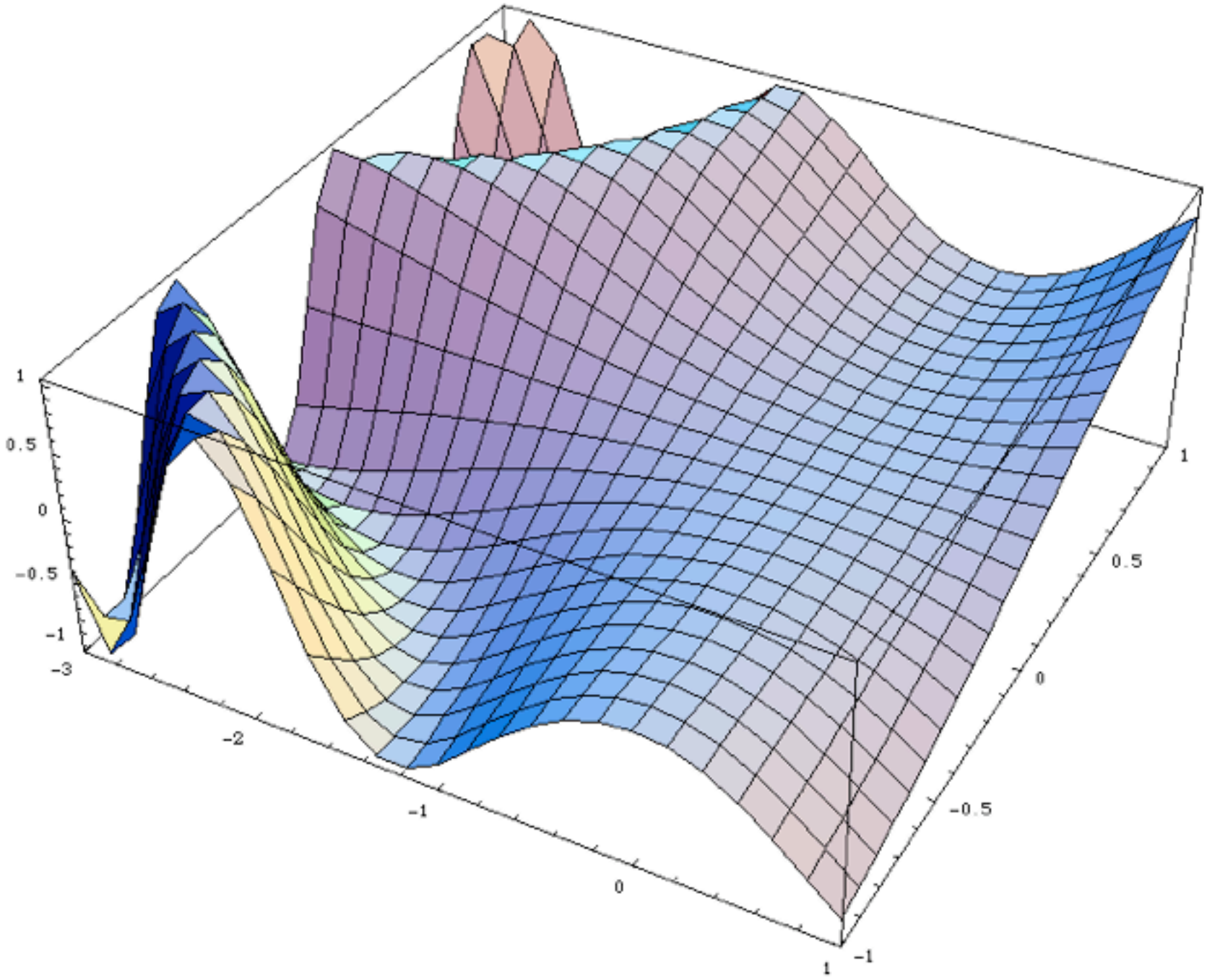
- use as a calculator
- use as a graphing calculator
- use as a computer algebra system

use as a calculator


New
Play
View
Slides
Untitled-1
In[1]:=
1234123412341234123412341234 *
1234123412341234123412341234
Out[1]=
152306059688771785469372975:
4389148085725664275 6
In[6]:=
N[Pi, 100]
Out[6]=
3.14159265358979323846264335:
8327950288419716939937510 5:
8209749445923078164062862 0:
8998628034825342117068
In[10]:=
2^(2^(2^2))
Out[10]=
65536
125%
300%
Macintosh HD
athematica_2006

use as graphing calculator

In[6]:= **Plot3D[Sin[x^2 y], {x, -3, 1}, {y, -1, 1}]**



Out[6]= - SurfaceGraphics -

use as computer algebra system

In[9]:=
```
Integrate[Sin[x + y]^10, {x, 0, Pi/2}, {y, 0, Pi/2}]
```

Out[9]=
$$\frac{21}{50} + \frac{63\,\pi^2}{1024}$$

In[10]:=
```
Integrate[Sin[Sqrt[x]], x]
```

Out[10]=
$$-2\sqrt{x}\,\text{Cos}\left[\sqrt{x}\right] + 2\,\text{Sin}\left[\sqrt{x}\right]$$

In[11]:=
```
f[x_, y_, z_] := Log[x y] + Sin[Cos[x^2 + y]]
D[f[x, y, z], {x, 2}] + D[f[x, y, z], {y, 2}] +
 D[f[x, y, z], {z, 2}]
```

Out[12]=
$$-\frac{1}{x^2} - \frac{1}{y^2} - \text{Cos}[x^2+y]\,\text{Cos}[\text{Cos}[x^2+y]] - 4\,x^2\,\text{Cos}[x^2+y]\,\text{Cos}[\text{Cos}[x^2+y]] - 2\,\text{Cos}[\text{Cos}[x^2+y]]\,\text{Sin}[x^2+y] - \text{Sin}[x^2+y]^2\,\text{Sin}[\text{Cos}[x^2+y]] - 4\,x^2\,\text{Sin}[x^2+y]^2\,\text{Sin}[\text{Cos}[x^2+y]]$$

In[20]:=
```
Series[ Cos[ Pi (x + 1)] + Sin[x], {x, 0, 4}]
```

Out[20]=
$$-1 + x + \frac{\pi^2\,x^2}{2} - \frac{x^3}{6} - \frac{\pi^4\,x^4}{24} + O[x]^5$$

the assignment

- getting the assignment
- walk through
- the actual problems
- tips for working
- fine tuning graphics
- submitting the problems

getting the file

Math 21a, Fall 2007
Multivariable Calculus
NEWS

Course head: Oliver Knill
Office: SciCtr 434
Email: knill@math.harvard.edu

- The Mathematica project is now available on the laboratory page. The assignment is due the last day of class before the winterbreak.
- We will also this year compute the final grade as the maximum of the average grade and the final grade if certain conditions are fulfilled. See syllabus for details.
- Barbie movie from Fall 2006 in Ipod format [35 Meg]. The movie had been rendered in Povray where similar as in the asteroid gallery, the individual video frames are used as textures on the surfaces.

ox File Edit View History Bookmarks Tools Window Help Sun 23:03

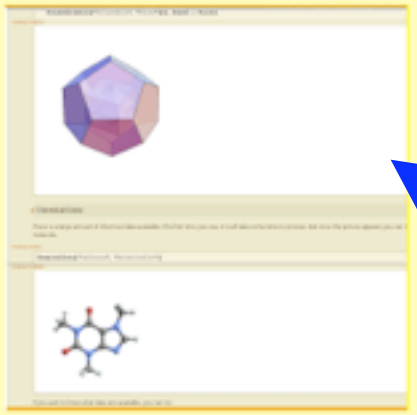
Lab

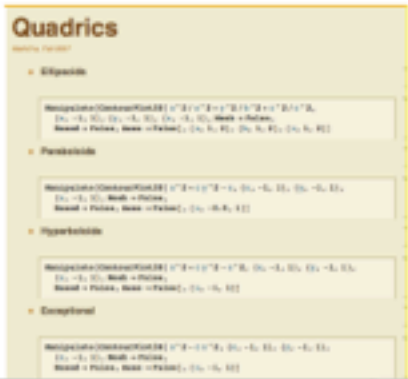
http://www.courses.fas.harvard.edu/~math21a/labs/index.html

Google ha 21 21b /. di sp TD cnn wp nyt leo rk ma ok adv ip courses expos math Harvard Math Webm...

Email: knill@math.harvard.edu

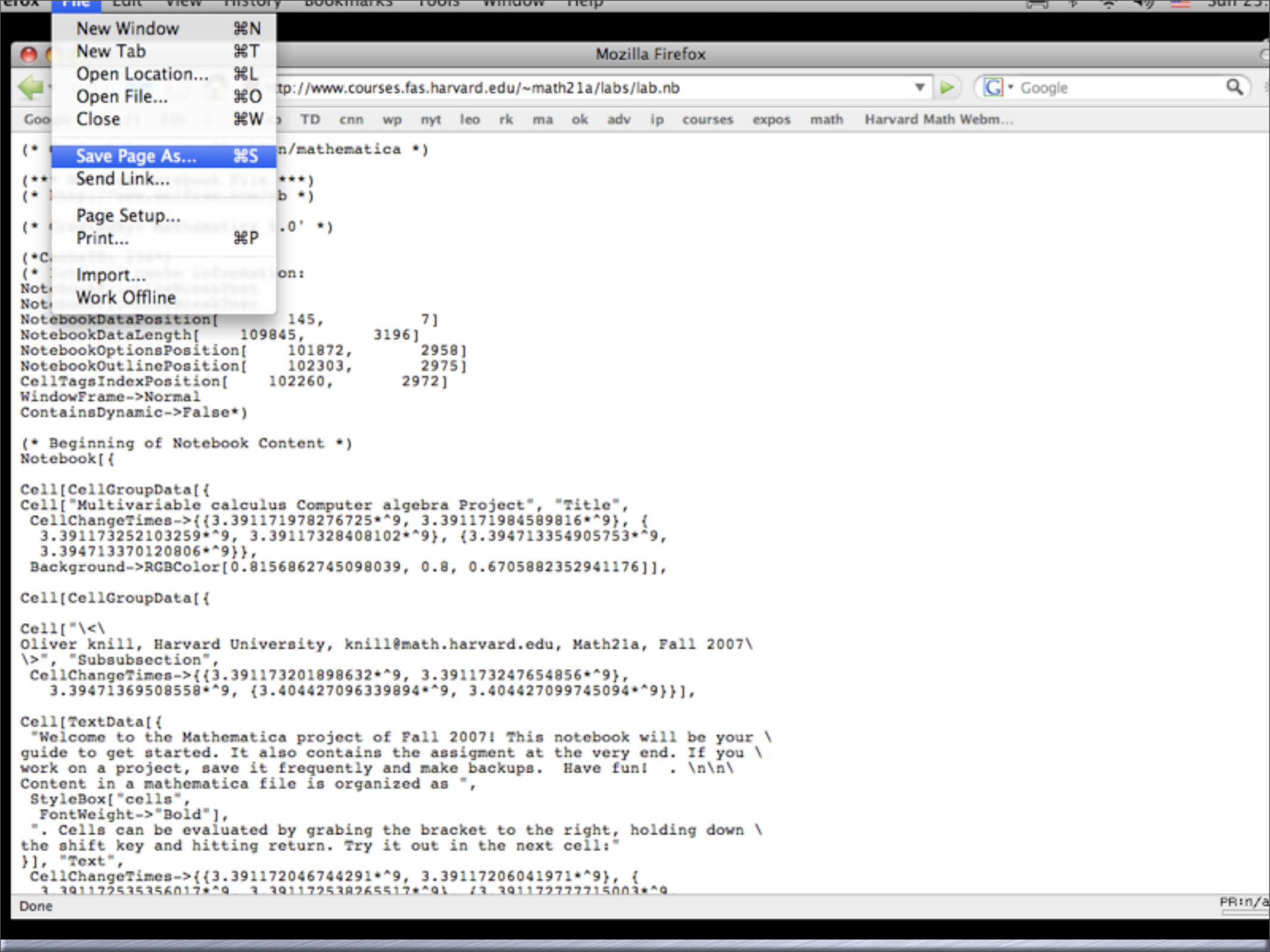
NEW SYLLABUS CALENDAR SECTION HOMEWORK EXAM EXHIBIT HANDOUT LAB FAQ CHECKLISTS LINKS

Mathematica	You can install Mathematica 6 on your own computer. Get it here.
Installation	Start up the application and follow the instructions. Have ready the **Harvard Licence nu** **Machine ID** which will have to be entered into the Mathematica Registration page. In re email. This is what you see during installation in • Mac OSX. • Windows XP. Send email to math21a, if you plan to use Mathematica on a linux system. We can provic
Getting the notebook	 k on the link and save it on r computer. If you open the notebook with



Done

PR:n/a


File
New Window ⌘N
New Tab ⌘T
Open Location... ⌘L
Open File... ⌘O
Close ⌘W
Save Page As... ⌘S
Send Link...
Page Setup...
Print... ⌘P
Import...
Work Offline
Mozilla Firefox
http://www.courses.fas.harvard.edu/~math21a/labs/lab.nb
Google
TD cnn wp nyt leo rk ma ok adv ip courses expos math Harvard Math Webm...
n/mathematica *)
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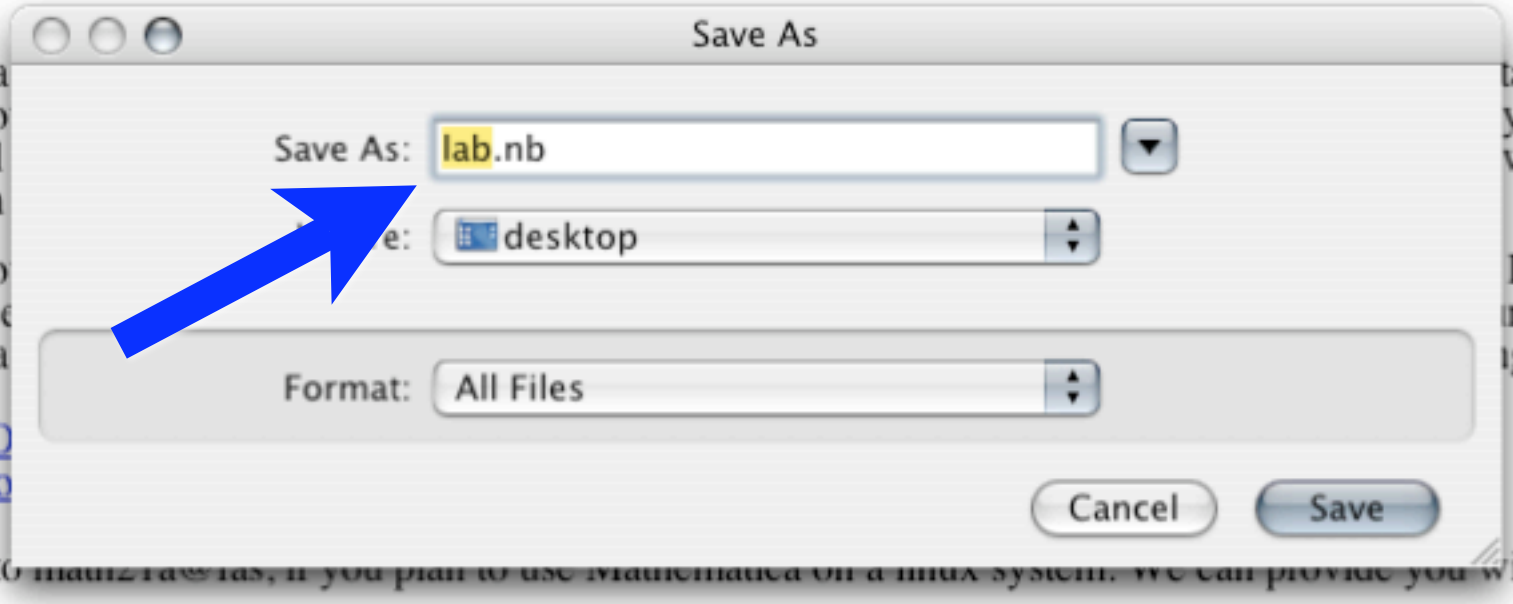
on:
NotebookDataPosition[145, 7]
NotebookDataLength[109845, 3196]
NotebookOptionsPosition[101872, 2958]
NotebookOutlinePosition[102303, 2975]
CellTagsIndexPosition[102260, 2972]
WindowFrame->Normal
ContainsDynamic->False*)
(* Beginning of Notebook Content *)
Notebook[{
Cell[CellGroupData[{
Cell["Multivariable calculus Computer algebra Project", "Title",
CellChangeTimes->{{3.391171978276725*^9, 3.391171984589816*^9}, {
3.3911732521032 59*^9, 3.39117328408102*^9}, {3.394713354905753*^9,
3.394713370120806*^9}},
Background->RGBColor[0.8156862745098039, 0.8, 0.6705882352941176]],
Cell[CellGroupData[{
Cell["\<\
Oliver knill, Harvard University, knill@math.harvard.edu, Math21a, Fall 2007\
\>", "Subsubsection",
CellChangeTimes->{{3.391173201898632*^9, 3.391173247654856*^9},
3.394713695085 58*^9, {3.404427096339894*^9, 3.404427099745094*^9}}],
Cell[TextData[{
"Welcome to the Mathematica project of Fall 2007! This notebook will be your \
guide to get started. It also contains the assigment at the very end. If you \
work on a project, save it frequently and make backups. Have fun! . \n\n\
Content in a mathematica file is organized as ",
StyleBox["cells",
FontWeight->"Bold"],
". Cells can be evaluated by grabing the bracket to the right, holding down \
the shift key and hitting return. Try it out in the next cell:"
}], "Text",
CellChangeTimes->{{3.391172046744291*^9, 3.391172061041971*^9}, {
3.391172535356017*^9, 3.391172538265517*^9}, {3.391172777715003*^9
Done
PR:n/a

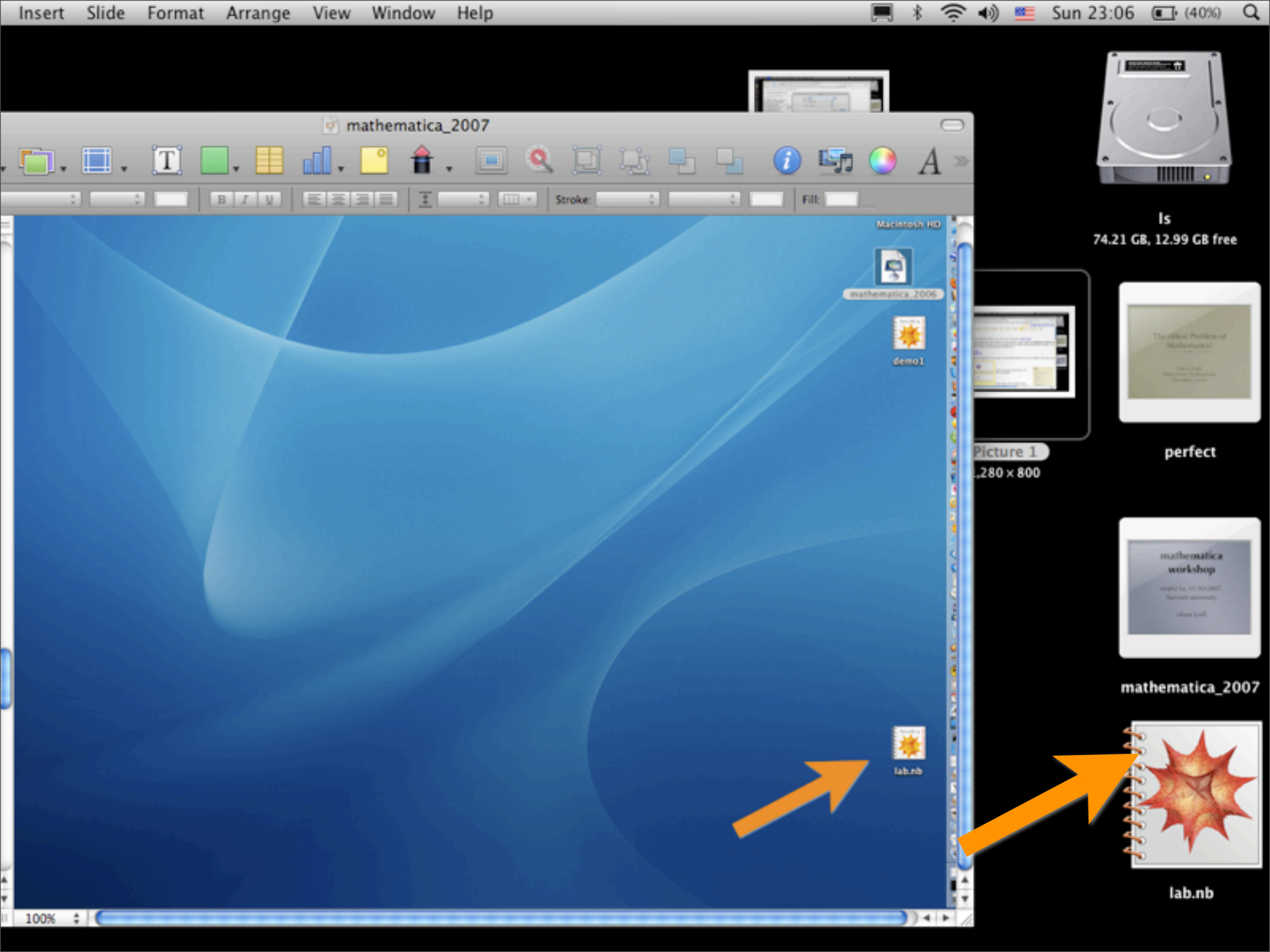
Important: Save with .nb not .txt



- The Mathematica laboratory assignment is now available. Download it here!

```
(* Mathematica code to classify critical points, O. Knill, 2000 *)
f[x_,y_]:=4 x y - x^3 y - x y^3;
a[x_,y_]:=D[f[u,v],u] /. {u->x,v->y}; b[x_,y_]:=D[f[u,v],v] /. {u->x,v->y};
A=Solve[{a[x,y]==0,b[x,y]==0},{x,y}];
CriticalPoints=Table[{A[[i,1,2]],A[[i,2,2]]},{i,Length[A]}];
H[{x_,y_}]:={{D[f[u,v],{u,2}],D[D[f[u,v],v],u]},{D[D[f[u,v],u],v],D[f[u,v],{v,2}]}} /. {u->x,v->y};
F[A_]:=A[[1,1]]; Discriminant=Map[Det,Map[H,CriticalPoints]]
FirstEntry=Map[F,Map[H,CriticalPoints]]
Decide[B_]:=If[Det[B]<0,"saddle",If[B[[1,1]]<0,"max","min"]];
Analysis=Map[Decide, Map[H,CriticalPoints]];
Table[{CriticalPoints[[i]],Analysis[[i]]},{i,Length[CriticalPoints]}]
```

Here is a slicker code, doing the same and even presenting it as a nice table (credit: Matt Leingang, 2006)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mathematica_2007
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Fill:
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mathematica_2006
demo1
lab.nb
100%
ls
74.21 GB, 12.99 GB free
Picture 1
,280 × 800
perfect
mathematica workshop
mathematica_2007
lab.nb

walk through

ultivariable calculus Computer algebra Project

Oliver knill, Harvard University, knill@math.harvard.edu, Math21a, Fall 2007

Welcome to the Mathematica project of Fall 2007! This notebook will be your guide to get started. It also contains the assigment at the very end. If you work on a project, save it frequently and make backups. Have fun! .

Content in a mathematica file is organized as **cells**. Cells can be evaluated by grabing the bracket to the right, holding down the shift key and hitting return. Try it out in the next cell:

```
Plot[ Sin[x] / x, {x, -30, 30}]
```

After evaluating the cell, an output cell has been added to the input cell. The output cell can be made interactive as in the following example:

```
Manipulate[Plot[Sin[x] / x, {x, -c, c}], {c, 1, 20}]
```

Lets get started. I suggest you read through the examples and evaluate the ones you are interested in which are hopefully all. If you are unpatient, grab the most outer bracket to the right which contains the entire notebook and evalute it. All the cells will be evaluated.

A calculator

Anything you can do on a graphics calculator you can do with a computer algebra system, only better and more accurately. Here is an exmple to compute a numerical expression

```
234^10 + Sin[Pi / 3]^3 + Sqrt[5]
```

It did not compute it numerically and left terms like square roots of integers intact. To get a numerical varlue or a numerical value jor a value with accuracy 200 digits, access the pre
expression (called %) and

```
N[%, 200]
```

Lets play with this:

```
Manipulate[N[Sqrt[5], digits], {digits, 1, 1000}]
```

Or look at the list of prime numbers

```
Manipulate[Prime[Floor[n]], {n, 1, 300000000}]
```

or binominal expressions

```
Manipulate[Expand[(x + y)^Floor[n]], {n, 1, 60}]
```

Some single variable calculus

the problems

```
S = Table[SpinnerPict[i], {i, 1, MM}];

Animate[S[[Floor[k]]], {k, 1, MM}]
```

Image manipulation

A graphics can be saved in many file formats. Here is an example

```
Export["dodecahedron.jpg", Graphics3D[{PolyhedronData["Dodecahedron", "Faces"]}, Boxed -> False], "JPEG"]
```

We can import the picture back as a raster image.

```
A = Import["dodecahedron.jpg"];
```

Lets darken the picture a bit.

```
Show[Graphics[Raster[0.8 * A[[1, 1]], A[[1, 2]], A[[1, 3]], A[[1, 4]]], A[[2]], A[[3]]]]
```

Assignment

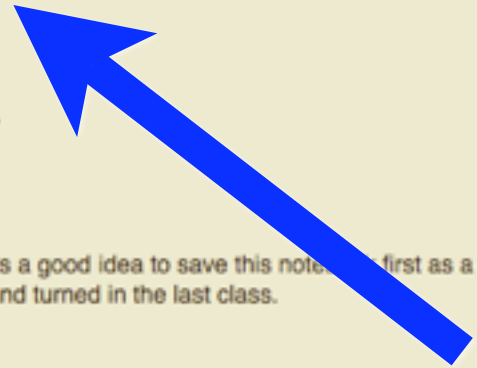
To get full credit for this Mathematica assignment, you have to hand in :

1) (2 points) A printout of a parametric surface r (u, v) = (x (u, v), y (u, v), z (u, v)) of your choice.
2) (2 points) A printout of a spherical plot or an implicit surface.
3) (2 points) Plot a molecule plot of your favorate molecule and plot the stock data of your favorate company.
4) (2 points) Compute numerically the arc length of the rurve r[t_] := {Cos[3t],Sin[7t]}, where t goes from 0 to 2pi.
5) (2 points) Produce graphics object of your choice, which involves discs, lines, polygons or points.

Your examples should be different from any example which appear in this notebook.

If you find something cool during your experiments, feel free to include it also.In order to work on your project it is a good idea to save this note[illegible] first as a different document, do the assignment notebook and print out the relevant pages at the very end on a printer.The assignments have to be printed out and turned in the last class.

Oliver Knill, November 18, 2007, email: knill@math.harvard.edu



5 problems

5 problems

Assignment

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notebook and print out the relevant pages at the very end on a printer.The assignments h

Oliver Knill, November 18, 2007, email: knill@math.harvard.edu

tips

- save frequently
- start a new notebook
- careful with parameters
- make backups
- print early
- start a week early

submitting the problems

File Edit View Go Tools Bookmarks Window Help

New From Clipboard ⌘N
Open... ⌘O
Open Recent ▶

Close ⌘W
Save ⌘S
Save As... ⇧⌘S
Revert

Import Image...
Grab ▶
Password...

Page Setup... ⇧⌘P
Print... ⌘P

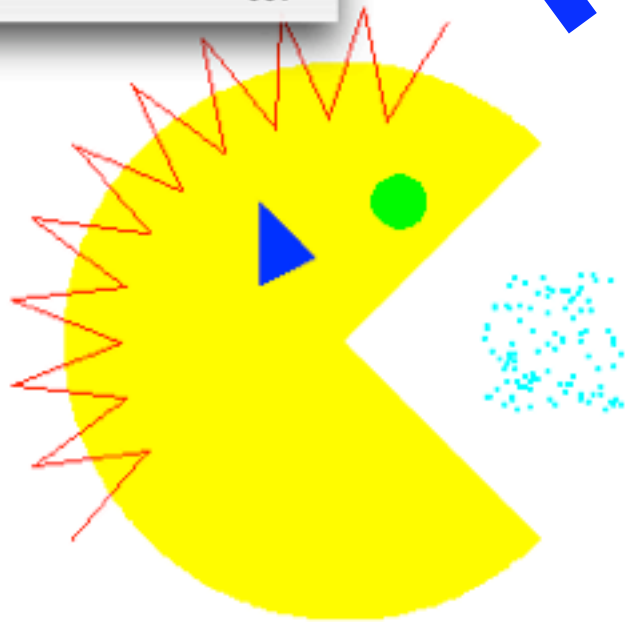
lab.nb

Save As: mysolution

Where: desktop

Cancel Save

```
1, 0], D
1, 0], D
0, 1], P
t],
= 0,
Line[Table[r[k], {k, 10, 30}]]];
Rando[] / 2, (Random[] - 0.5) / 2}];
1, 1], Table[rp, {100}]};
{A1, A2, A3, A4, A5}], PlotRange → {{-1.3, 1.3}, {-1.3, 1.3}}, AspectRatio → 1]
```



Out[167]= -Graphics-

Assignment

New Play Slides

Besides polygons, you can use lines, discs or point

Save As: mysolution
Where: desktop
Cancel Save

In[159]:=
```
A1 = {RGBColor[1, 1, 0], D
A2 = {RGBColor[0, 1, 0], D
A3 = {RGBColor[0, 0, 1], P
r[t_] := 1.2 + {Cos[2 Pi t],
f[k_] := If[Mod[k, 2] == 0,
A4 = {RGBColor[1, 0, 0], Line[Table[r[k], {k, 10, 30}]]};
rp := Point[{0.5 + Random[] / 2, (Random[] - 0.5) / 2}];
A5 = {RGBColor[0, 1, 1], Table[rp, {100}]};
S = Show[Graphics[{A1, A2, A3, A4, A5}], PlotRange → {{-1.3, 1.3}, {-1.3, 1.3}}, AspectRatio → 1]
```

Out[167]= -Graphics-

Assignment

To get full credit for this *Mathematica* assignment, you have to hand in:

1) A printout of a graph of a function f(x,y) of two variables of your choice.

2) A printout of a parametric surface r(u,v) = (x(u,v),y(u,v),z(u,v)) of your choice.

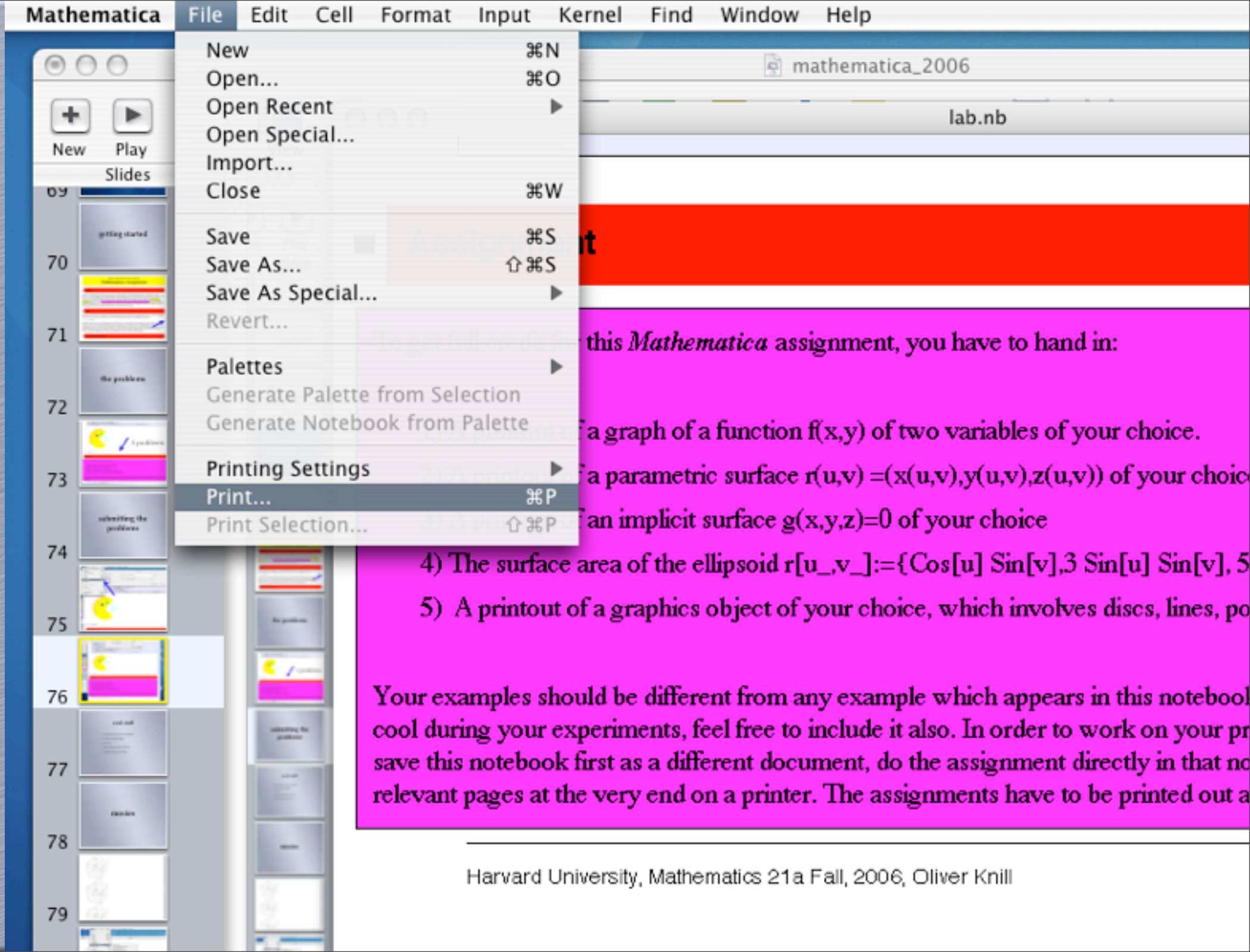
3) A printout of an implicit surface g(x,y,z)=0 of your choice

4) The surface area of the ellipsoid r[u_,v_] = {Cos[u] Sin[v],3 Sin[u] Sin[v], 5 Cos[v]}.

5) A printout of a graphics object of your choice, which involves discs, lines, polygons or points.

Your examples should be different from any example which appears in this notebook. If you find something cool during your experiments, feel free to include it also. In order to work on your project it is a good idea to save this notebook first as a different document, do the assignment directly in that notebook and print out the relevant pages at the very end on a printer. The assignments have to be printed out and turned in the last class.

100%


Mathematica
File
Edit
Cell
Format
Input
Kernel
Find
Window
Help
New ⌘N
Open... ⌘O
Open Recent
Open Special...
Import...
Close ⌘W
Save ⌘S
Save As... ⇧⌘S
Save As Special...
Revert...
Palettes
Generate Palette from Selection
Generate Notebook from Palette
Printing Settings
Print... ⌘P
Print Selection... ⇧⌘P
mathematica_2006
lab.nb
New
Play
Slides
this Mathematica assignment, you have to hand in:
a graph of a function f(x,y) of two variables of your choice.
a parametric surface r(u,v) =(x(u,v),y(u,v),z(u,v)) of your choic
an implicit surface g(x,y,z)=0 of your choice
4) The surface area of the ellipsoid r[u_,v_]:={Cos[u] Sin[v],3 Sin[u] Sin[v], 5
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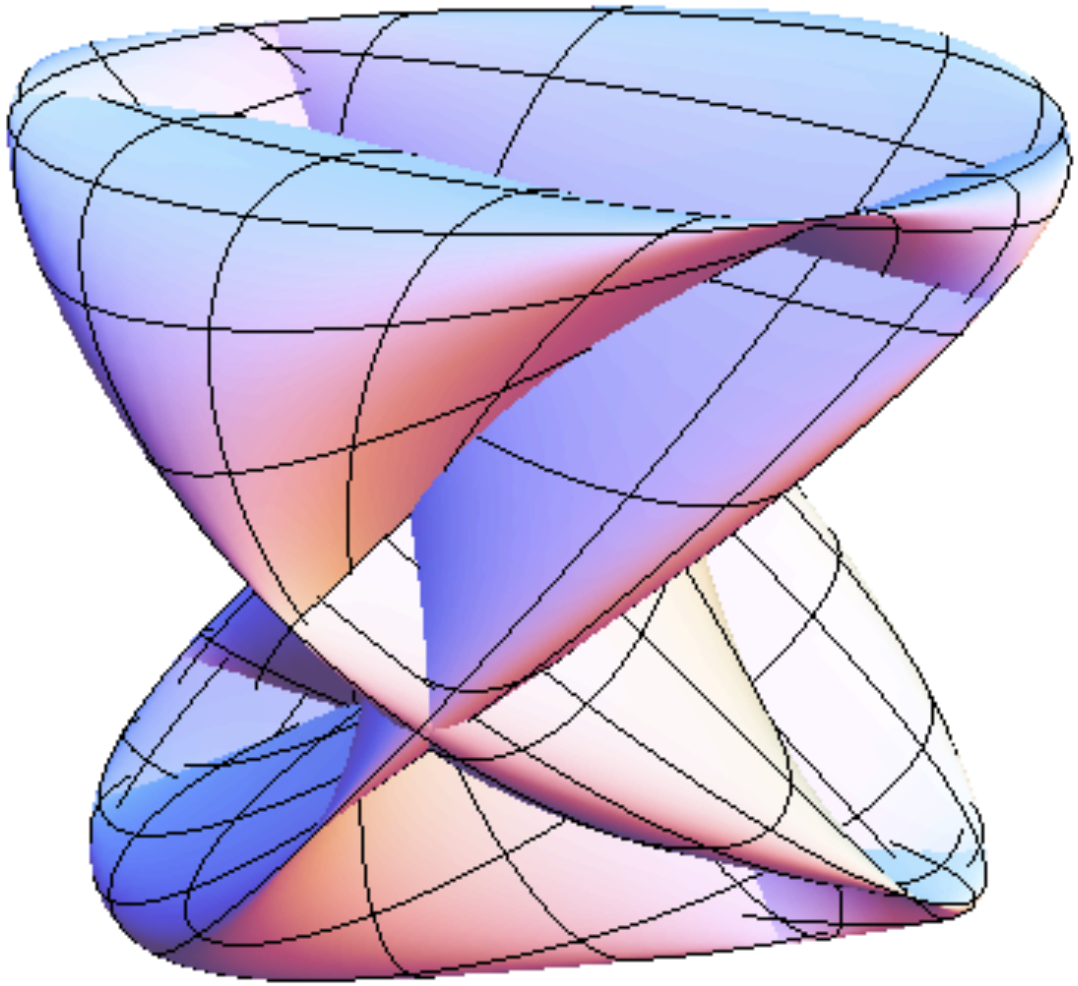
save this notebook first as a different document, do the assignment directly in that no
relevant pages at the very end on a printer. The assignments have to be printed out a
Harvard University, Mathematics 21a Fall, 2006, Oliver Knill

tricks for assignment

- parameters, parameters paramers
- pepping up graphics
- simple programming

animation for exploration



Paste Snapshot

Add To Bookmarks...

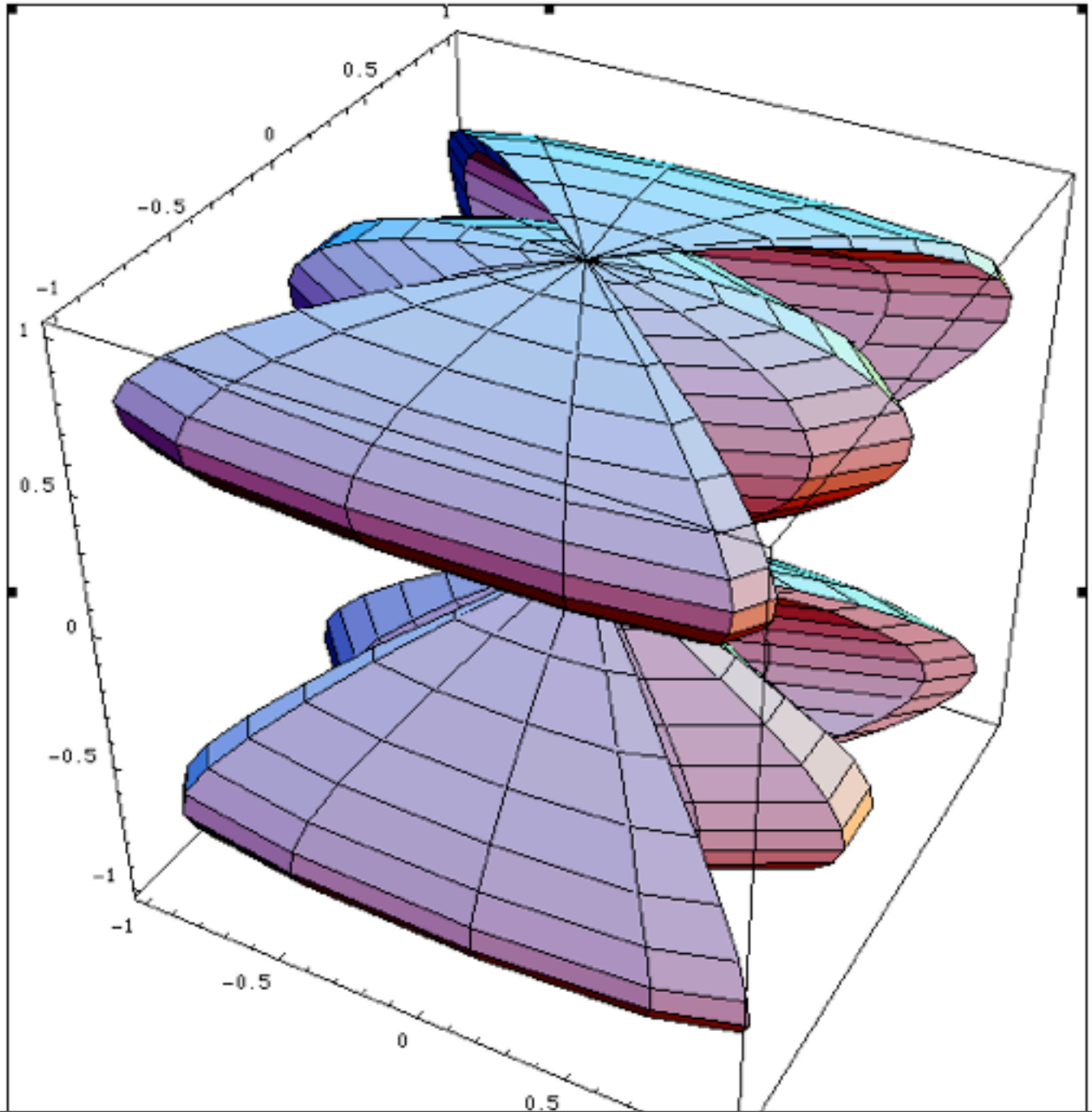
Initial Settings

Paste Bookmarks
Animate Bookmarks

Autorun

pepping up graphics

```
ParametricPlot3D[{ Sin[2 v] Cos[3 u], Sin[2 v] Sin[u], Cos[v]},
 {u, 0, 2 Pi}, {v, 0, Pi}]
```



? ParametricPlot3D

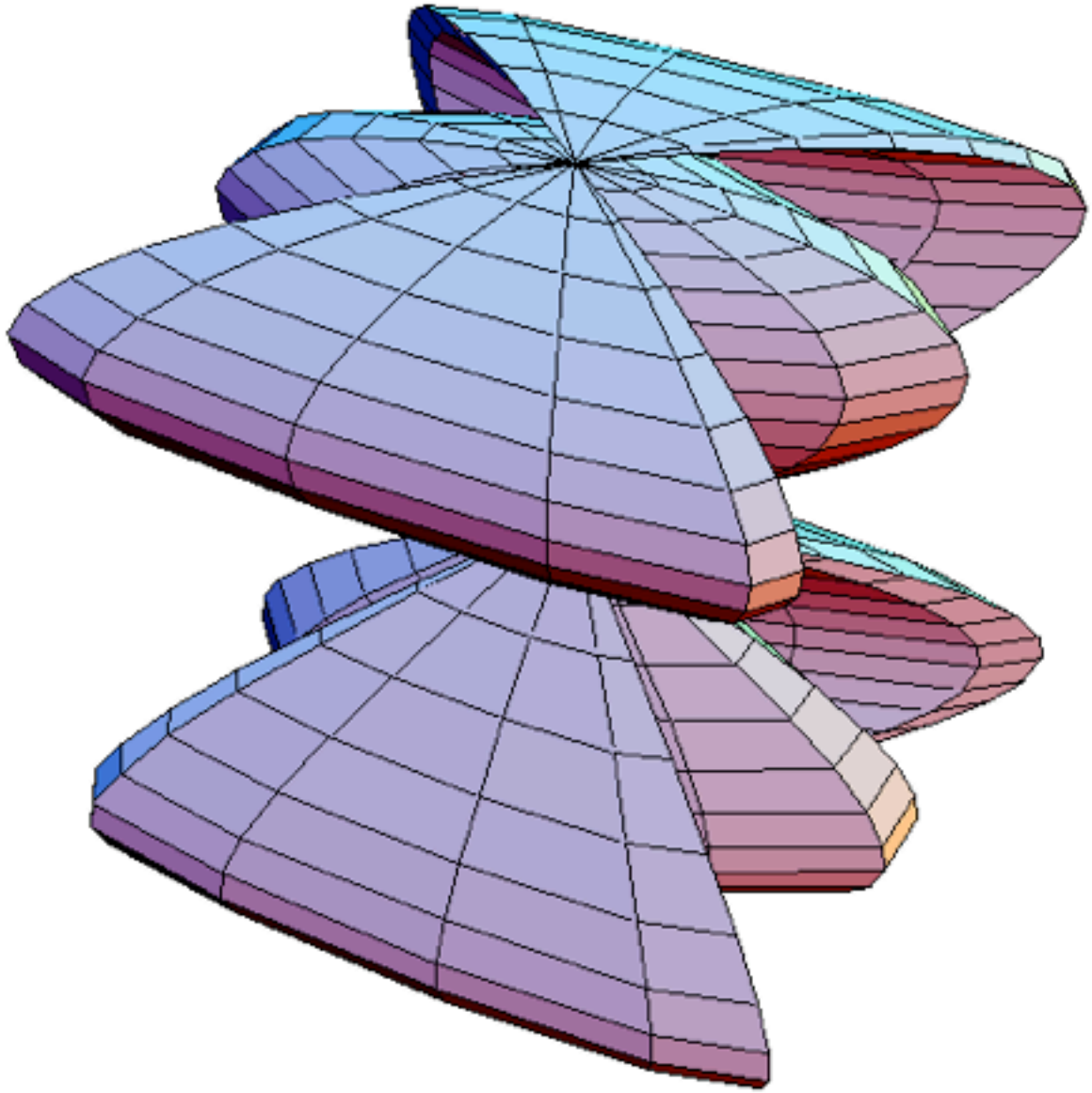
```
ParametricPlot3D[{fx, fy, fz}, {u, umin, umax}] produces a three-dimensional
   space curve parametrized by a variable u which runs from umin to
   umax. ParametricPlot3D[{fx, fy, fz}, {u, umin, umax}, {v, vmin,
   vmax}] produces a three-dimensional surface parametrized by u and v.
   ParametricPlot3D[{fx, fy, fz, s}, ... ] shades the plot according
   to the color specification s. ParametricPlot3D[{{fx, fy, fz},
   {gx, gy, gz}, ... }, ... ] plots several objects together.
```
More...

?? ParametricPlot3D

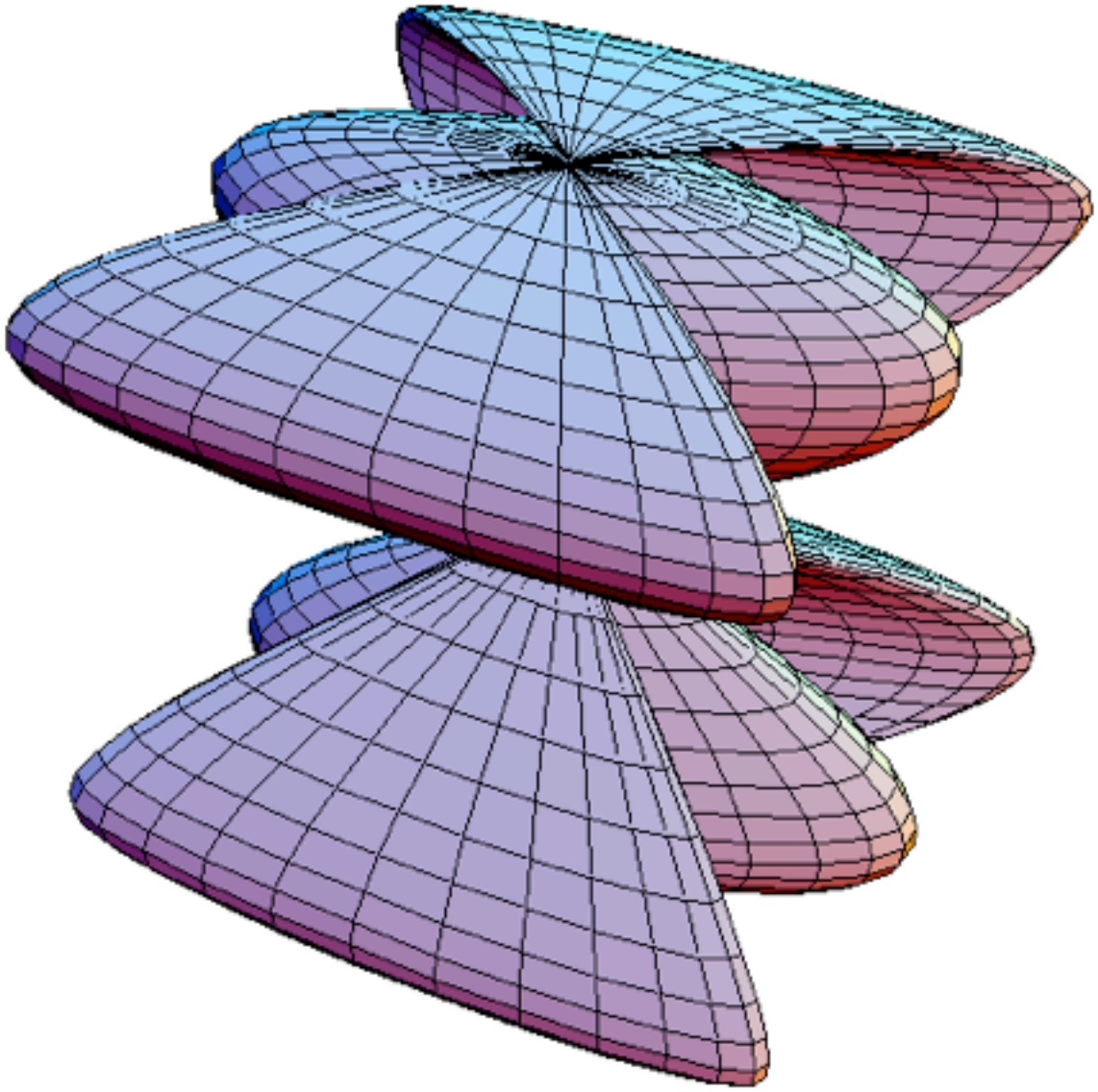
```
Attributes[ParametricPlot3D] = {HoldAll, Protected}


Options[ParametricPlot3D] =
 {AmbientLight → GrayLevel[0.], AspectRatio → Automatic, Axes → True,
  AxesEdge → Automatic, AxesLabel → None, AxesStyle → Automatic,
  Background → Automatic, Boxed → True, BoxRatios → Automatic,
  BoxStyle → Automatic, ColorOutput → Automatic, Compiled → True,
  DefaultColor → Automatic, DefaultFont :→ $DefaultFont,
  DisplayFunction :→ $DisplayFunction, Epilog → {}, FaceGrids → None,
  FormatType :→ $FormatType, ImageSize → Automatic, Lighting → True,
  LightSources → {{{1., 0., 1.}, RGBColor[1, 0, 0]},
    {{1., 1., 1.}, RGBColor[0, 1, 0]}, {{0., 1., 1.}, RGBColor[0, 0, 1]}},
  Plot3Matrix → Automatic, PlotLabel → None, PlotPoints → Automatic,
  PlotRange → Automatic, PlotRegion → Automatic, PolygonIntersections → True,
  Prolog → {}, RenderAll → True, Shading → True, SphericalRegion → False,
  TextStyle :→ $TextStyle, Ticks → Automatic, ViewCenter → Automatic,
  ViewPoint → {1.3, -2.4, 2.}, ViewVertical → {0., 0., 1.}}
```

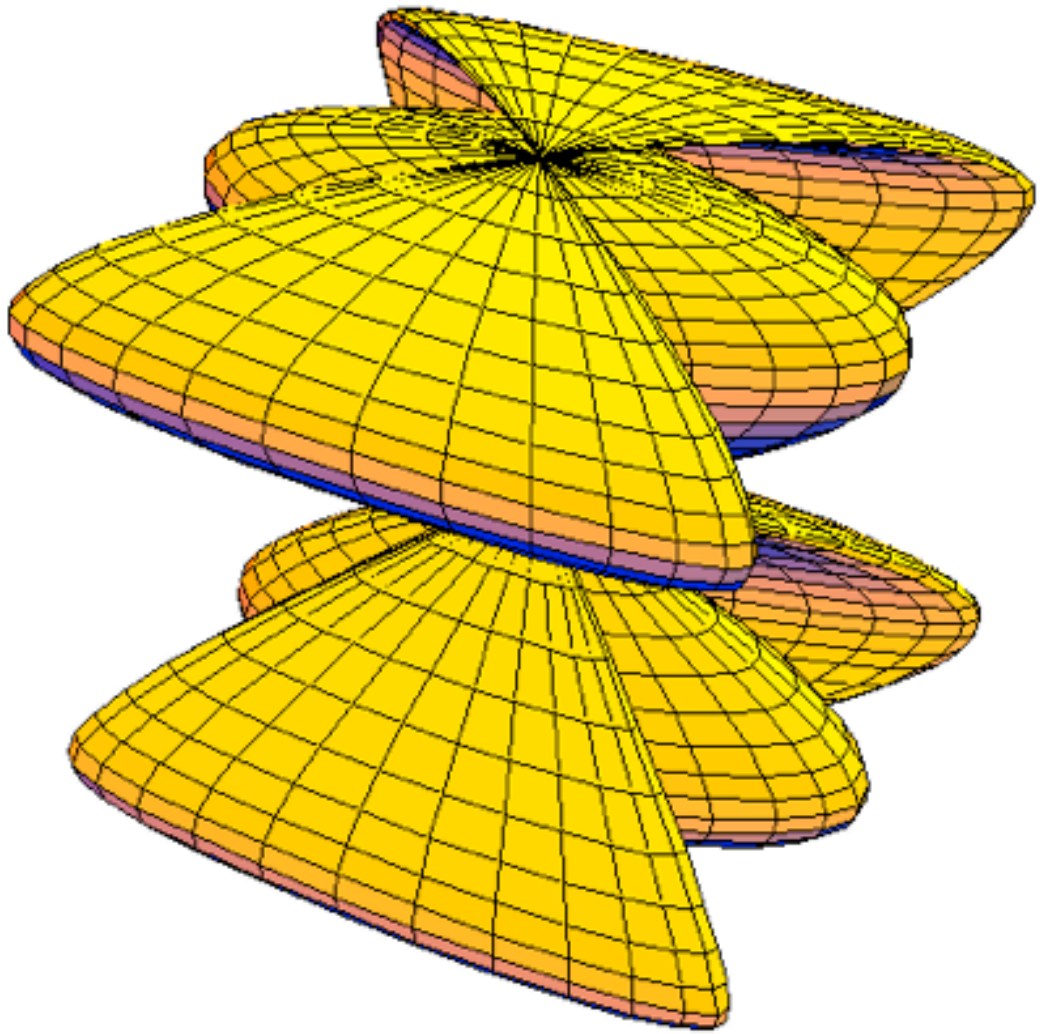
```
ParametricPlot3D[{ Sin[2 v] Cos[3 u], Sin[2 v] Sin[u], Cos[v]},
 {u, 0, 2 Pi}, {v, 0, Pi}, Boxed → False, Axes → False]
```



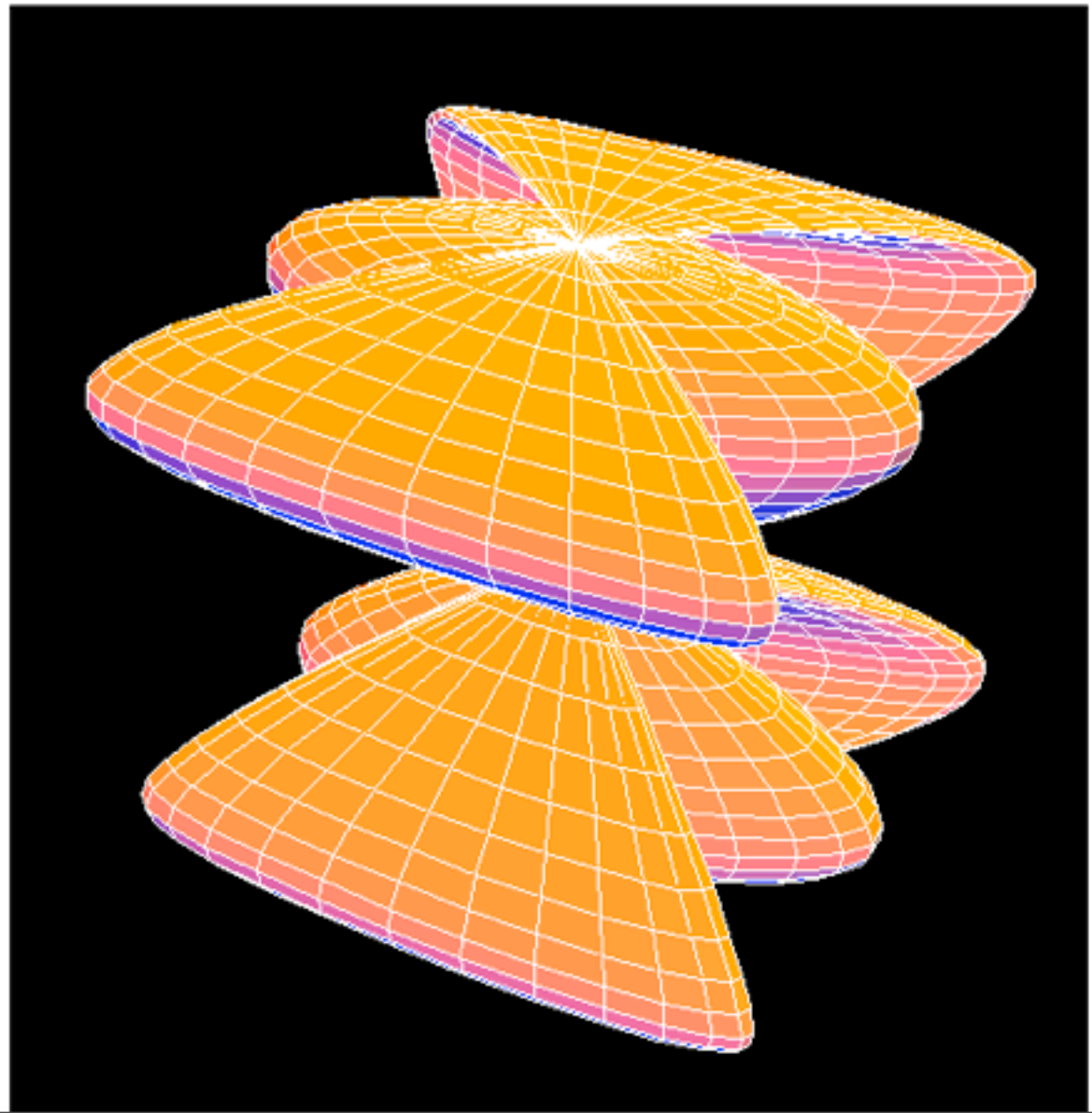
In[182]:=
```
ParametricPlot3D[{ Sin[2 v] Cos[3 u], Sin[2 v] Sin[u], Cos[v]},
 {u, 0, 2 Pi}, {v, 0, Pi}, Boxed → False, Axes → False,
 PlotPoints → {80, 40}]
```

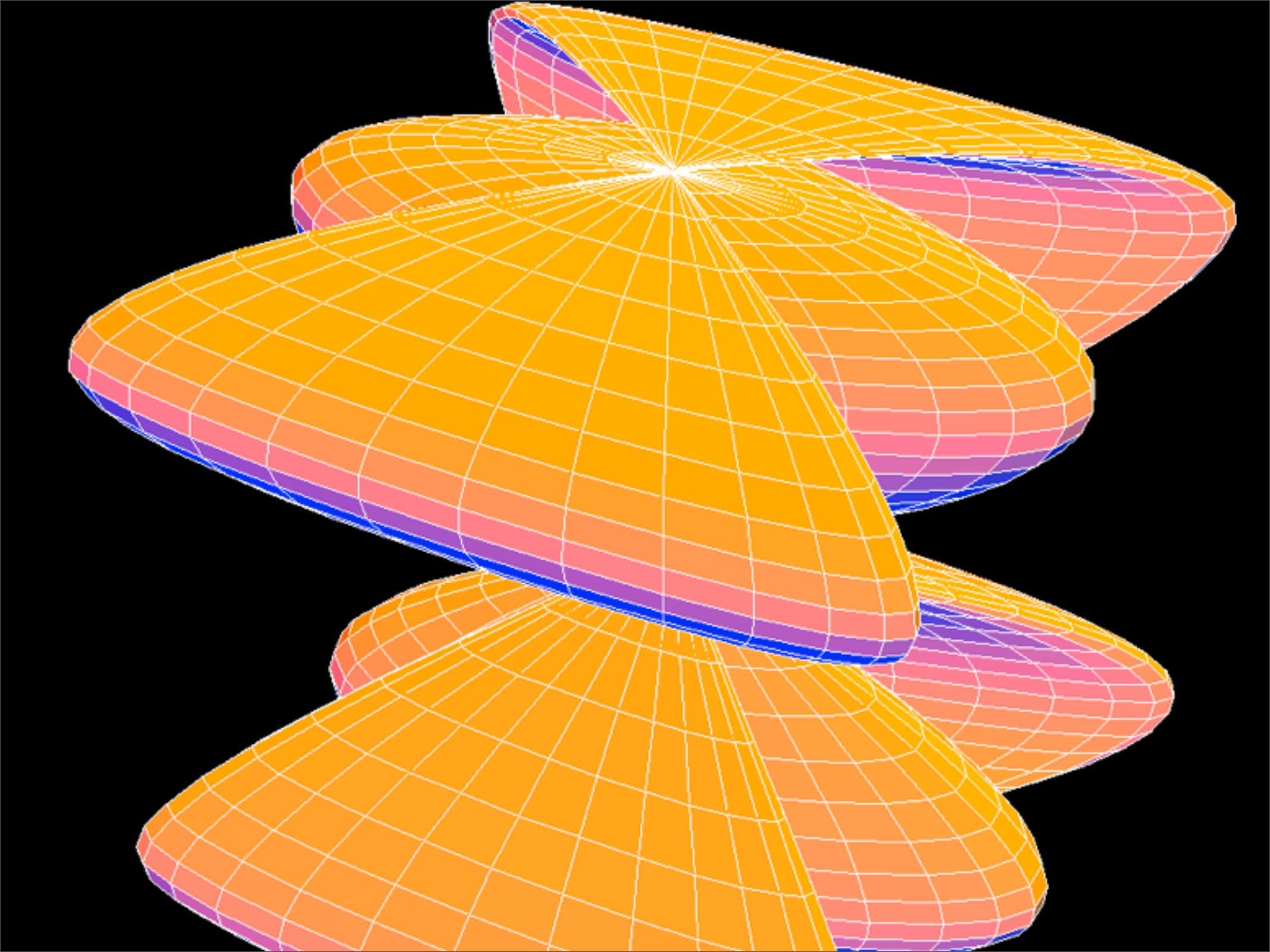


```
ParametricPlot3D[{ Sin[2 v] Cos[3 u], Sin[2 v] Sin[u], Cos[v]},
 {u, 0, 2 Pi}, {v, 0, Pi}, Boxed → False, Axes → False,
 LightSources → {
    {{1, 2, 3},    RGBColor[1, 1, 0]},
    {{0, 1, 1},    RGBColor[1, 0, 0]},
    {{-1, -3, 0}, RGBColor[0, 0, 1]}}, PlotPoints → {80, 40}]
```

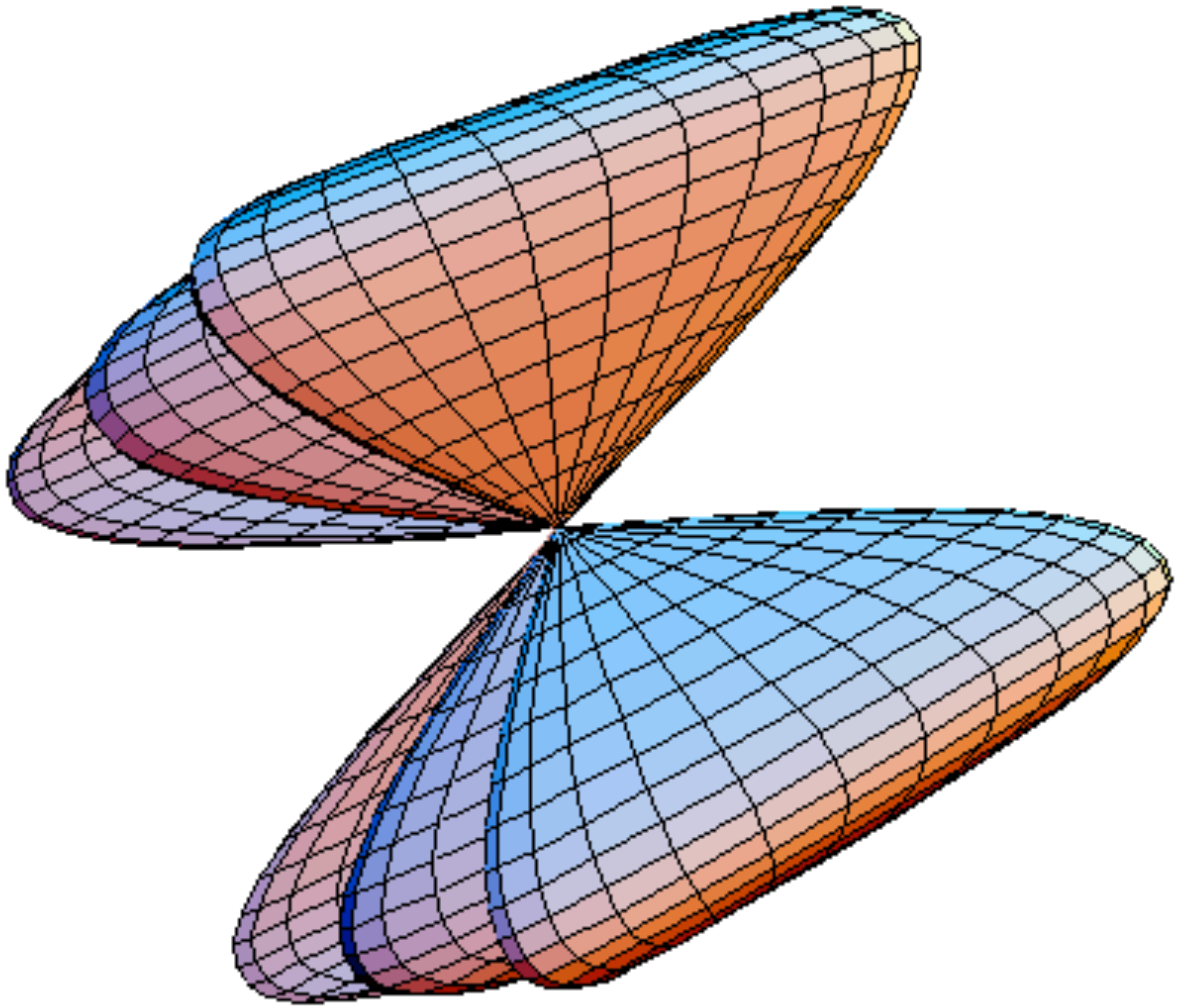


```
{u, 0, 2 Pi}, {v, 0, Pi}, Boxed → False, Axes → False,
Background → RGBColor[0, 0, 0],
LightSources → {
   {{1, 2, 3},    RGBColor[1, 0.7, 0]},
   {{0, 1, 1},    RGBColor[1, 0, 0]},
   {{-1, -3, 0.8}, RGBColor[0, 0, 1]}}, PlotPoints → {80, 40}]
```





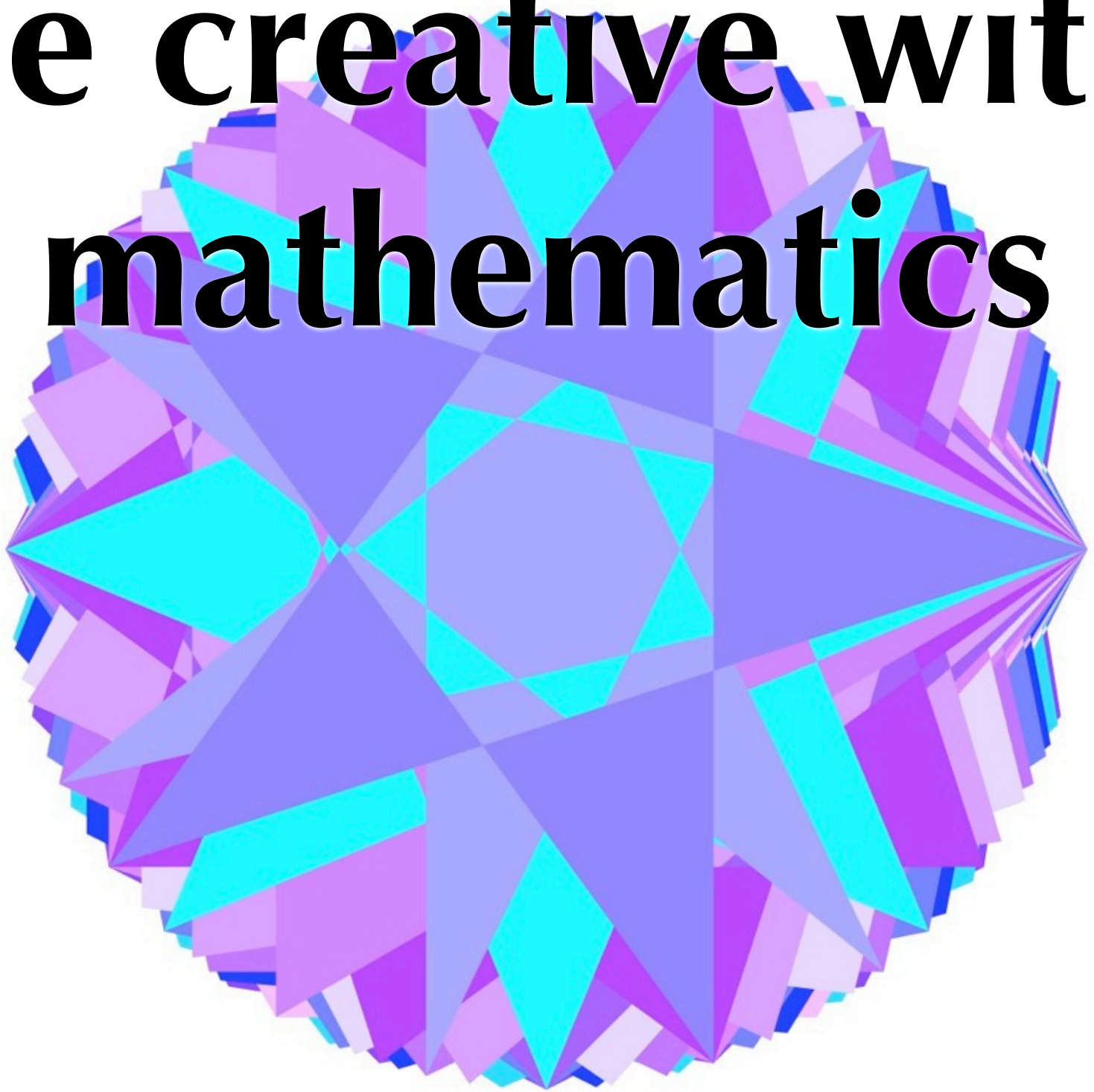
```
ParametricPlot3D[{ Sin[2 v] Cos[3 u],  Sin[2 v] Sin[u],
 {u, 0, 2 Pi}, {v, 0, Pi}, Boxed → False, Axes → False,
 ViewPoint → {1.3, 2.4, 0}, ViewVertical → {0, 1, 1}, Pl
```



drawing

- there is built in graphics drawing help.
- Don’t use it. Its not forbidden but diminuishes the chance to get into the hall of fame.

be creative with mathematics



fun

- sound and images
- movies
- external files
- simple programming
- demonstration project

sound

```
PlaySong[hull_, tune_, name_, ground_] :=
 Module[{}, u = ToCharacterCode[name];
  soundfilename = FromCharacterCode[
    Join[u, {46, 119, 97, 118}]];
  scale[n_] := ground*2^(n/12); beatlength = 1/5;
  songlength = Length[tune]*beatlength;
  frequency[x_] := tune[[1 + Floor[x/beatlength]]];
  song[t_] := hull[scale[frequency[t]]*t];
  P = Play[song[t], {t, 0, songlength}];
  Export[soundfilename, P, "WAV"];]

t1 = {0, 0, 4, 4, 7, 7, 5, 4, 2, 2, 0, 4, 7, 4, 0, 0, 0, 0, 0, 2, 0};
f1[x_] := Sin[x]; n1 = "sin"; g1 = 2000;
PlaySong[f1, t1, n1, g1]
```

In[21]:=

```
Play[Sin[2 Pi 6000 x], {x, 0, 5}]
```

Out[21]= - Sound -

In[20]:=

```
Play[Random[], {x, 0, 1}]
```

In[24]:=
```
a = Import["desktop/mathematica_2006/jane.wav"];
```

In[25]:=
```
type = a[[1, 2]]; n = Length[a[[1, 1, 1]]];
song = {Table[a[[1, 1, 1, n - k]] / 2, {k, 0, n - 1}],
    Table[a[[1, 1, 2, n - k]] / 2, {k, 0, n - 1}]};

c = Sound[SampledSoundList[song, type]];
Export["desktop/jane_reversed.wav", c, "WAV"]
```

image

```
A=Import["desktop/mathematica_2006/alig.jpg"];
ApplyFilter[F_,A_]:=Graphics[Raster[F[A[[1,1]]],A[[1,2]],A[[1,3]],A[[1,4]]],A[[2]],A[[3]],A[[4]]]

Dim[x_]:=Round[x/2]; B1=ApplyFilter[Dim,A];
Brighten[x_]:=Round[120+2x/3]; B2=ApplyFilter[Brighten,A];
red[{r_,g_,b_}]:={r,0,0}; Rred[S_]:=Table[red[S[[i,j]]],{i,Length[S]},{j,Length[S[[1]]]}];
green[{r_,g_,b_}]:={0,g,0}; Ggreen[S_]:=Table[green[S[[i,j]]],{i,Length[S]},{j,Length[S[[1]]]}];
blue[{r_,g_,b_}]:={0,0,b}; Bblue[S_]:=Table[blue[S[[i,j]]],{i,Length[S]},{j,Length[S[[1]]]}];
rotate[{r_,g_,b_}]:={b,r,g}; Rotate[S_]:=Table[rotate[S[[i,j]]],{i,Length[S]},{j,Length[S[[1]]]}]
reflect[{r_,g_,b_}]:={255-r,255-g,255-b}; Reflect[S_]:=Table[reflect[S[[i,j]]],{i,Length[S]},{j,L

Show[ApplyFilter[Dim,A]]
Show[ApplyFilter[Rred,A]];
Show[ApplyFilter[Ggreen,A]];
Show[ApplyFilter[Reflect,A]];
```

- Graphics -

Combine

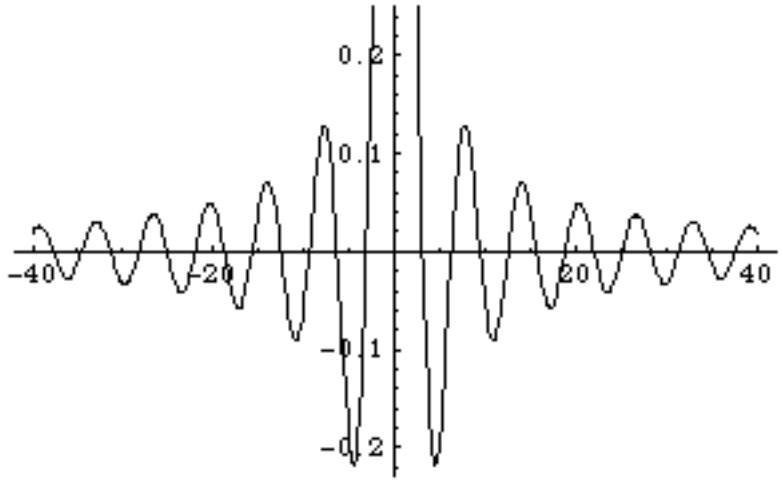
```
A1=Import["desktop/mathematica_2006/alig.jpg"]; A2=Import["desktop/mathematica_2006/borat.jpg"];
Combine[F_,U_,V_]:=Graphics[Raster[F[U[[1,1]],V[[1,1]]],U[[1,2]],U[[1,3]],U[[1,4]]],U[[2]],U[[3]]
LinearCombination[a_]:=Function[{x,y},(1-a)*x+a*y];

Do[Show[Combine[LinearCombination[k/10],A1,A2]],{k,10}]
```

importing, exporting files

Save as JPG

In[2]:=
```
S = Plot[Sin[x] / x, {x, -40, 40}]
```



Out[2]= - Graphics -

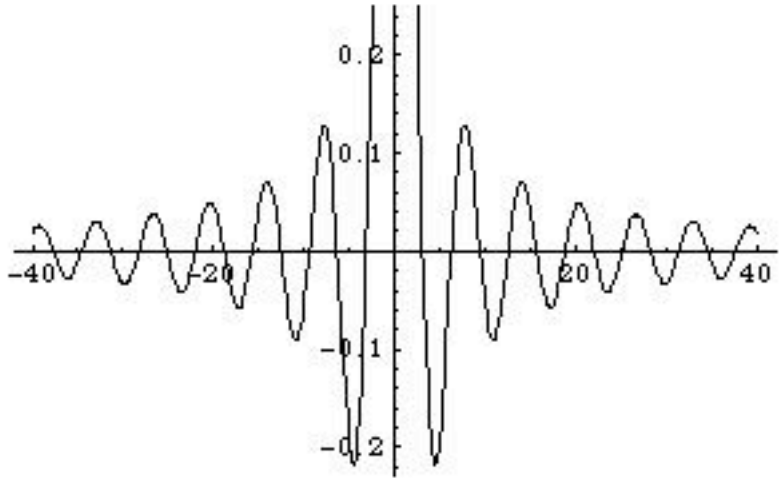
In[3]:=
```
Display["picture.jpg", S, "JPG"]
```

Out[3]= - Graphics -

In[4]:=
```
A = Import["picture.jpg"]
```

Out[4]= - Graphics -

In[5]:=
```
Show[A]
```



Out[5]= - Graphics -

Save as Wave

In[6]:=
```
S = Play[Sin[4000 x^2], {x, 0, 5}]
```

Out[6]= - Sound -

In[8]:=
```
Export["sound.wav", S, "WAV"]
```

Out[8]= sound.wav

In[9]:=
```
A = Import["sound.wav"]
```

Out[9]= - Sound -

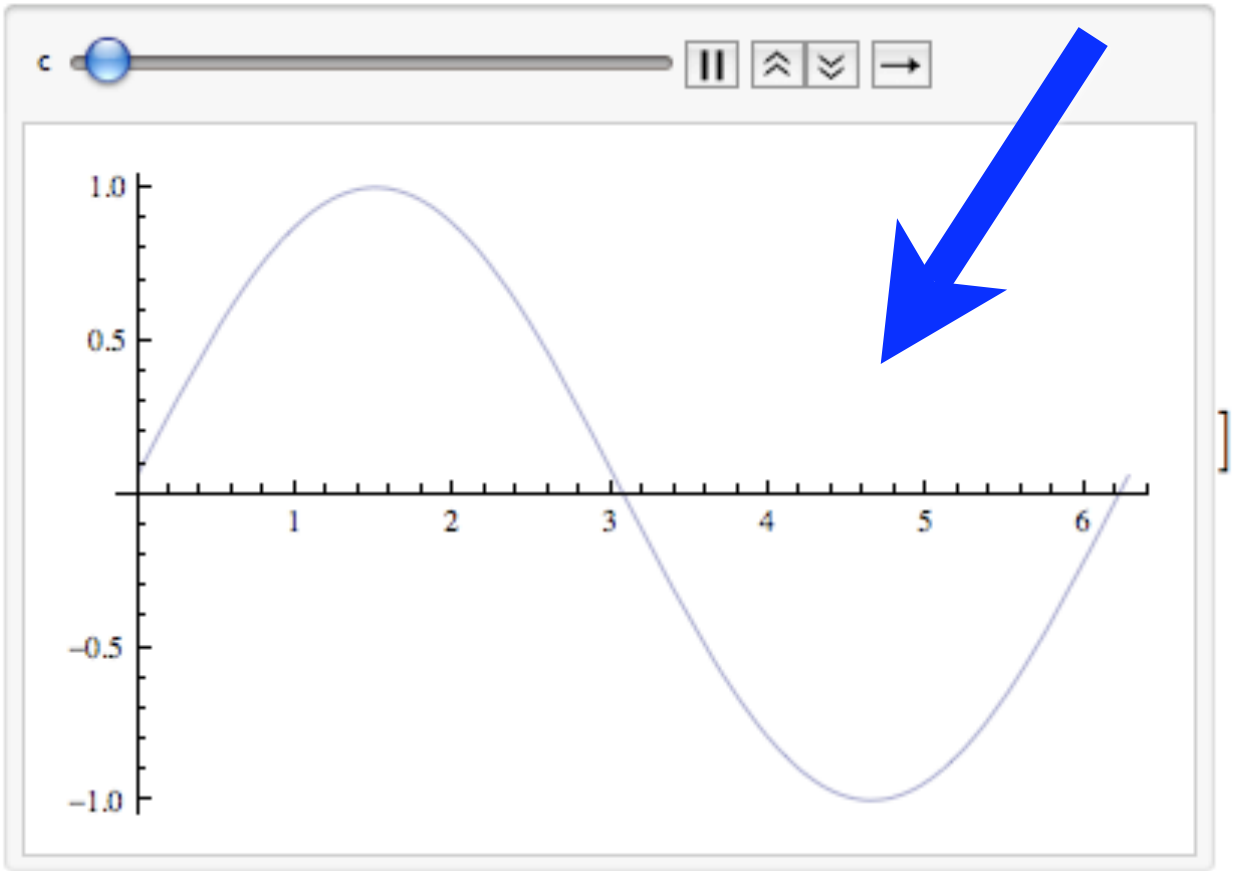
In[13]:=
```
Run["open sound.wav"]
```

saveanimation

In[28]:=
```
Animate[Plot[Sin[x + c], {x, 0, 2 Pi}], {c, 0, 2 Pi}]
```

In[29]:=
```
Export["sin.swf",
```

Save as Flash



Out[29]= sin.swf

```
A = Import["http://www.cnn.com", "Data"];

InputForm[A]

Export["formula.html",
 Expand[(a + b)^50 Sqrt[a]]]
```

import HTML

Firefox File Edit View History Bookmarks Tools Window Help

Untitled

file://localhost/Users/knill/formula.html

Google

Google FAS Software Downlo... Lineintegral ha 21 21b /. di sp TD cnn wp nyt ma ok adv ip courses expos math

$$a^{101/2} + 50\, a^{99/2} b + 1225\, a^{97/2} b^2 + 19\,600\, a^{95/2} b^3 + 230\,300\, a^{93/2} b^4 +$$
$$2\,118\,760\, a^{91/2} b^5 + 15\,890\,700\, a^{89/2} b^6 + 99\,884\,400\, a^{87/2} b^7 + 536\,878\,650\, a^{85/2} b^8 +$$
$$2\,505\,433\,700\, a^{83/2} b^9 + 10\,272\,278\,170\, a^{81/2} b^{10} + 37\,353\,738\,800\, a^{79/2} b^{11} +$$
$$121\,399\,651\,100\, a^{77/2} b^{12} + 354\,860\,518\,600\, a^{75/2} b^{13} + 937\,845\,656\,300\, a^{73/2} b^{14} +$$
$$2\,250\,829\,575\,120\, a^{71/2} b^{15} + 4\,923\,689\,695\,575\, a^{69/2} b^{16} + 9\,847\,379\,391\,150\, a^{67/2} b^{17} +$$
$$18\,053\,528\,883\,775\, a^{65/2} b^{18} + 30\,405\,943\,383\,200\, a^{63/2} b^{19} + 47\,129\,212\,243\,960\, a^{61/2} b^{20} +$$
$$67\,327\,446\,062\,800\, a^{59/2} b^{21} + 88\,749\,815\,264\,600\, a^{57/2} b^{22} + 108\,043\,253\,365\,600\, a^{55/2} b^{23} +$$
$$121\,548\,660\,036\,300\, a^{53/2} b^{24} + 126\,410\,606\,437\,752\, a^{51/2} b^{25} +$$
$$121\,548\,660\,036\,300\, a^{49/2} b^{26} + 108\,043\,253\,365\,600\, a^{47/2} b^{27} +$$
$$88\,749\,815\,264\,600\, a^{45/2} b^{28} + 67\,327\,446\,062\,800\, a^{43/2} b^{29} + 47\,129\,212\,243\,960\, a^{41/2} b^{30} +$$
$$30\,405\,943\,383\,200\, a^{39/2} b^{31} + 18\,053\,528\,883\,775\, a^{37/2} b^{32} + 9\,847\,379\,391\,150\, a^{35/2} b^{33} +$$
$$4\,923\,689\,695\,575\, a^{33/2} b^{34} + 2\,250\,829\,575\,120\, a^{31/2} b^{35} + 937\,845\,656\,300\, a^{29/2} b^{36} +$$
$$354\,860\,518\,600\, a^{27/2} b^{37} + 121\,399\,651\,100\, a^{25/2} b^{38} + 37\,353\,738\,800\, a^{23/2} b^{39} +$$
$$10\,272\,278\,170\, a^{21/2} b^{40} + 2\,505\,433\,700\, a^{19/2} b^{41} + 536\,878\,650\, a^{17/2} b^{42} +$$
$$99\,884\,400\, a^{15/2} b^{43} + 15\,890\,700\, a^{13/2} b^{44} + 2\,118\,760\, a^{11/2} b^{45} +$$
$$230\,300\, a^{9/2} b^{46} + 19\,600\, a^{7/2} b^{47} + 1225\, a^{5/2} b^{48} + 50\, a^{3/2} b^{49} + \sqrt{a}\, b^{50}$$

Save as HTM

simple programming

In[56]:=
```
RandomDots := Module[{}, s = {};
    Do[
      {x, y} = {Random[], Random[]}; l = Random[] / 20;
      {r, g, b} = {Random[], Random[], Random[]};
     If[(x - 1 / 2) ^ 2 + (y - 1 / 2) ^ 2 < 1 / 4,
       s = Append[s, {RGBColor[r, g, b], Disk[{x, y}, l]}]],
      {i, 1, 300}
    ];
    Show[Graphics[s], AspectRatio → 1, PlotRange → {{-0.2, 1.2}, {-0.2, 1.2}},
     ImageSize → 600]];
```

In[57]:=
```
RandomDots
```

demonstration project

Tippe Top

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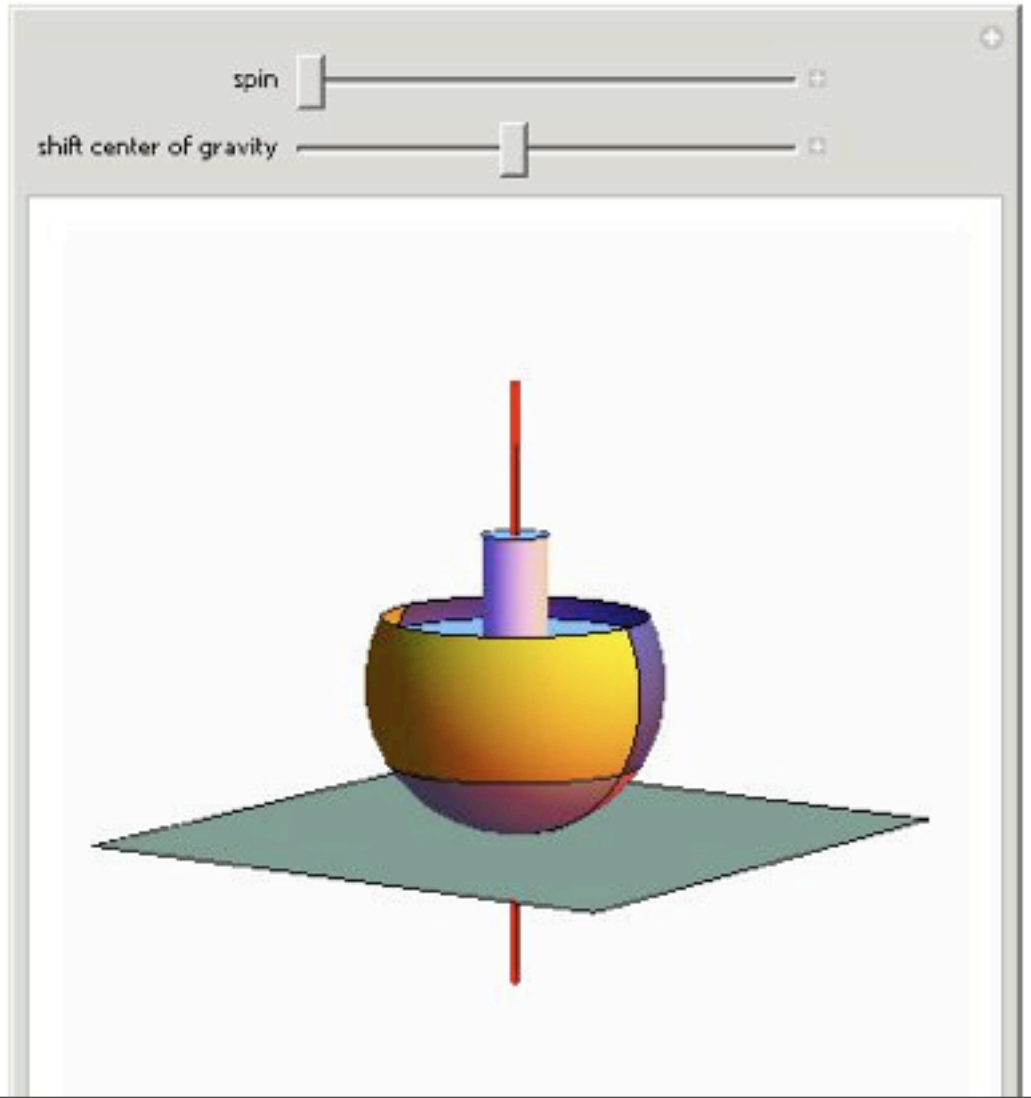

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- Forces on a Simple Pendulum
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- Anharmonic Oscillator Phase Space Trajectories 2D
- Synchronization of Coupled Phase Oscillators
- Classical Particle in a


turn the project
in on time!

the end