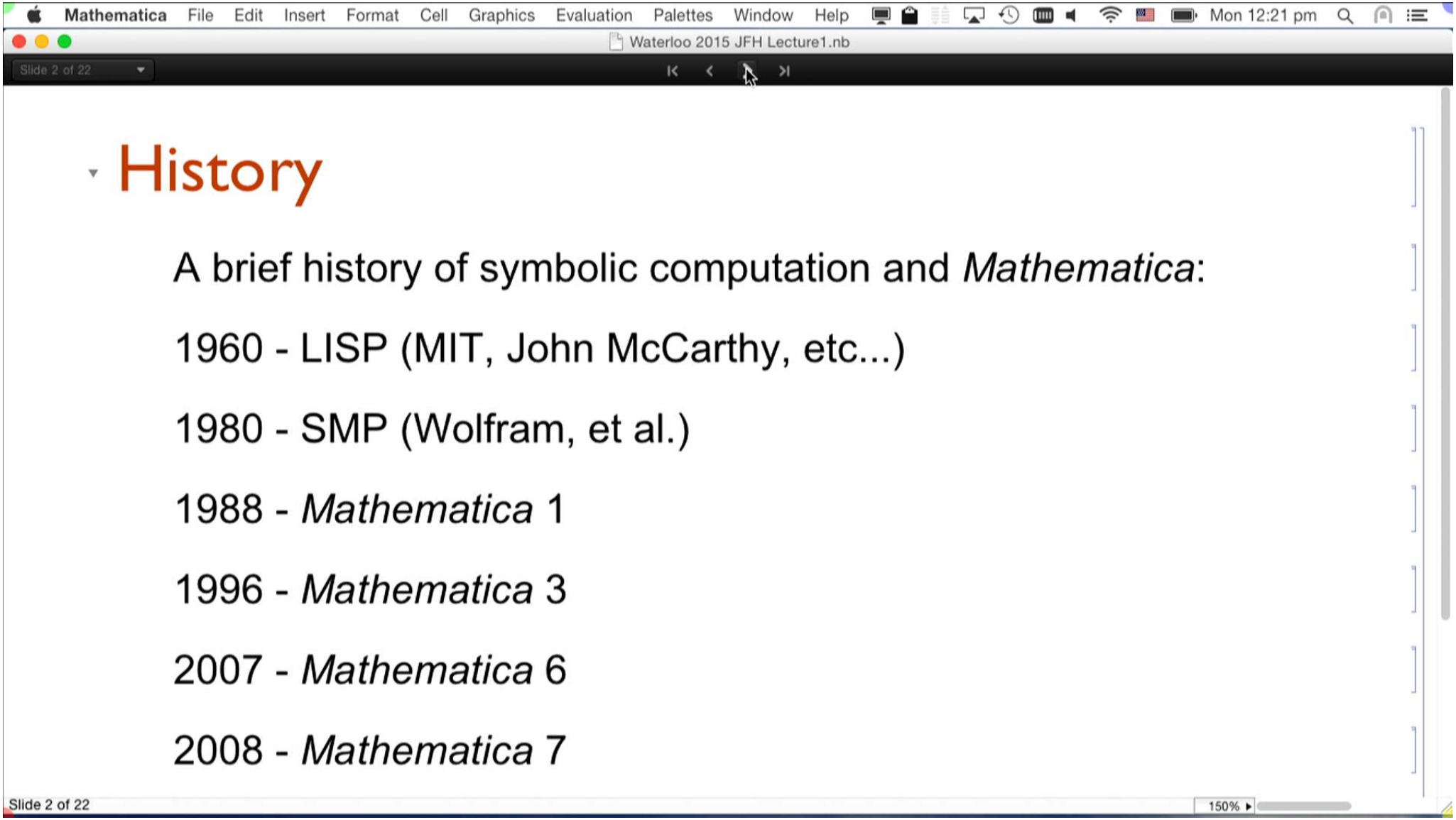
Title: TBA

Date: Aug 24, 2015 12:00 PM

URL: http://pirsa.org/15080042

Abstract: TBA

This talk gives a fast introduction to *Mathematica*. It is not so much intended to educate you about the use of *Mathematica* in Physics, rather its aim is to establish a minimum base level of *Mathematica* necessary for the succeeding days of the summer school. It will also focus on some points that are likely outside the scope of the other talks in the summer school. A range of topics will be covered including the graphics system, visualization, symbolic computation, and numeric computation. However the main focus will be the core language, and demonstrating how to drive the front end and how to interact with *Mathematica*. Since *Mathematica* is such a vast system, this talk will of course be only an introduction to the core of *Mathematica*.


Mathematica File Edit Insert Format Cell Graphics Evaluation Palettes Window Help Mon 12:21 pm
Waterloo 2015 JFH Lecture1.nb
Slide 2 of 22
History
A brief history of symbolic computation and Mathematica:
1960 - LISP (MIT, John McCarthy, etc...)
1980 - SMP (Wolfram, et al.)
1988 - Mathematica 1
1996 - Mathematica 3
2007 - Mathematica 6
2008 - Mathematica 7
Slide 2 of 22
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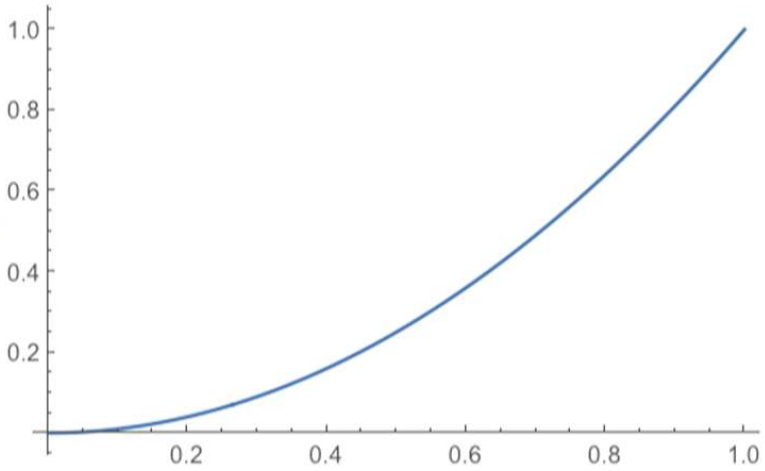
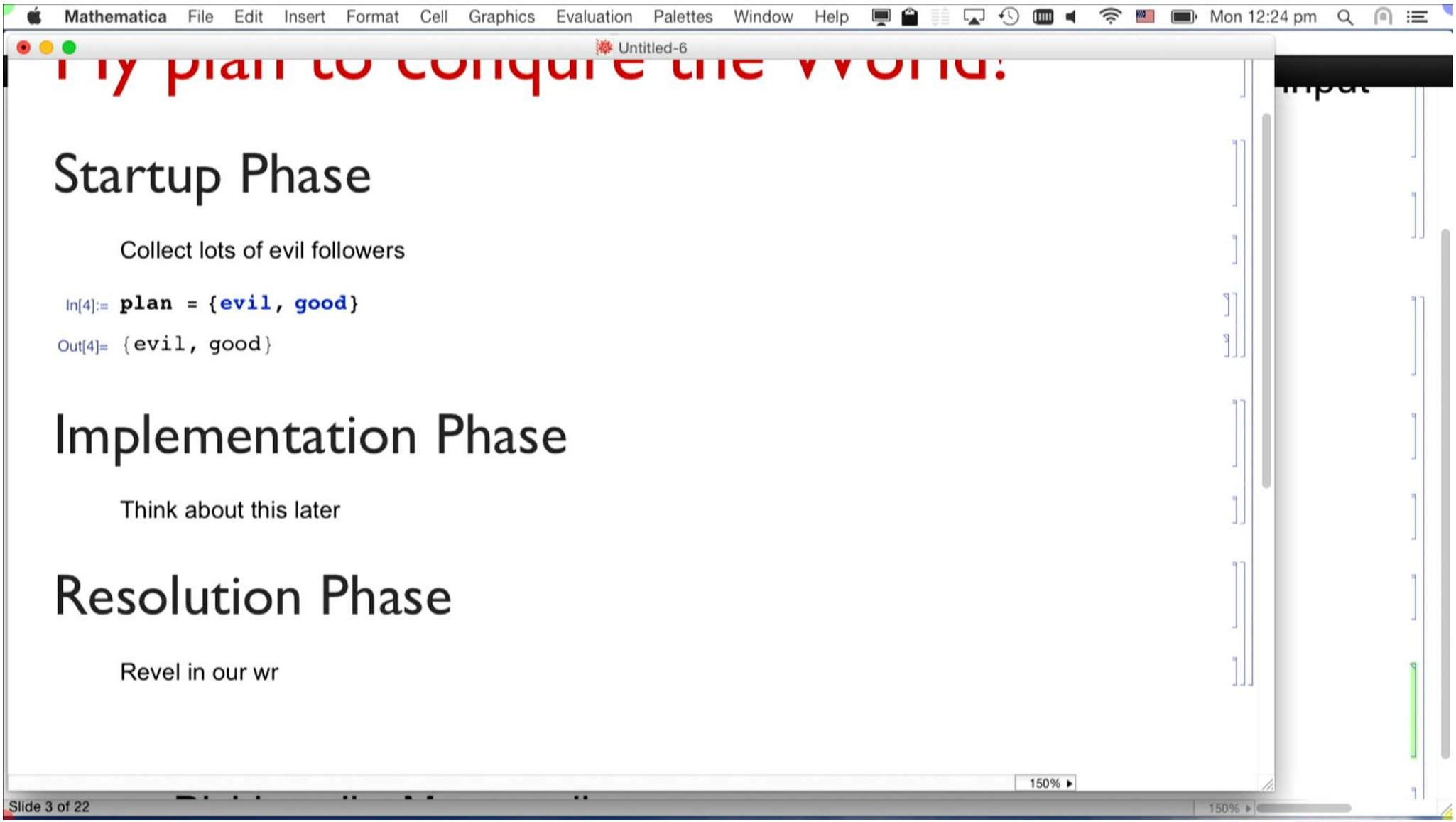
Notebook Interface

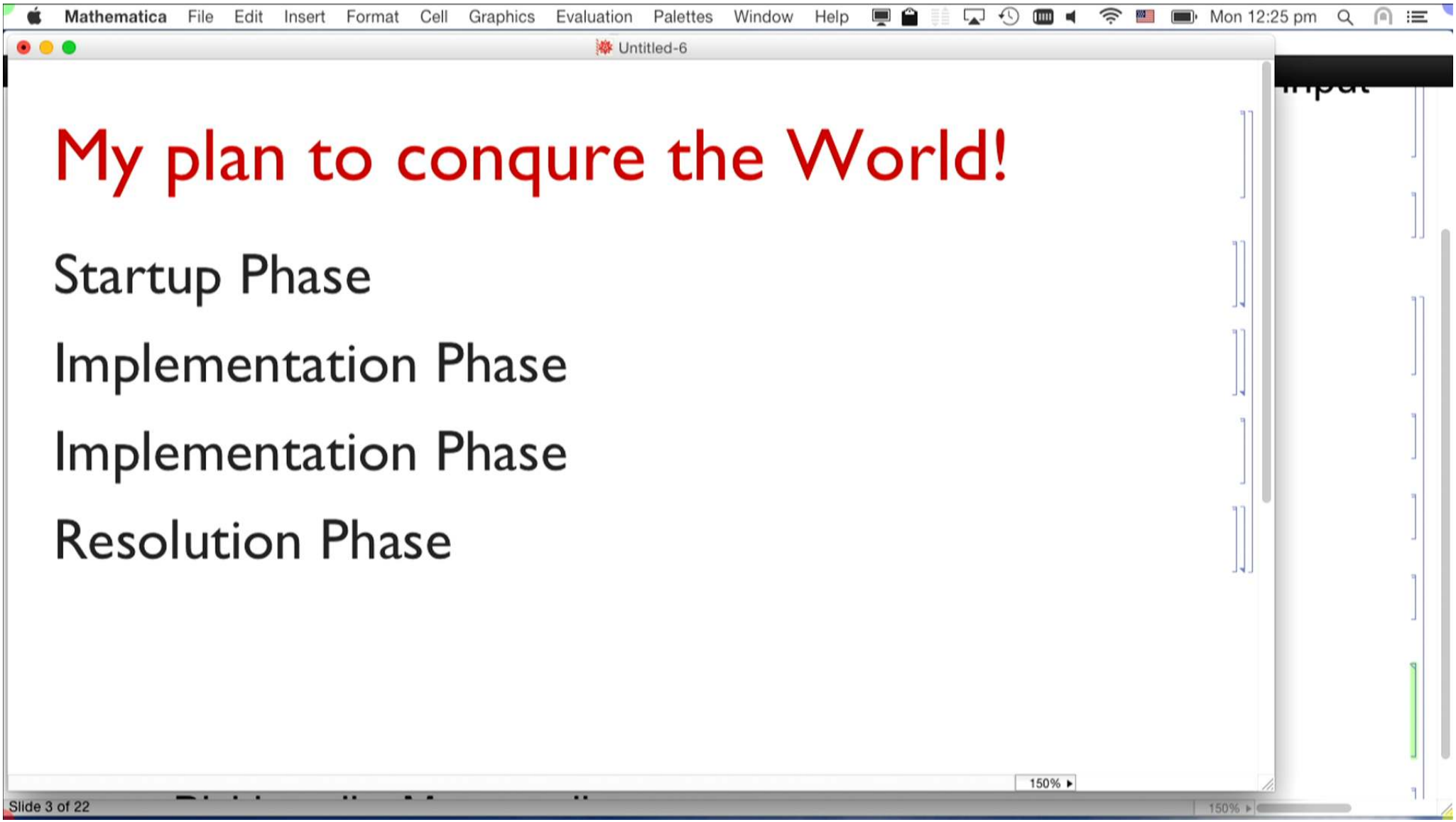
In[2]:= `Plot[x^2, {x, 0, 1}]`

Out[2]=



The front end uses a notebook, interface with cells, graphics, input output all mixed together.


Mathematica File Edit Insert Format Cell Graphics Evaluation Palettes Window Help Mon 12:24 pm
Untitled-6
My plan to conquer the World!
Startup Phase
Collect lots of evil followers
In[4]:= plan = {evil, good}
Out[4]= {evil, good}
Implementation Phase
Think about this later
Resolution Phase
Revel in our wr
150%
Slide 3 of 22
150%


Mathematica File Edit Insert Format Cell Graphics Evaluation Palettes Window Help Mon 12:25 pm
Untitled-6
My plan to conqure the World!
Startup Phase
Implementation Phase
Implementation Phase
Resolution Phase
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Slide 3 of 22
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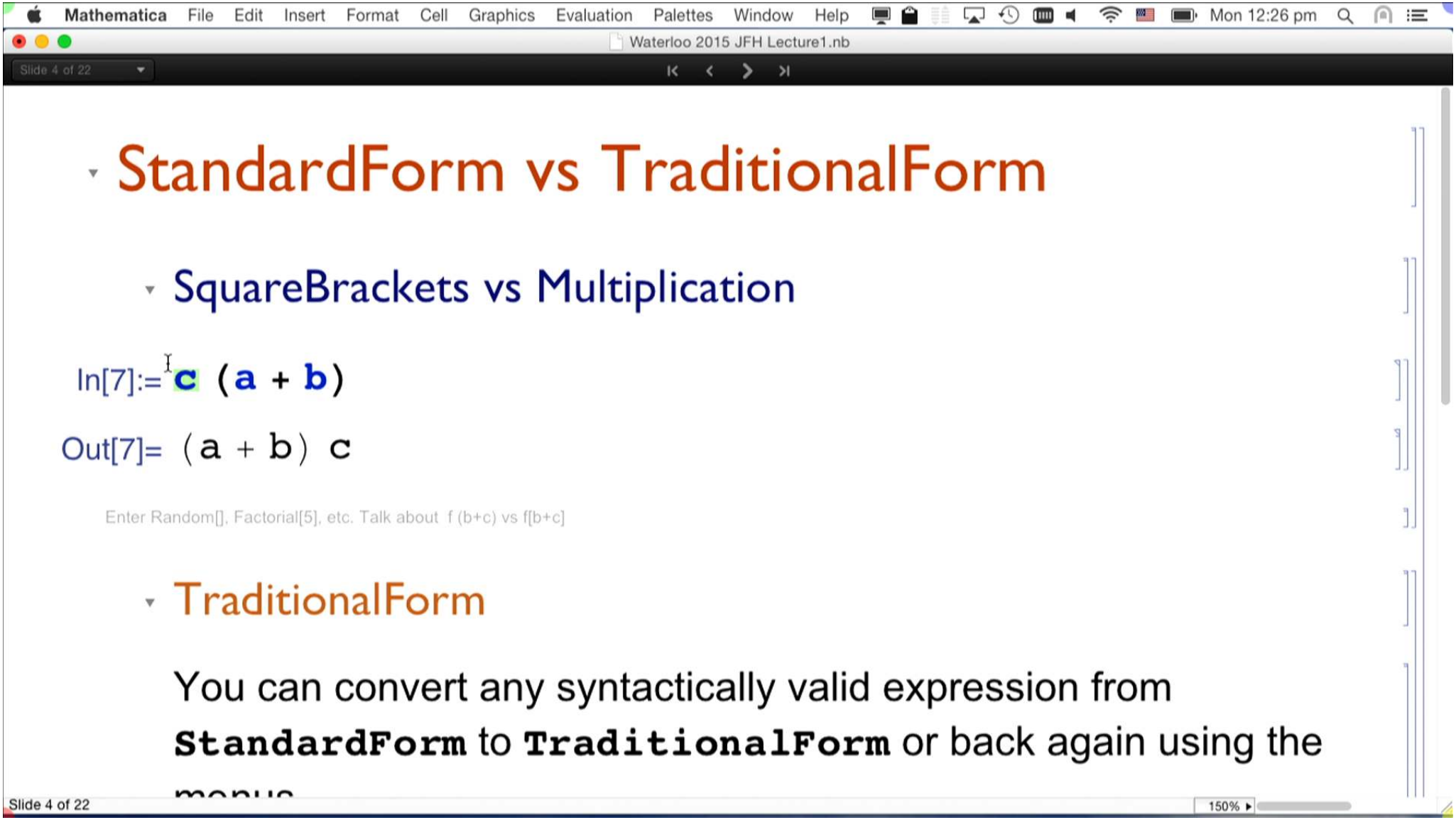
Mathematica File Edit Insert Format Cell Graphics Evaluation Palettes Window Help Mon 12:26 pm
Waterloo 2015 JFH Lecture1.nb
Slide 4 of 22
StandardForm vs TraditionalForm
SquareBrackets vs Multiplication
In[7]:= c (a + b)
Out[7]= (a + b) c
Enter Random[], Factorial[5], etc. Talk about f (b+c) vs f[b+c]
TraditionalForm
You can convert any syntactically valid expression from StandardForm to TraditionalForm or back again using the
Slide 4 of 22
150%


Mathematica File Edit Insert Format Cell Graphics Evaluation Palettes Window Help Mon 12:27 pm
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Slide 4 of 22
StandardForm vs TraditionalForm
SquareBrackets vs Multiplication
In[14]:= f(a + b)
Out[14]=
f [a + b]
Enter Random[], Factorial[5], etc. Talk about f (b+c) vs f[b+c]
TraditionalForm
You can convert any syntactically valid expression from
StandardForm to TraditionalForm or back again using the
Slide 4 of 22
150%

TraditionalForm

You can convert any syntactically valid expression from **StandardForm** to **TraditionalForm** or back again using the menus.

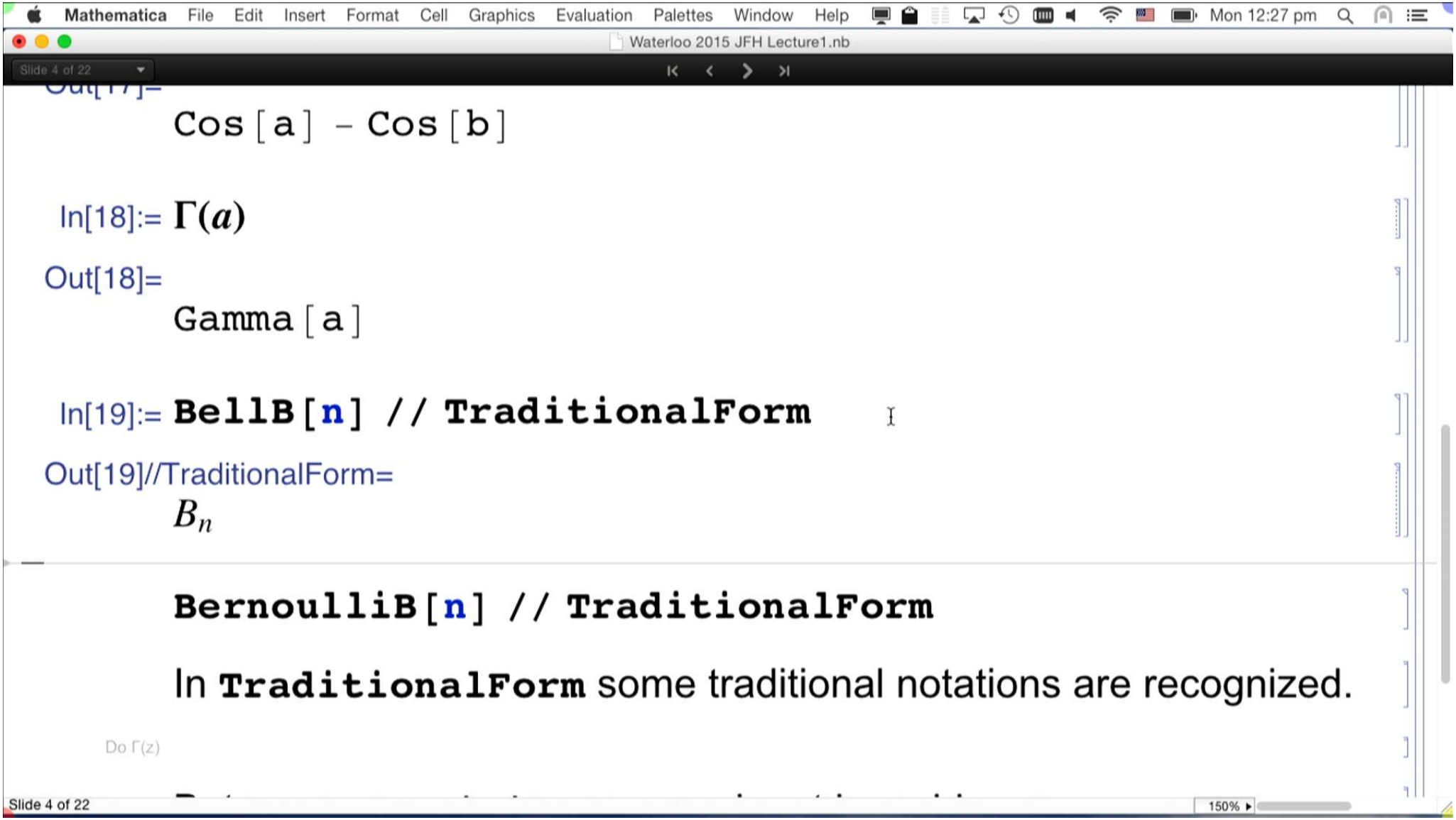
$$\int_a^b \text{Sin}[x]\, dx$$

```
Gamma[a]
```

```
BellB[n] // TraditionalForm
```

```
BernoulliB[n] // TraditionalForm
```

In **TraditionalForm** some traditional notations are recognized.


Mathematica File Edit Insert Format Cell Graphics Evaluation Palettes Window Help Mon 12:27 pm
Waterloo 2015 JFH Lecture1.nb
Slide 4 of 22
Cos[a] - Cos[b]
In[18]:= Γ(a)
Out[18]=
Gamma[a]
In[19]:= BellB[n] // TraditionalForm
Out[19]//TraditionalForm=
B_n
BernoulliB[n] // TraditionalForm
In TraditionalForm some traditional notations are recognized.
Do Γ(z)
Slide 4 of 22
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Slide 4 of 22

In[19]:= **BellB[n] // TraditionalForm**

Out[19]//TraditionalForm=

$$B_n$$

In[20]:= **BernoulliB[n] // TraditionalForm**

Out[20]//TraditionalForm=

$$B_n$$

In[23]:= $\boldsymbol{B_n}$

Out[23]=

BernoulliB[n]

In **TraditionalForm** some traditional notations are recognized.

Slide 4 of 22

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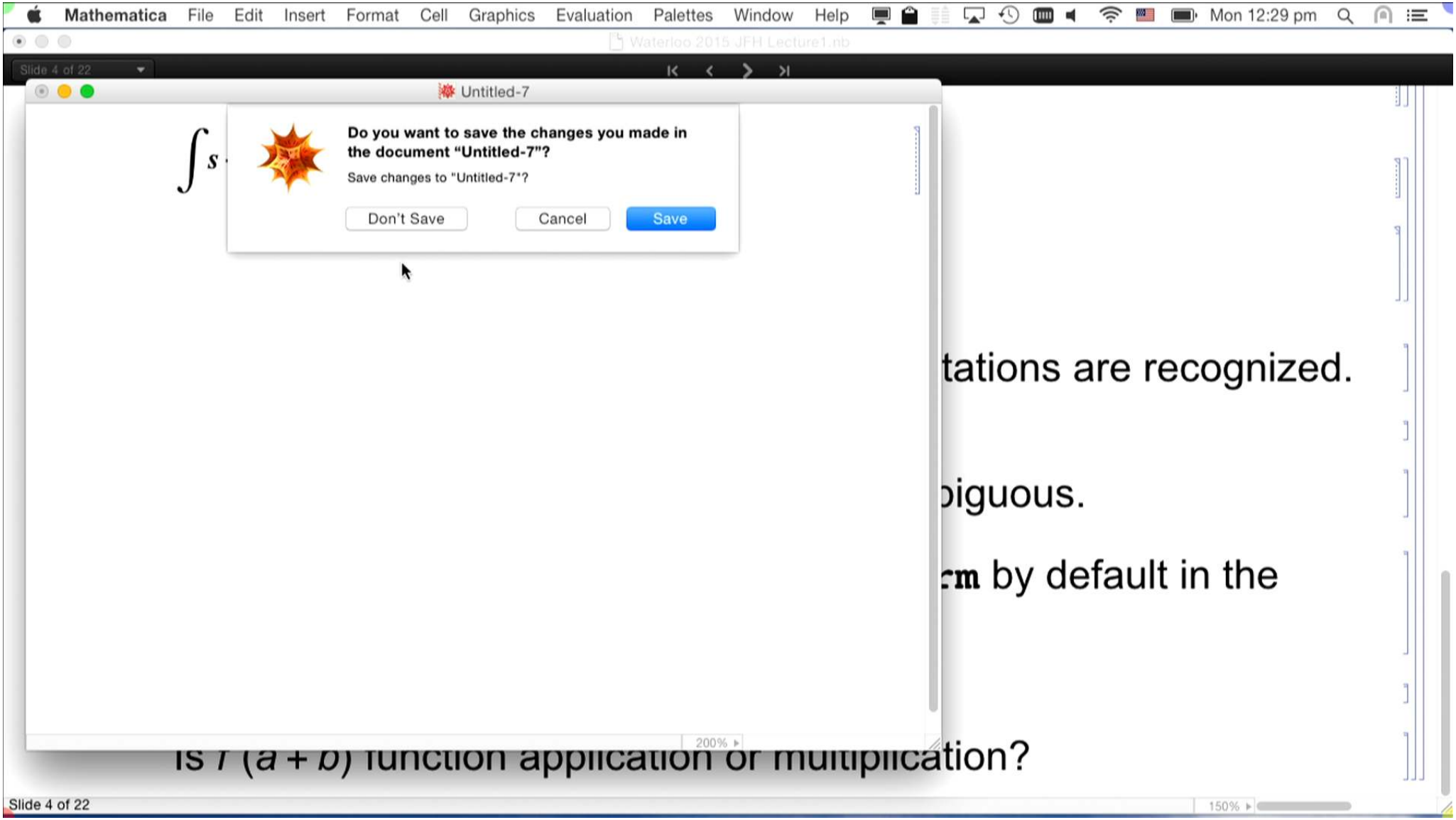
Mathematica File Edit Insert Format Cell Graphics Evaluation Palettes Window Help Mon 12:29 pm
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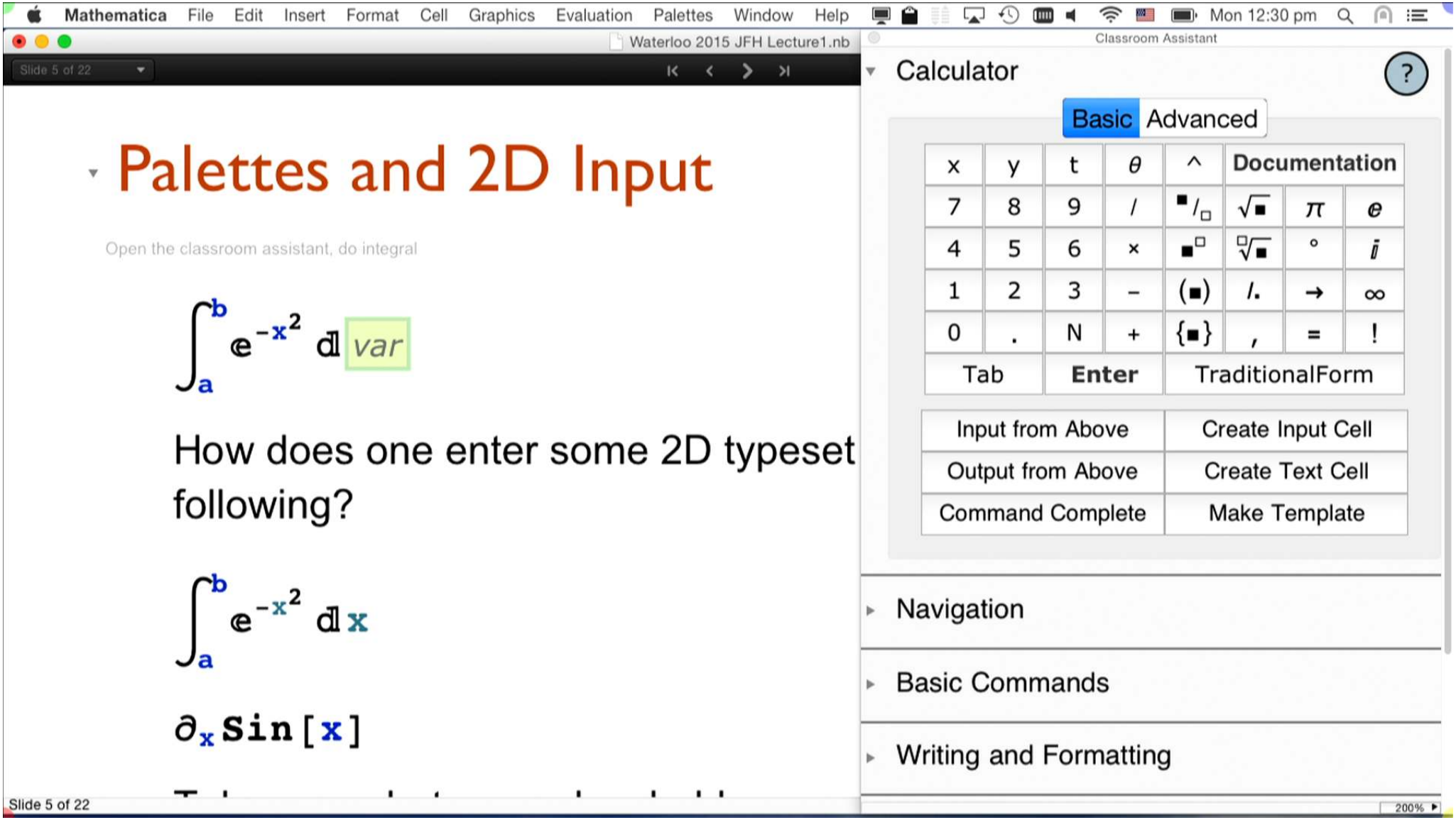
Slide 4 of 22
Untitled-7
Do you want to save the changes you made in the document "Untitled-7"?
Save changes to "Untitled-7"?
Don't Save
Cancel
Save
200%
tations are recognized.
biguous.
:m by default in the
is f (a + b) function application or multiplication?
Slide 4 of 22
150%


Mathematica File Edit Insert Format Cell Graphics Evaluation Palettes Window Help
Mon 12:30 pm
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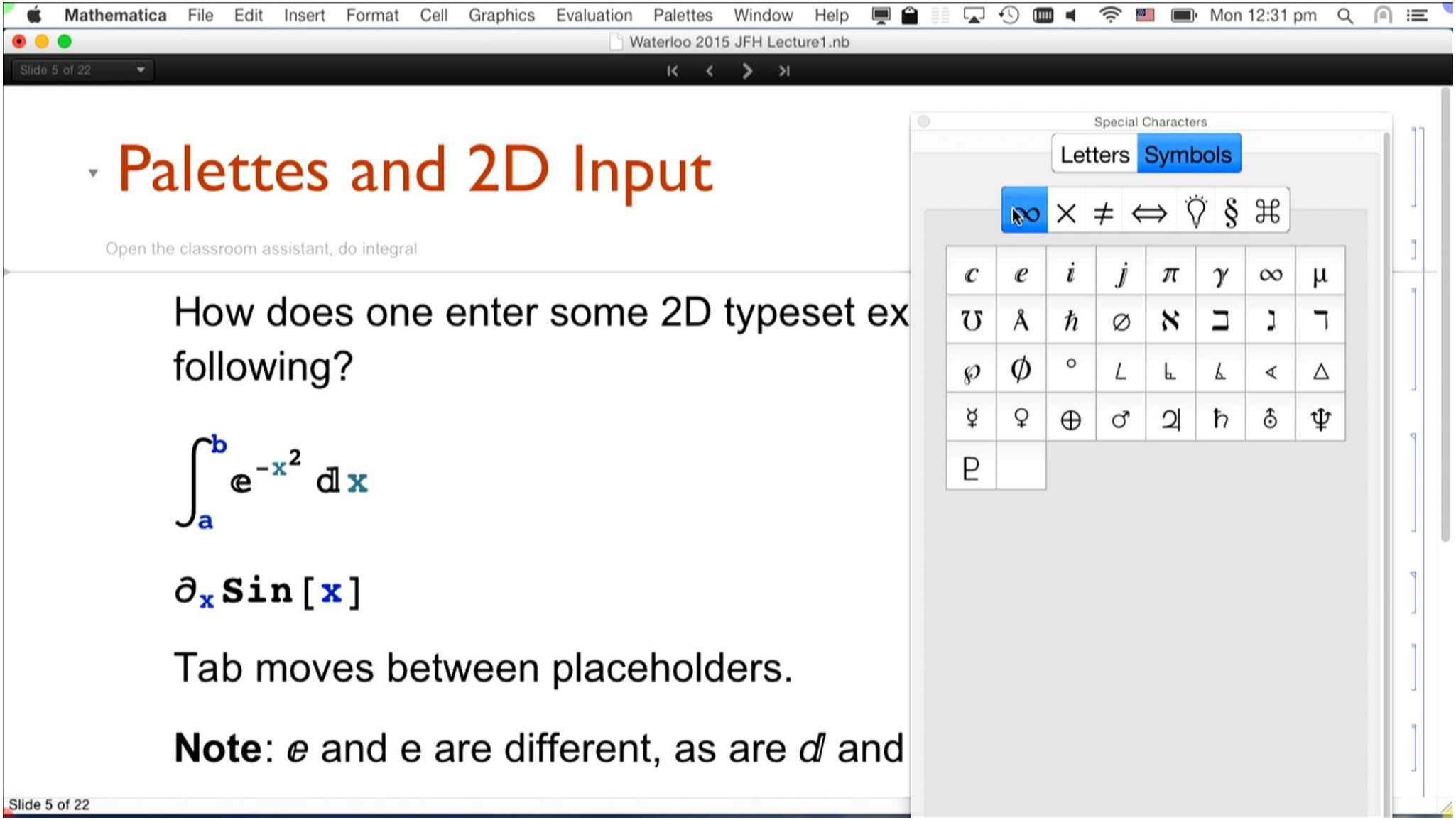
Slide 5 of 22
Palettes and 2D Input
Open the classroom assistant, do integral
$\int_a^b e^{-x^2}\, dvar$
How does one enter some 2D typeset following?
$\int_a^b e^{-x^2}\, dx$
$\partial_x \mathrm{Sin}[x]$
Slide 5 of 22
Classroom Assistant
Calculator
Basic Advanced
x y t θ ^ Documentation
7 8 9 / ■/□ √■ π e
4 5 6 × ■□ √□■ ° i
1 2 3 − (■) /. → ∞
0 . N + {■} , = !
Tab Enter TraditionalForm
Input from Above Create Input Cell
Output from Above Create Text Cell
Command Complete Make Template
Navigation
Basic Commands
Writing and Formatting
200%


Mathematica File Edit Insert Format Cell Graphics Evaluation Palettes Window Help Mon 12:31 pm
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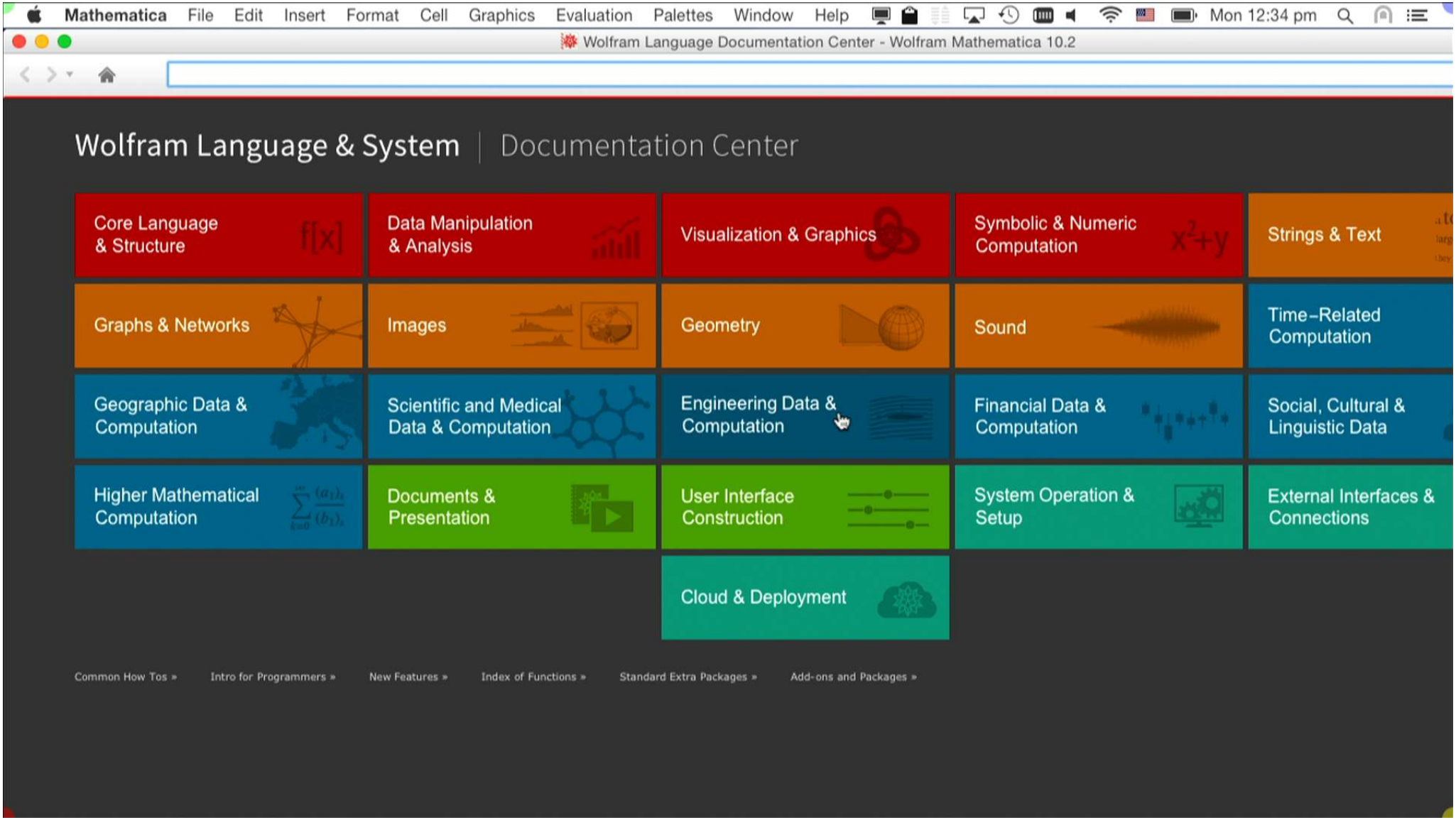
Slide 5 of 22
Palettes and 2D Input
Open the classroom assistant, do integral
How does one enter some 2D typeset ex
following?
$\int_a^b e^{-x^2}\,dx$
$\partial_x \mathrm{Sin}[x]$
Tab moves between placeholders.
Note: e and e are different, as are d and
Slide 5 of 22
Special Characters
Letters
Symbols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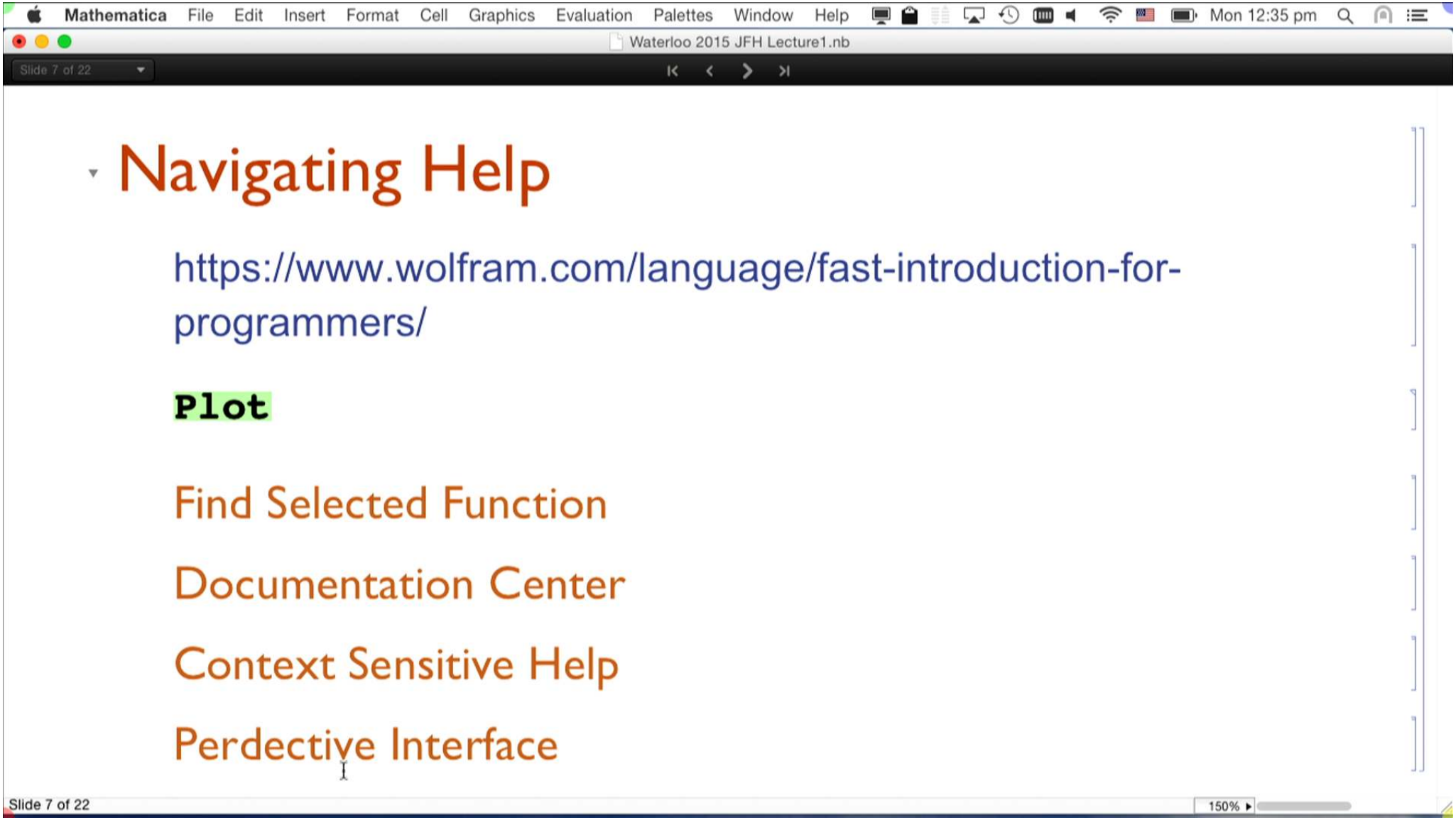
Wolfram Language Documentation Center - Wolfram Mathematica 10.2
Wolfram Language & System | Documentation Center
Core Language & Structure
Data Manipulation & Analysis
Visualization & Graphics
Symbolic & Numeric Computation
Strings & Text
Graphs & Networks
Images
Geometry
Sound
Time-Related Computation
Geographic Data & Computation
Scientific and Medical Data & Computation
Engineering Data & Computation
Financial Data & Computation
Social, Cultural & Linguistic Data
Higher Mathematical Computation
Documents & Presentation
User Interface Construction
System Operation & Setup
External Interfaces & Connections
Cloud & Deployment
Common How Tos »
Intro for Programmers »
New Features »
Index of Functions »
Standard Extra Packages »
Add-ons and Packages »


Mathematica File Edit Insert Format Cell Graphics Evaluation Palettes Window Help Mon 12:35 pm
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Slide 7 of 22
Navigating Help
https://www.wolfram.com/language/fast-introduction-for-programmers/
Plot
Find Selected Function
Documentation Center
Context Sensitive Help
Perdective Interface
Slide 7 of 22
150%

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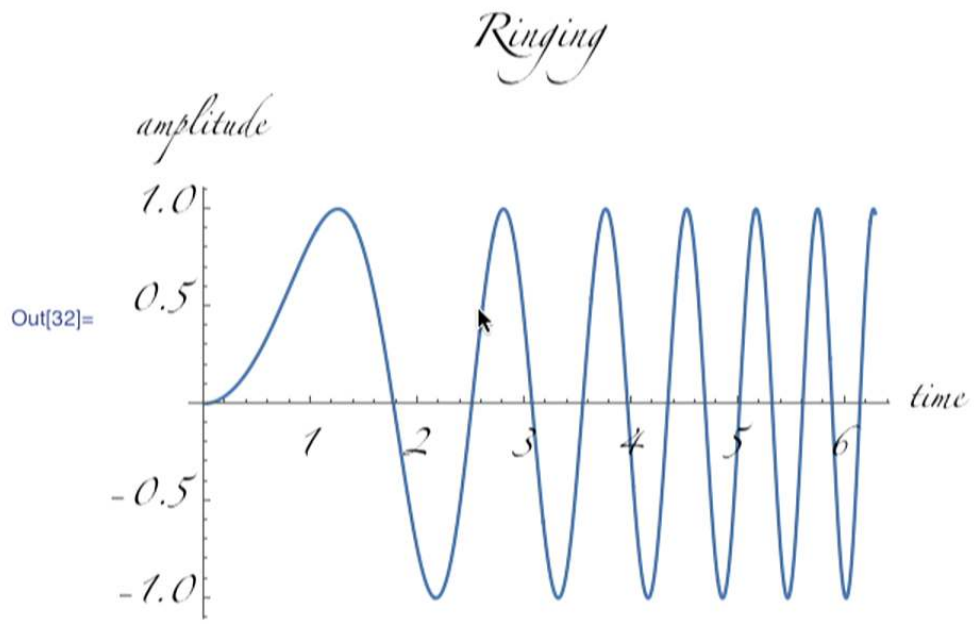
Slide 7 of 22

Untitled-9

```
PlotLabel → HoldForm[Ringing],
LabelStyle → {FontFamily → "Zapfino", GrayLevel[0]}]
```



Out[32]=

frame... labels... axes image size more...

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uction-for-

Slide 7 of 22

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In[34]:= $\text{Assuming}\left[\frac{}{k\,T} > 0, \int_0 \frac{}{c^3 \sum_{n=0}^{\infty} e^{-\frac{h\,n\,\nu}{k\,T}}}\, d\nu\right]$

Out[34]=

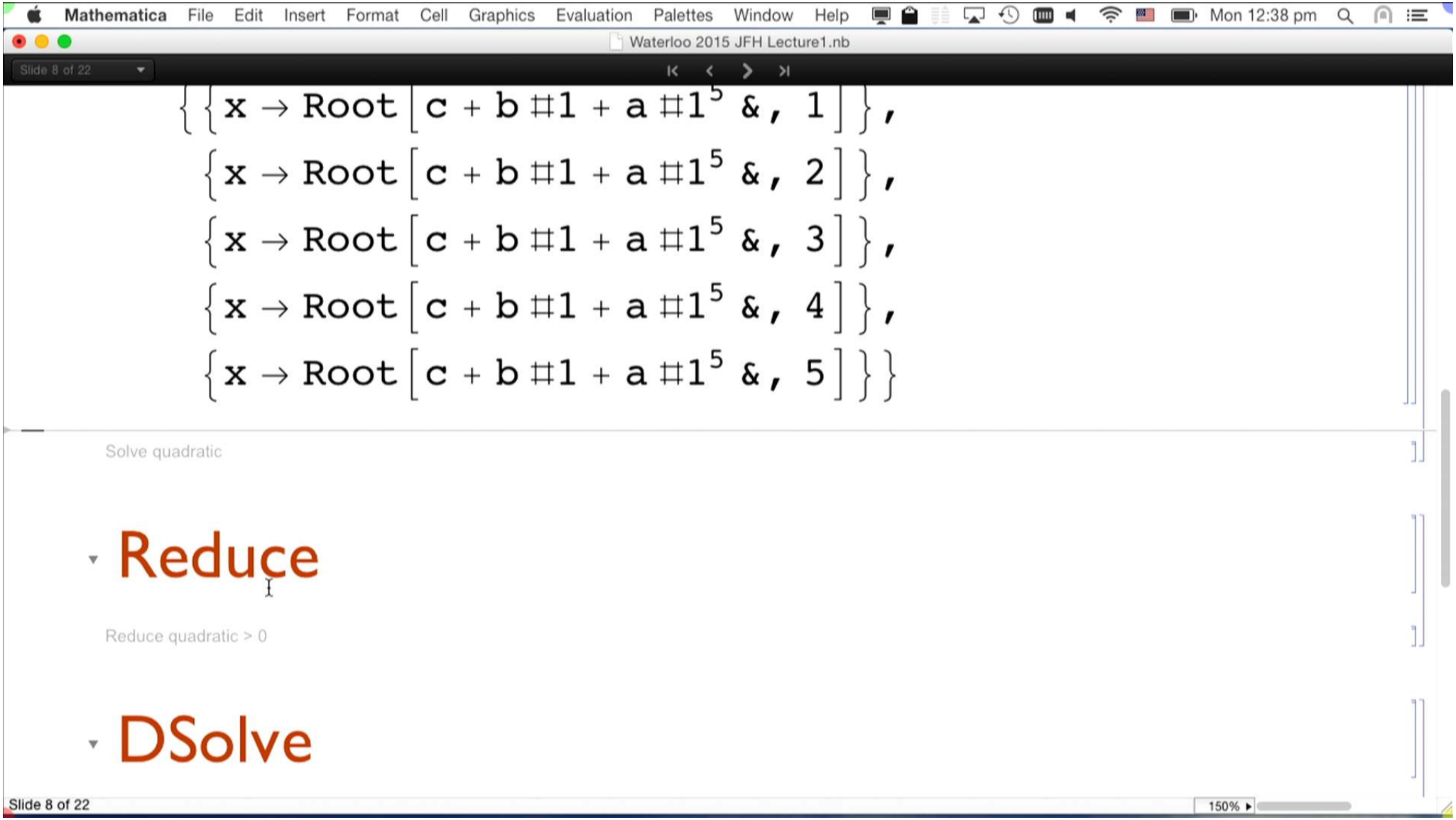
$$\frac{2\,k^4\,\pi^5\,T^4}{15\,c^3\,h^3}$$

Solve

```
Solve[a x^2 + b x + c ==
```

Solve quadratic

Reduce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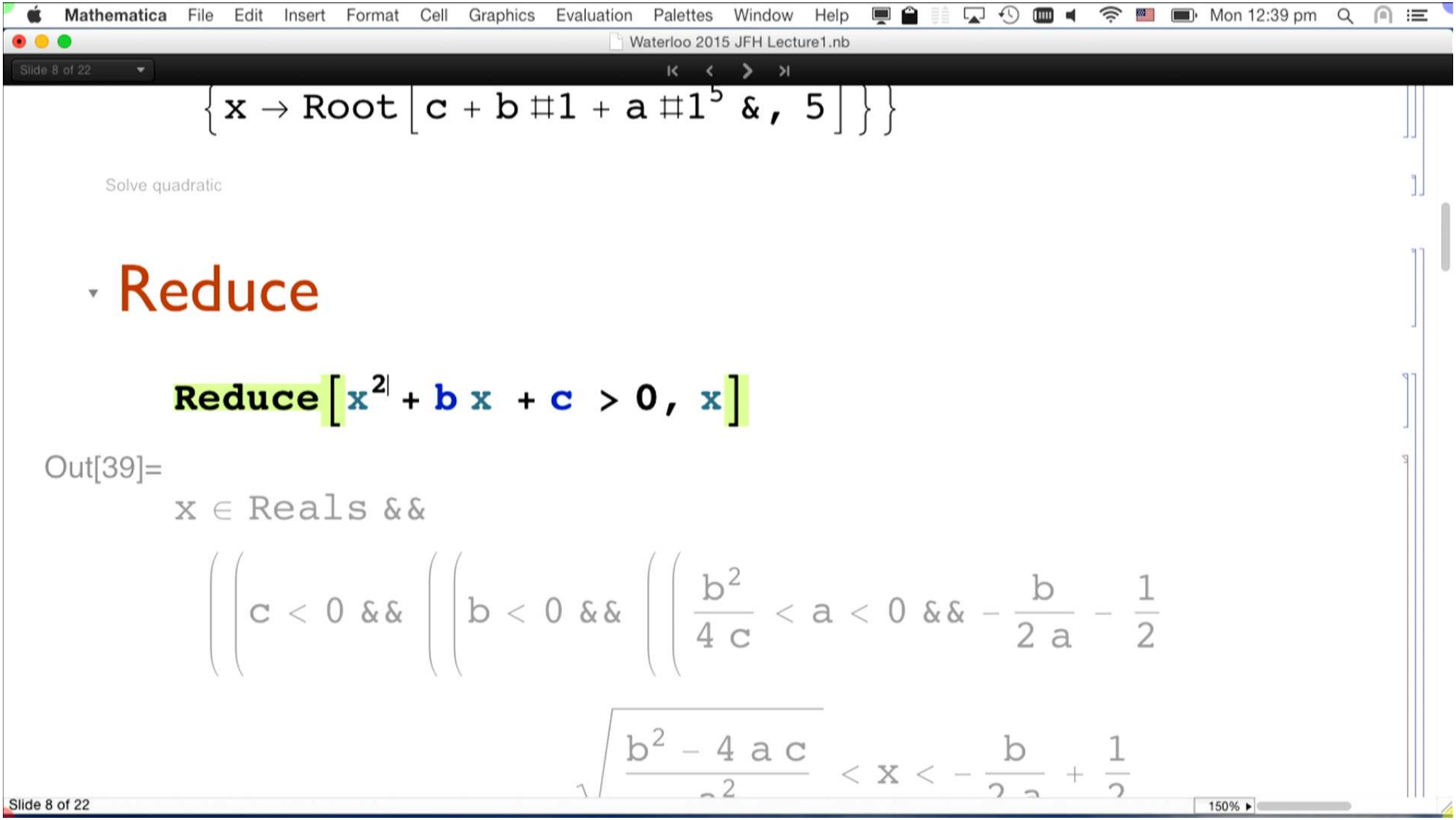
Slide 8 of 22
{{x → Root[c + b #1 + a #1^5 &, 1]},
{x → Root[c + b #1 + a #1^5 &, 2]},
{x → Root[c + b #1 + a #1^5 &, 3]},
{x → Root[c + b #1 + a #1^5 &, 4]},
{x → Root[c + b #1 + a #1^5 &, 5]}}
Solve quadratic
Reduce
Reduce quadratic > 0
DSolve
Slide 8 of 22
150%


Mathematica File Edit Insert Format Cell Graphics Evaluation Palettes Window Help Mon 12:39 pm
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Slide 8 of 22
{x → Root[c + b #1 + a #1^5 &, 5]}
Solve quadratic
Reduce
Reduce[x^2 + b x + c > 0, x]
Out[39]=
x ∈ Reals &&
(c < 0 && (b < 0 && (b^2/(4 c) < a < 0 && -b/(2 a) - 1/2
Slide 8 of 22
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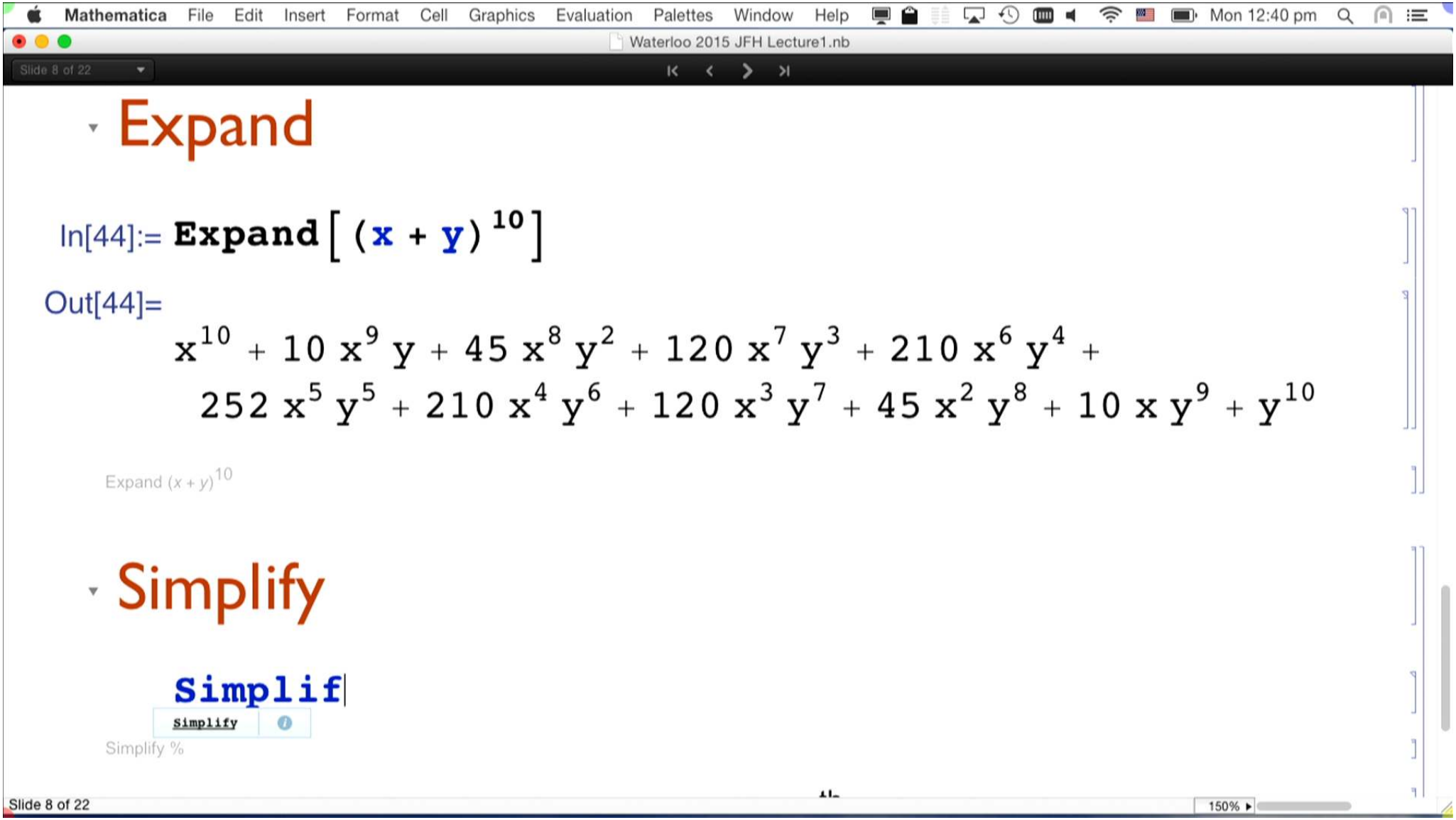
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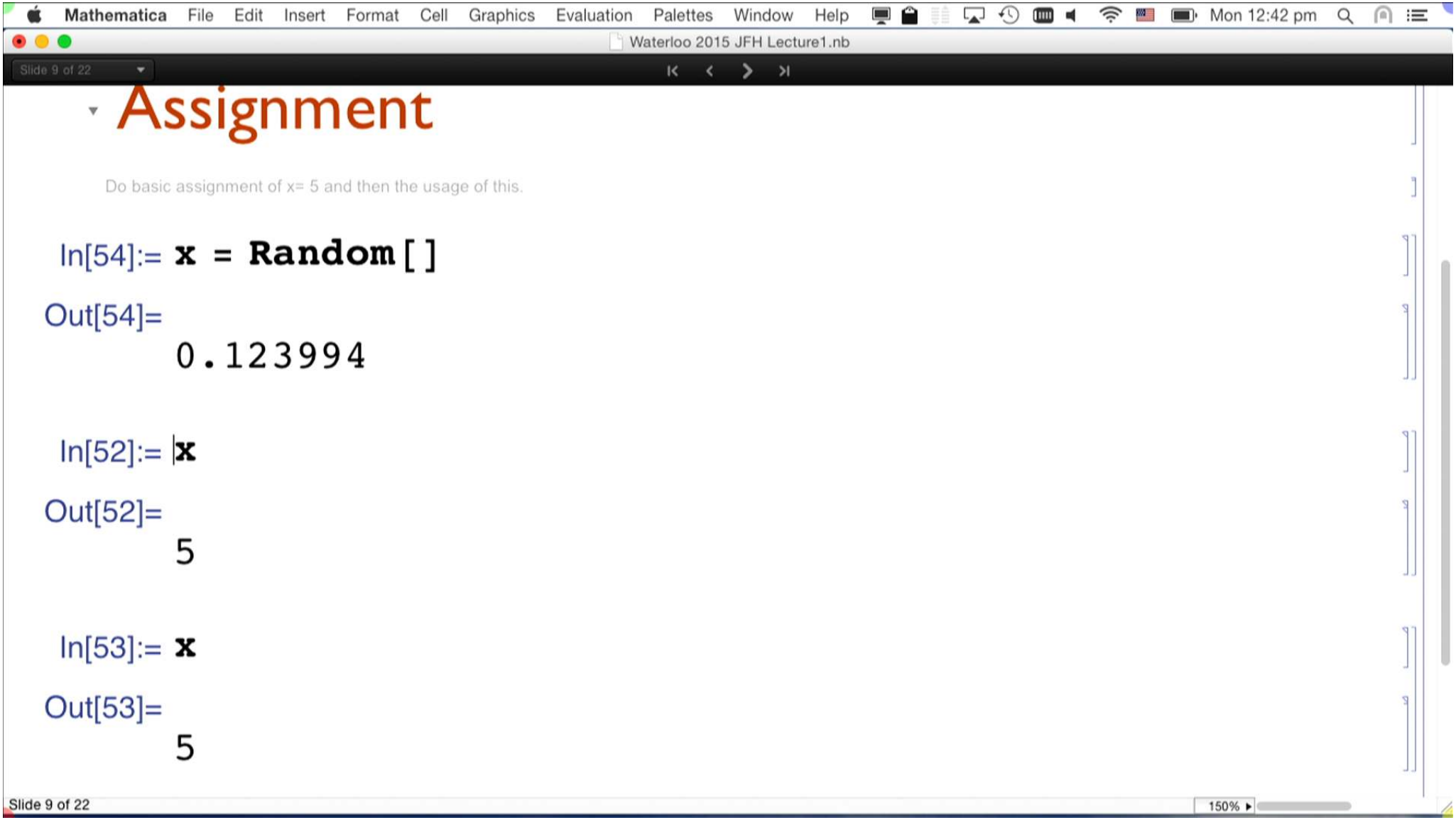
Slide 8 of 22
Expand
In[44]:= Expand[(x + y)^10]
Out[44]=
x^10 + 10 x^9 y + 45 x^8 y^2 + 120 x^7 y^3 + 210 x^6 y^4 +
252 x^5 y^5 + 210 x^4 y^6 + 120 x^3 y^7 + 45 x^2 y^8 + 10 x y^9 + y^10
Expand (x + y)^10
Simplify
Simplif
Simplify
Simplify %
Slide 8 of 22
150%


Mathematica File Edit Insert Format Cell Graphics Evaluation Palettes Window Help Mon 12:42 pm
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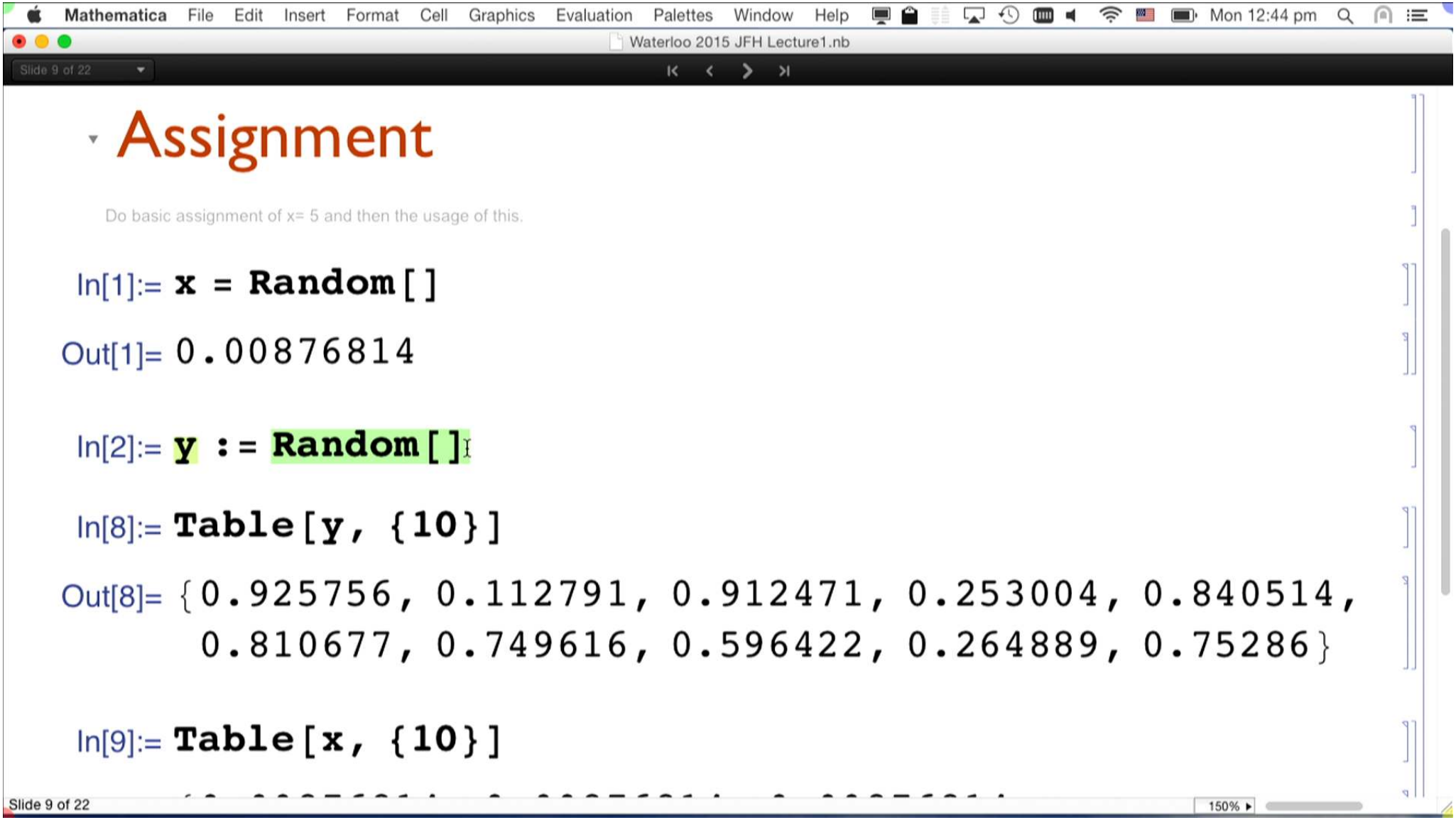
Slide 9 of 22
Assignment
Do basic assignment of x= 5 and then the usage of this.
In[54]:= x = Random[]
Out[54]= 0.123994
In[52]:= x
Out[52]= 5
In[53]:= x
Out[53]= 5
Slide 9 of 22
150%


Mathematica File Edit Insert Format Cell Graphics Evaluation Palettes Window Help Mon 12:44 pm
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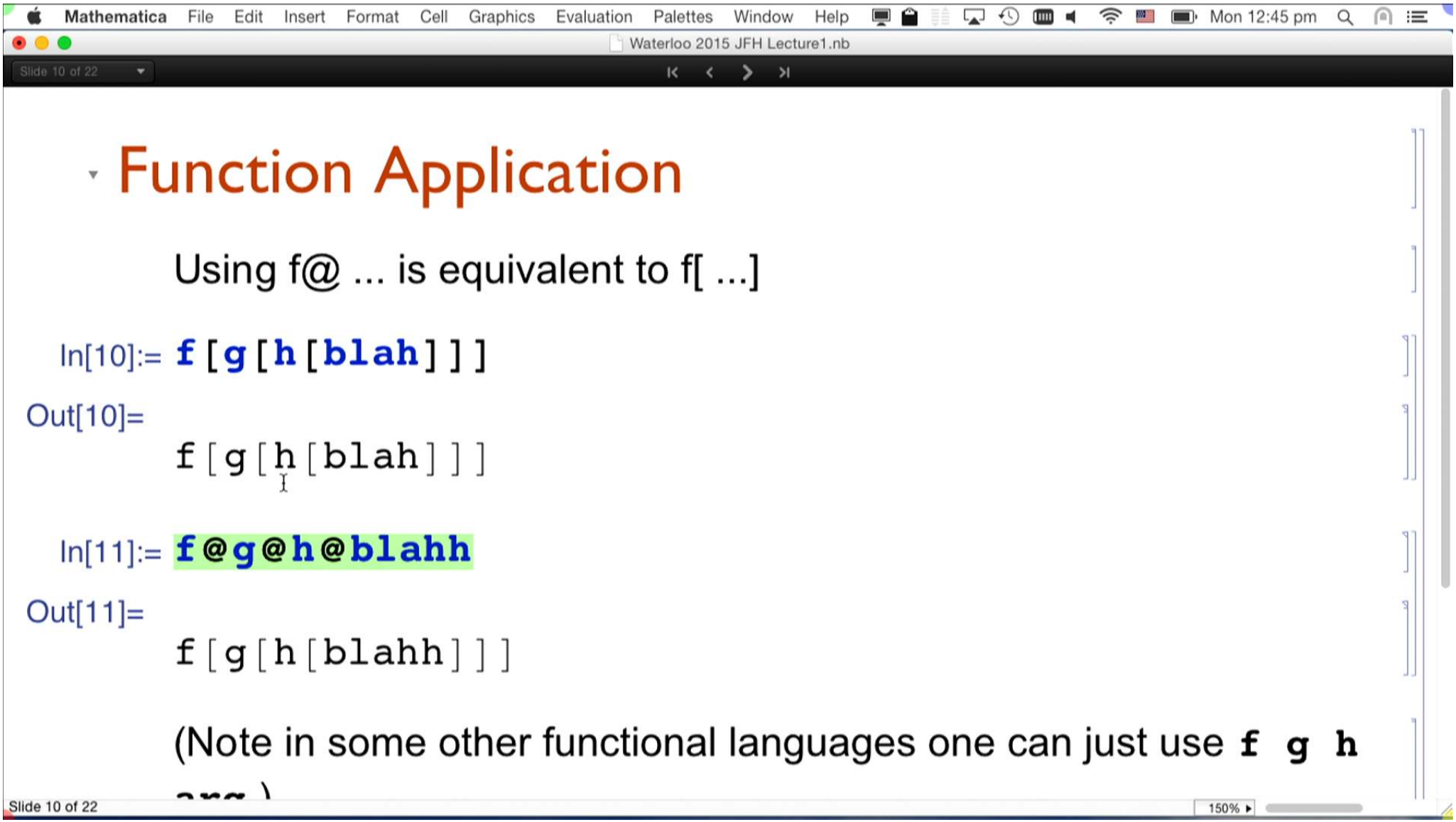
Slide 9 of 22
Assignment
Do basic assignment of x= 5 and then the usage of this.
In[1]:= x = Random[]
Out[1]= 0.00876814
In[2]:= y := Random[]
In[8]:= Table[y, {10}]
Out[8]= {0.925756, 0.112791, 0.912471, 0.253004, 0.840514,
0.810677, 0.749616, 0.596422, 0.264889, 0.75286}
In[9]:= Table[x, {10}]
Slide 9 of 22
150%


Mathematica File Edit Insert Format Cell Graphics Evaluation Palettes Window Help Mon 12:45 pm
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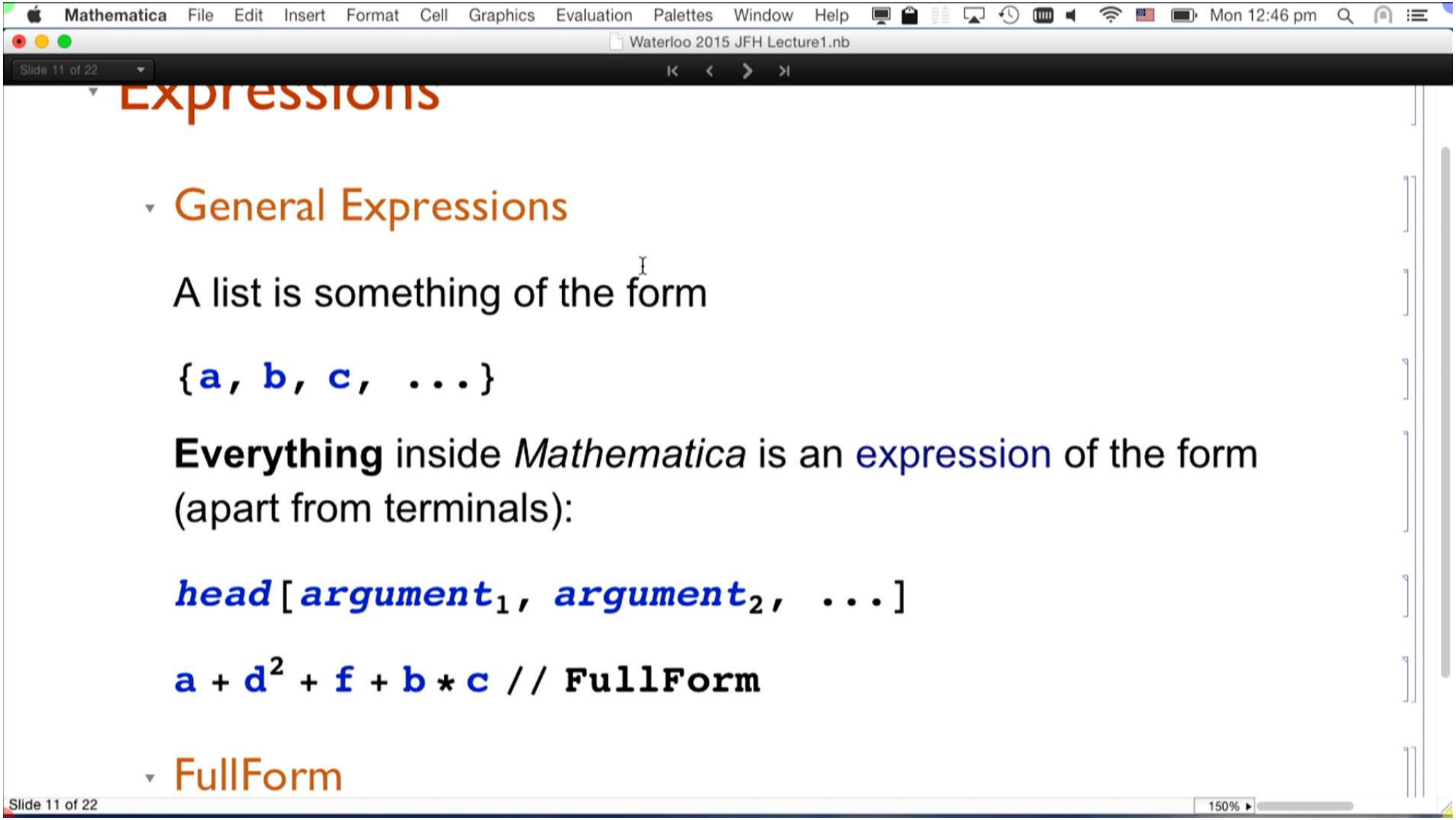
Slide 10 of 22
Function Application
Using f@ ... is equivalent to f[...]
In[10]:= f[g[h[blah]]]
Out[10]=
f[g[h[blah]]]
In[11]:= f@g@h@blahh
Out[11]=
f[g[h[blahh]]]
(Note in some other functional languages one can just use f g h
Slide 10 of 22
150%


Mathematica File Edit Insert Format Cell Graphics Evaluation Palettes Window Help Mon 12:46 pm
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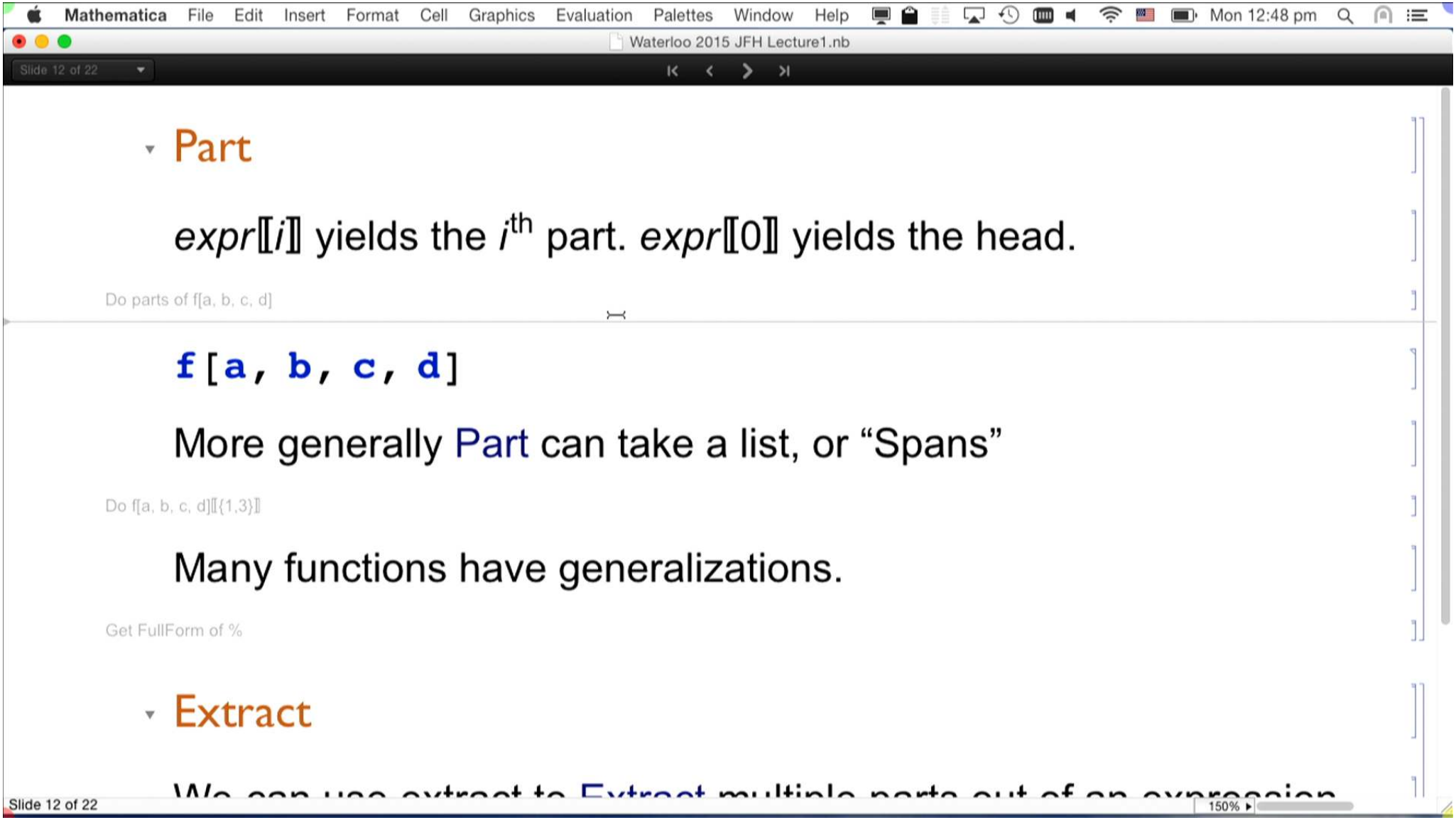
Slide 11 of 22
Expressions
General Expressions
A list is something of the form
{a, b, c, ...}
Everything inside Mathematica is an expression of the form (apart from terminals):
head[argument1, argument2, ...]
a + d^2 + f + b * c // FullForm
FullForm
Slide 11 of 22
150%

Calculator like Usage

- Integrate

$$\text{Assuming}\left[\frac{h}{k\,T} > 0,\ \int_0^\infty \frac{\left(2\,\pi\,\nu^2\right)\sum_{n=0}^{\infty} h\,n\,\nu\,e^{-\frac{h\,n\,\nu}{k\,T}}}{c^3\sum_{n=0}^{\infty} e^{-\frac{h\,n\,\nu}{k\,T}}}\,d\nu\right]$$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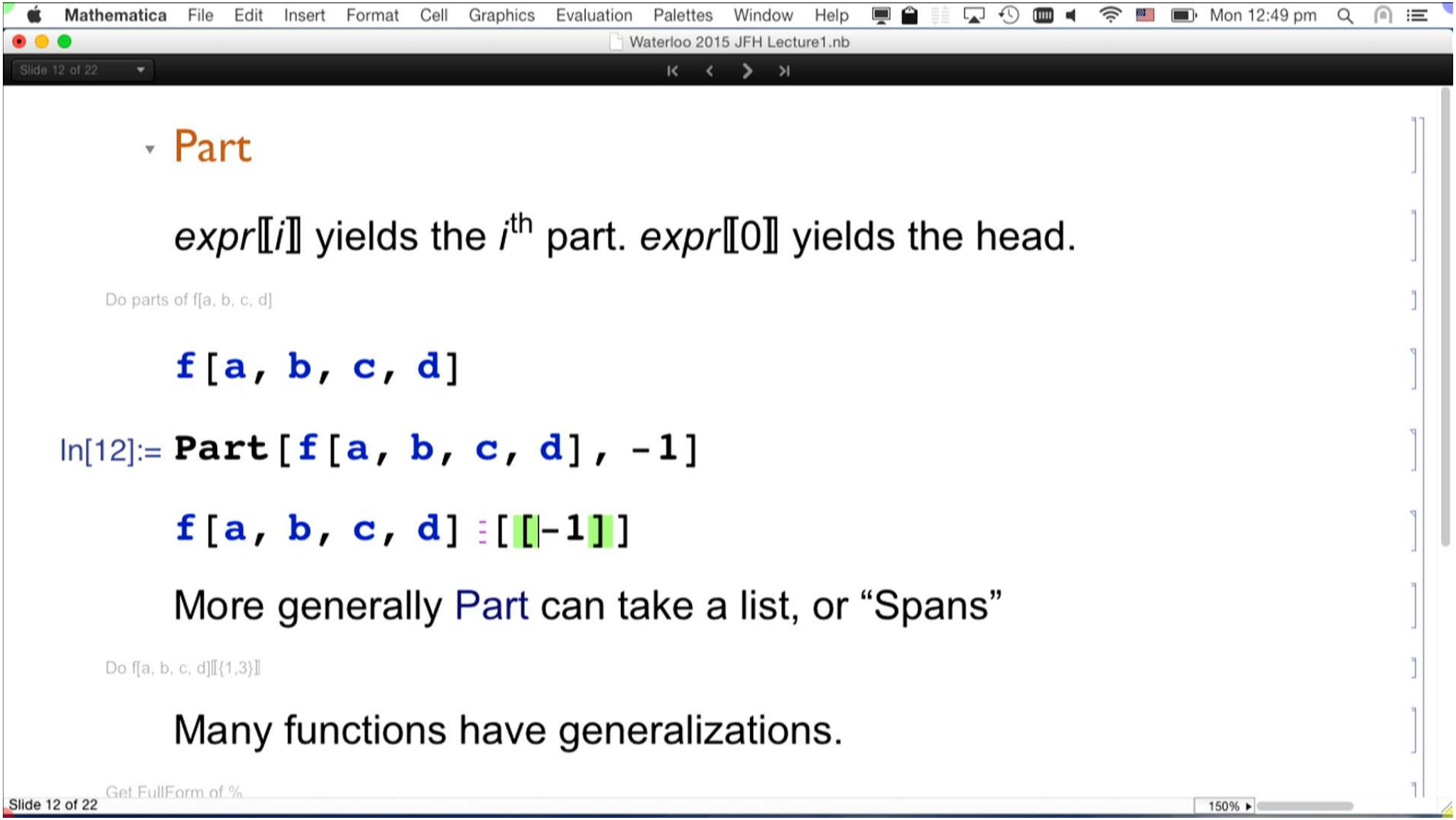
Slide 12 of 22
Part
expr[[i]] yields the i^{th} part. expr[[0]] yields the head.
Do parts of f[a, b, c, d]
f[a, b, c, d]
More generally Part can take a list, or "Spans"
Do f[a, b, c, d][[{1,3}]]
Many functions have generalizations.
Get FullForm of %
Extract
Slide 12 of 22
150%


Mathematica File Edit Insert Format Cell Graphics Evaluation Palettes Window Help Mon 12:49 pm
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Slide 12 of 22
Part
expr[[i]] yields the i^{th} part. expr[[0]] yields the head.
Do parts of f[a, b, c, d]
f[a, b, c, d]
In[12]:= Part[f[a, b, c, d], -1]
f[a, b, c, d][[-1]]
More generally Part can take a list, or “Spans”
Do f[a, b, c, d][[{1,3}]]
Many functions have generalizations.
Get FullForm of %
Slide 12 of 22
150%

Do f[a, b, c, d][[{1,3}]]

Many functions have generalizations.

Get FullForm of %

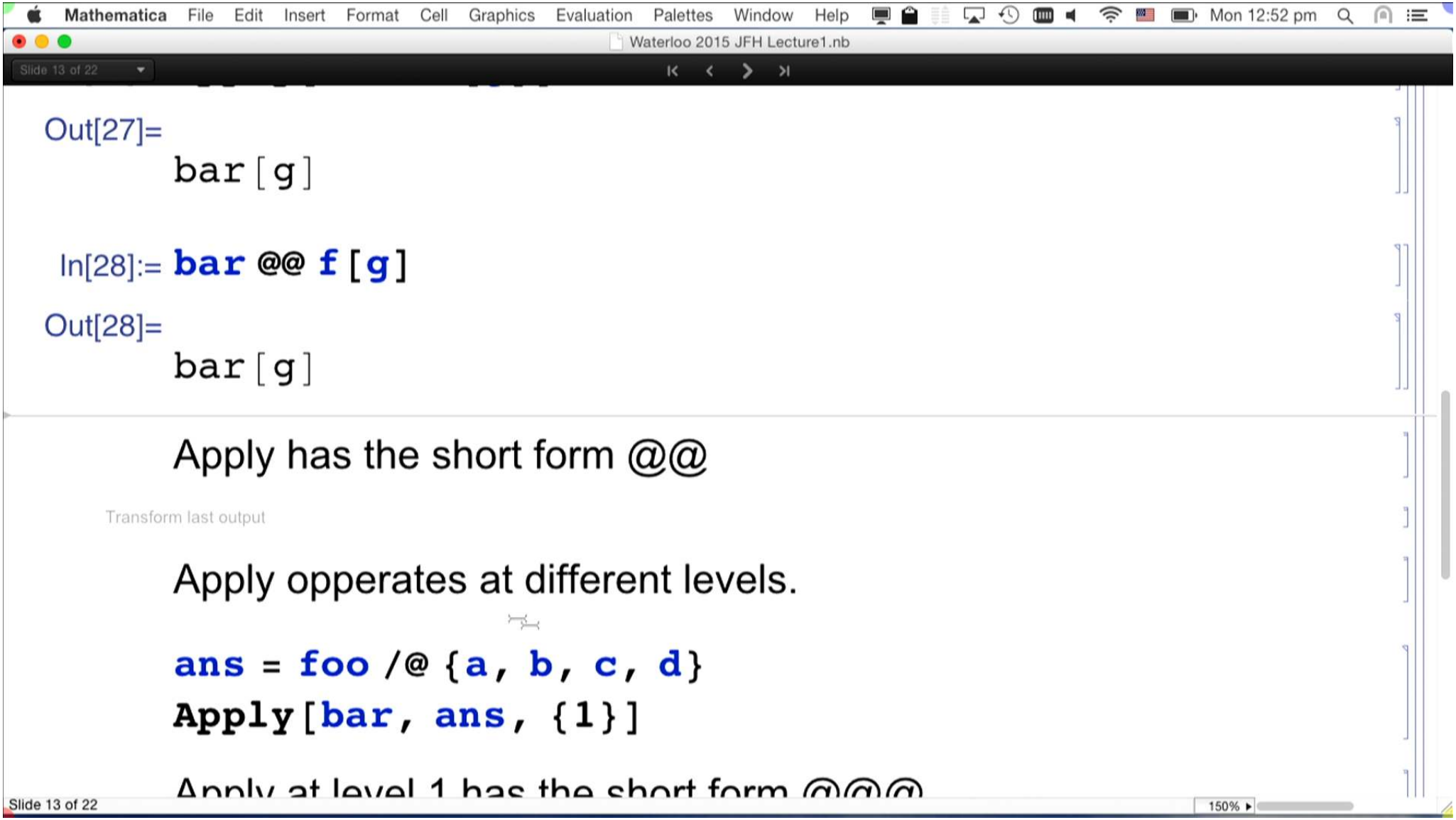
Extract

We can use extract to Extract multiple parts out of an expression. For example to extract *y* and *c* out of *f*[*a*, *b*[*x*, *y*], *c*, *d*]

```
Extract[f[a, b[x, y], c, d], {{2, 1}, {3}}]
```

```
f[a, b[x, y], c, d]
```

```
f[a, b[x, y], c, d]
```


Mathematica File Edit Insert Format Cell Graphics Evaluation Palettes Window Help Mon 12:52 pm
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Slide 13 of 22
Out[27]=
bar[g]
In[28]:= bar @@ f[g]
Out[28]=
bar[g]
Apply has the short form @@
Transform last output
Apply opperates at different levels.
ans = foo /@ {a, b, c, d}
Apply[bar, ans, {1}]
Apply at level 1 has the short form @@@
Slide 13 of 22
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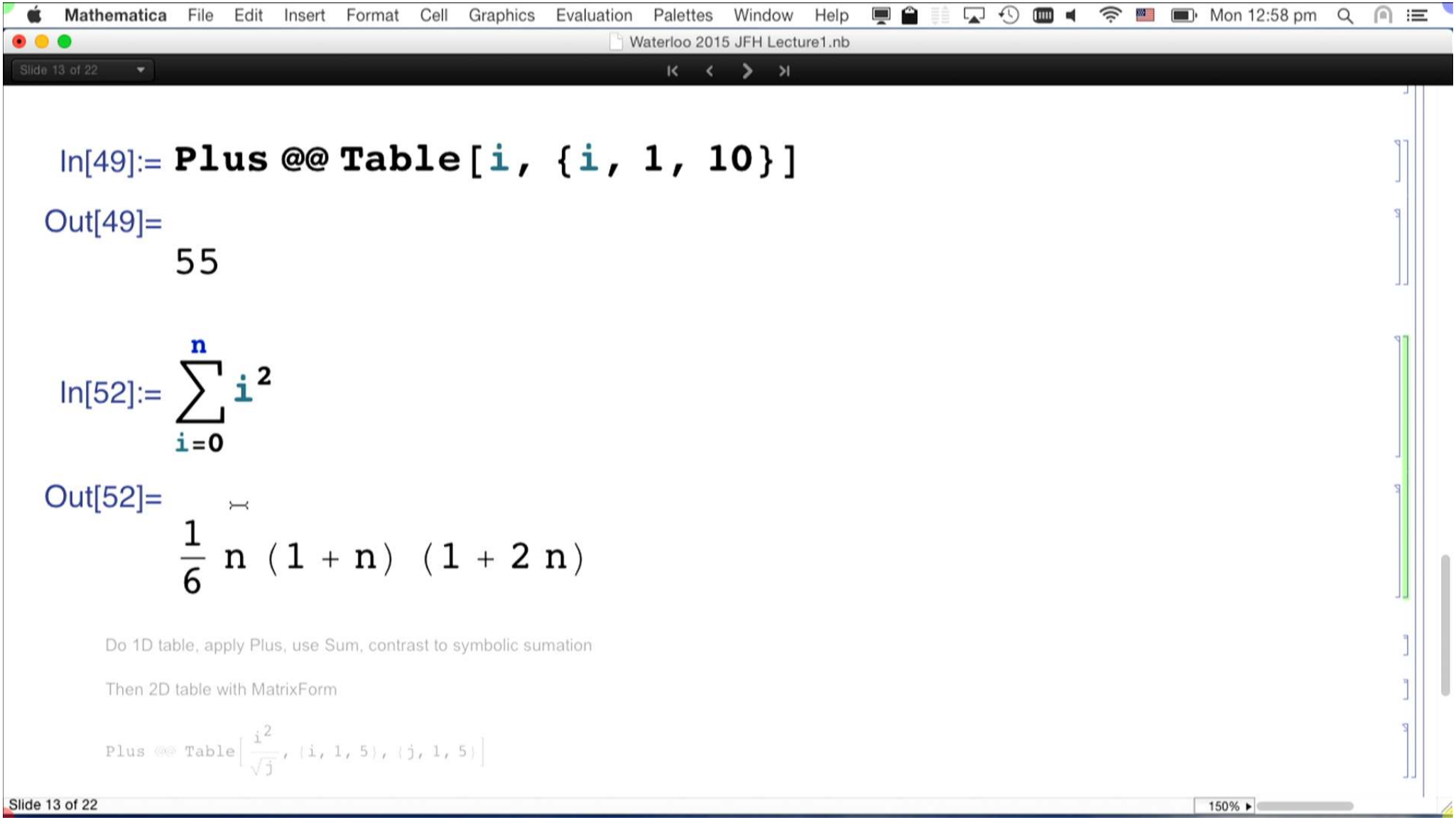

Mathematica File Edit Insert Format Cell Graphics Evaluation Palettes Window Help Mon 12:58 pm
Waterloo 2015 JFH Lecture1.nb
Slide 13 of 22
In[49]:= Plus @@ Table[i, {i, 1, 10}]
Out[49]= 55
In[52]:= $\sum_{i=0}^{n} i^2$
Out[52]= $\frac{1}{6} n (1 + n) (1 + 2 n)$
Do 1D table, apply Plus, use Sum, contrast to symbolic sumation
Then 2D table with MatrixForm
Plus @@ Table[$\frac{i^2}{\sqrt{j}}$, {i, 1, 5}, {j, 1, 5}]
Slide 13 of 22
150%

Restricting the Match of a Pattern

In[71]:=
```
ClearAll[fac]
```

In[67]:=
```
fac[n_] := n fac[n - 1]
fac[0] := 1
```

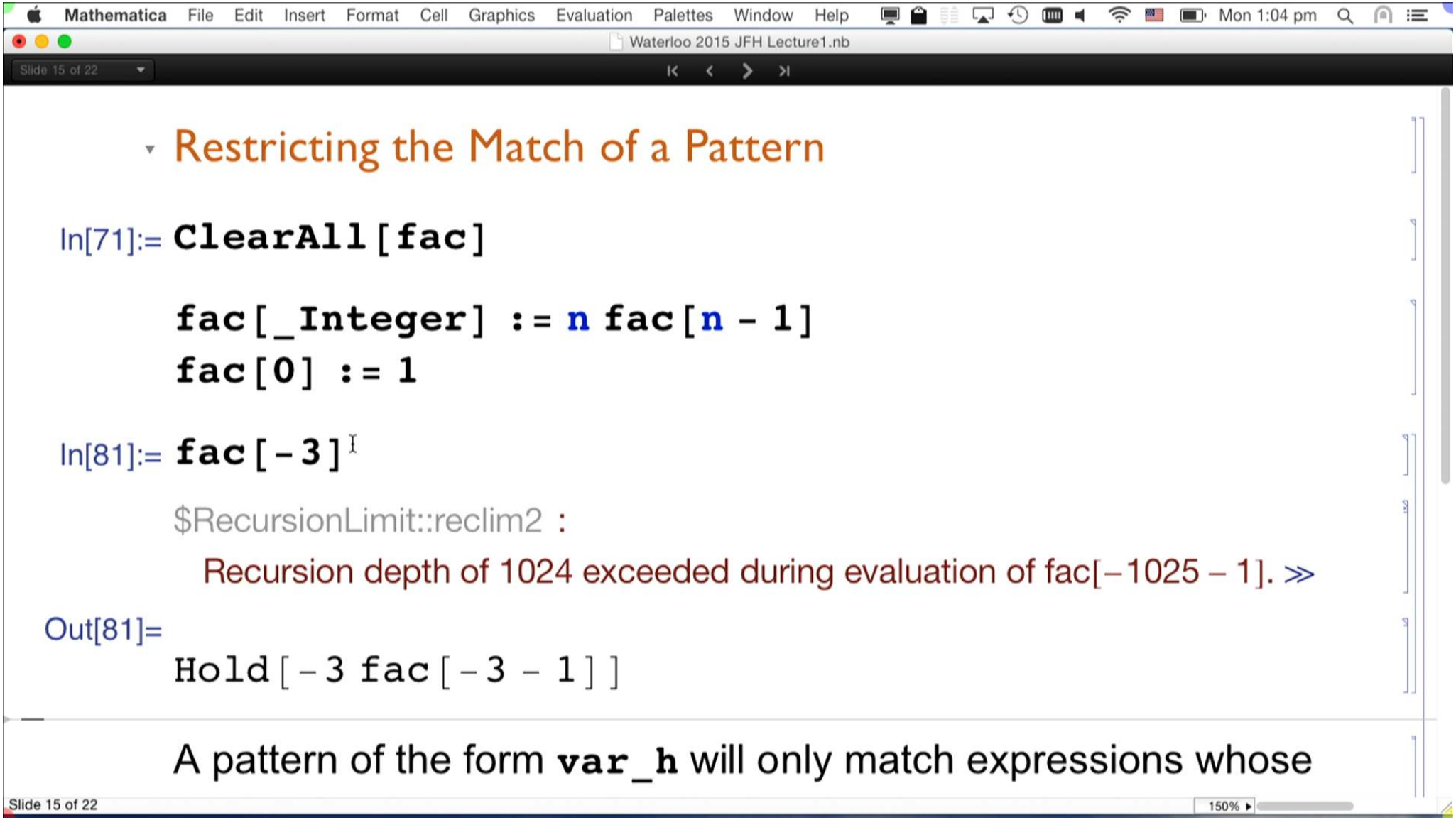
A pattern of the form **var_h** will only match expressions whose head is **h**.

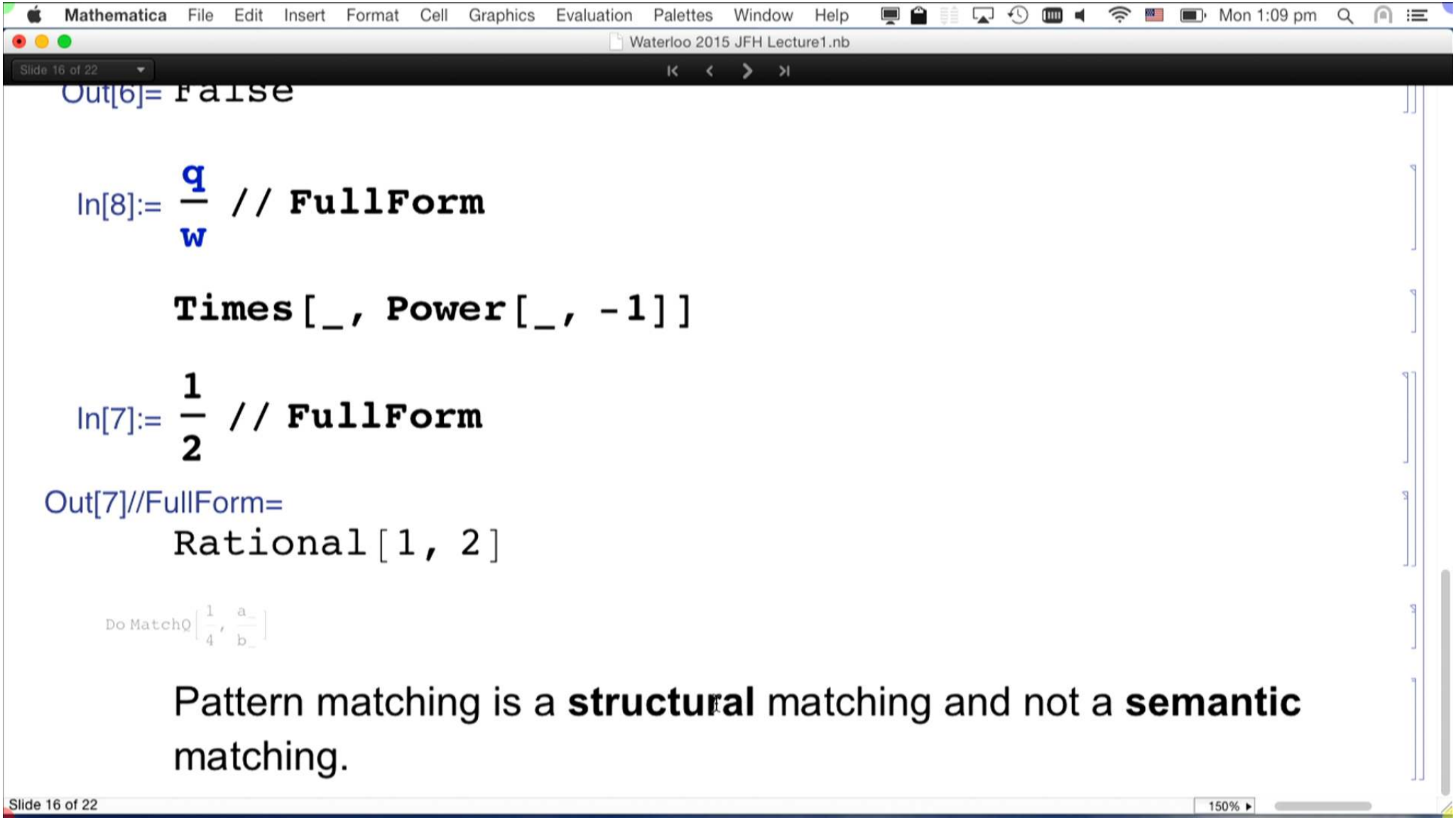
Evaluate our factorial for ' a', and then restrict to just _Integer

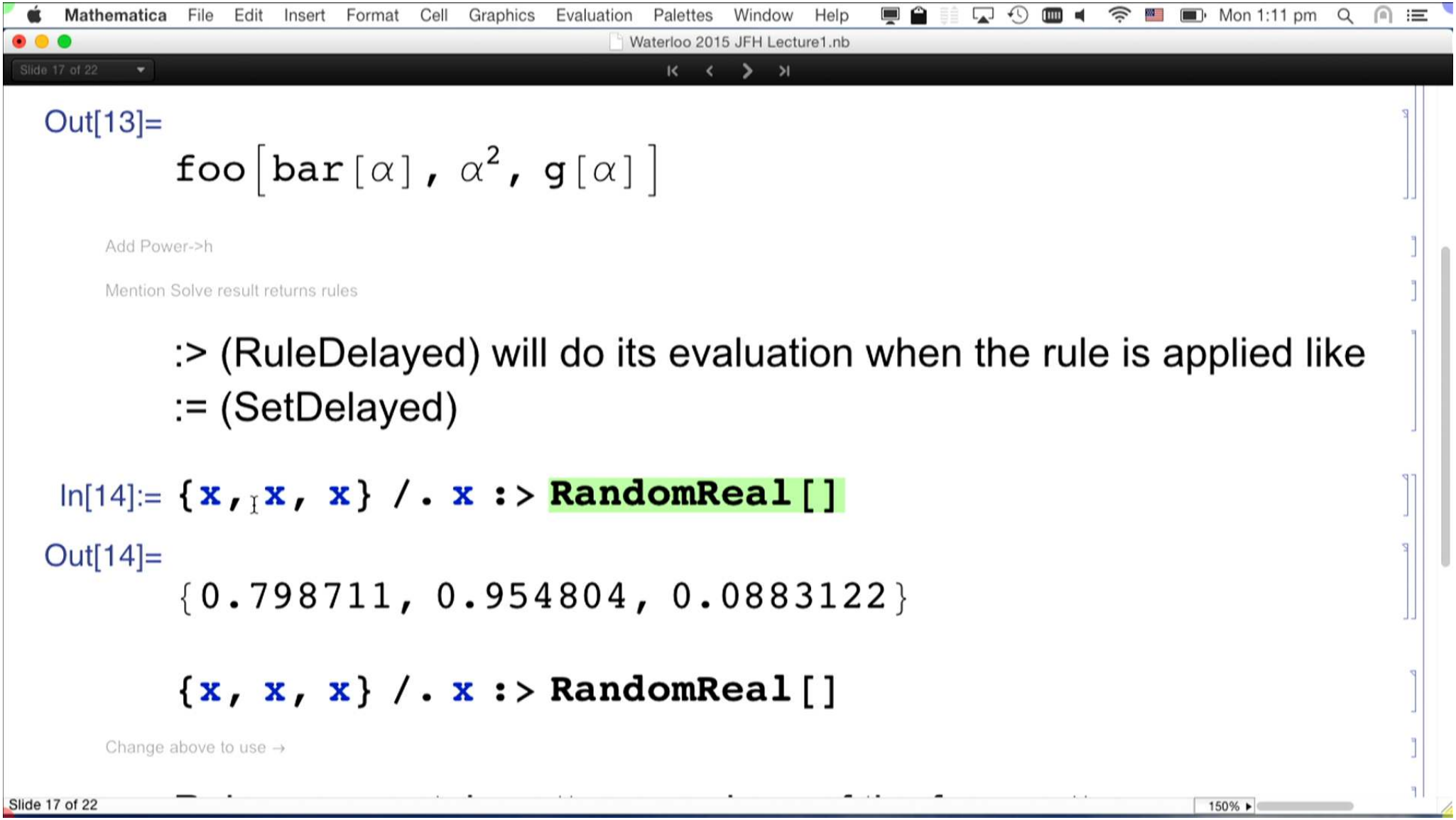
A pattern of the form **pat /; expression** will only match when expression evaluates to **True**.

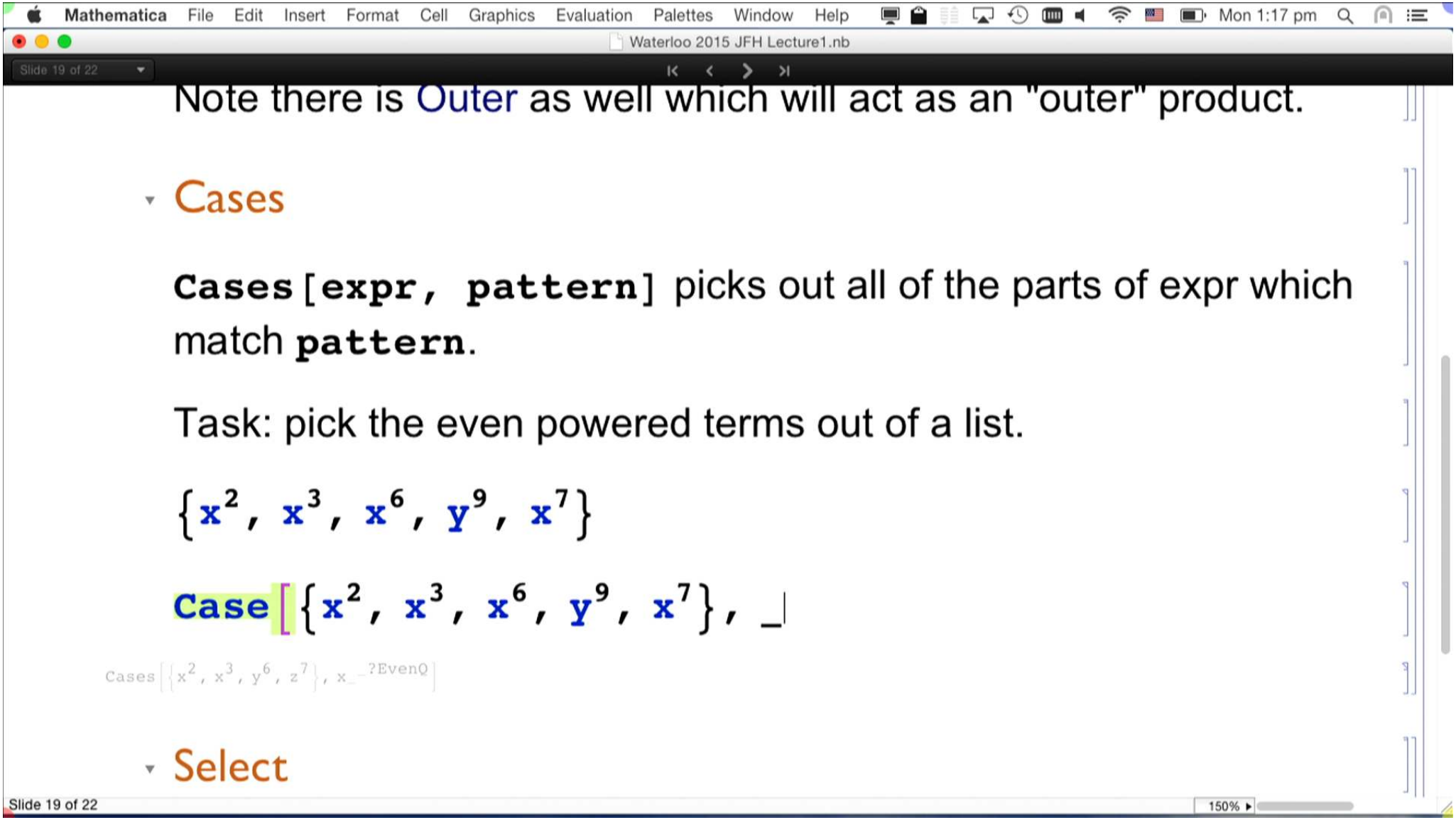
Restrict our factorial to only fire when the argument is >= 0.

ClearAll[factorial]


Mathematica File Edit Insert Format Cell Graphics Evaluation Palettes Window Help Mon 1:04 pm
Waterloo 2015 JFH Lecture1.nb
Slide 15 of 22
Restricting the Match of a Pattern
In[71]:= ClearAll[fac]
fac[_Integer] := n fac[n - 1]
fac[0] := 1
In[81]:= fac[-3]
$RecursionLimit::reclim2 :
Recursion depth of 1024 exceeded during evaluation of fac[-1025 - 1]. >>
Out[81]=
Hold[-3 fac[-3 - 1]]
A pattern of the form var_h will only match expressions whose
Slide 15 of 22
150%


Mathematica File Edit Insert Format Cell Graphics Evaluation Palettes Window Help
Mon 1:09 pm
Waterloo 2015 JFH Lecture1.nb
Slide 16 of 22
Out[6]= False
In[8]:= q/w // FullForm
Times[_, Power[_, -1]]
In[7]:= 1/2 // FullForm
Out[7]//FullForm=
Rational[1, 2]
Do MatchQ[1/4, a_/b_]
Pattern matching is a structural matching and not a semantic matching.
Slide 16 of 22
150%


Mathematica File Edit Insert Format Cell Graphics Evaluation Palettes Window Help
Mon 1:11 pm
Waterloo 2015 JFH Lecture1.nb
Slide 17 of 22
Out[13]=
foo[bar[α], α^2, g[α]]
Add Power->h
Mention Solve result returns rules
:> (RuleDelayed) will do its evaluation when the rule is applied like
:= (SetDelayed)
In[14]:= {x, x, x} /. x :> RandomReal[]
Out[14]=
{0.798711, 0.954804, 0.0883122}
{x, x, x} /. x :> RandomReal[]
Change above to use →
Slide 17 of 22
150%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Slide 19 of 22
Note there is Outer as well which will act as an "outer" product.
Cases
Cases[expr, pattern] picks out all of the parts of expr which match pattern.
Task: pick the even powered terms out of a list.
{x^2, x^3, x^6, y^9, x^7}
Case[{x^2, x^3, x^6, y^9, x^7}, _
Cases[{x^2, x^3, y^6, z^7}, x_?EvenQ]
Select
Slide 19 of 22
150%

Multi Argument Patterns

A pattern of the form x__ will match one or more arguments.

A pattern of the form x___ will match zero or more arguments.

```
f[a_, ___, a_] := g[a, b]
```

Task : sort the elements of a list

```
ClearAll @ MySort
```

Do bubble sort

The FullForms of Patterns

Multi Argument Patterns

A pattern of the form x__ will match one or more arguments.

A pattern of the form x___ will match zero or more arguments.

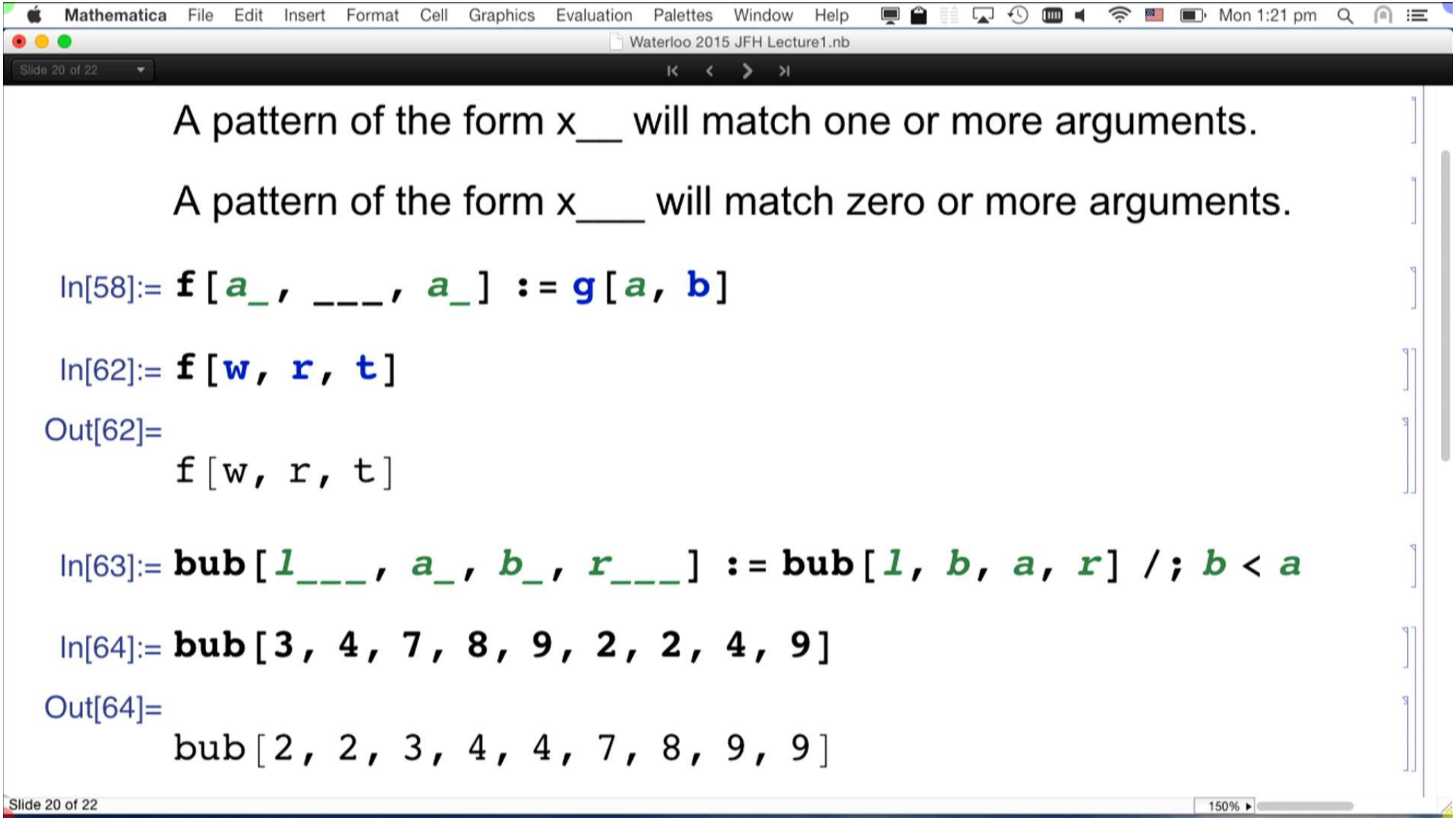
In[58]:=
```
f[a_, ___, a_] := g[a, b]
```

In[62]:=
```
f[w, r, t]
```

Out[62]=
```
f[w, r, t]
```

Task : sort the elements of a list

```
ClearAll @ MySort
```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Slide 20 of 22
A pattern of the form x__ will match one or more arguments.
A pattern of the form x___ will match zero or more arguments.
In[58]:= f[a_, ___, a_] := g[a, b]
In[62]:= f[w, r, t]
Out[62]=
f[w, r, t]
In[63]:= bub[l___, a_, b_, r___] := bub[l, b, a, r] /; b < a
In[64]:= bub[3, 4, 7, 8, 9, 2, 2, 4, 9]
Out[64]=
bub[2, 2, 3, 4, 4, 7, 8, 9, 9]
Slide 20 of 22
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