Title: TBA

Date: Aug 24, 2015 12:00 PM

URL: http://pirsa.org/15080042

Abstract: TBA

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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*.

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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

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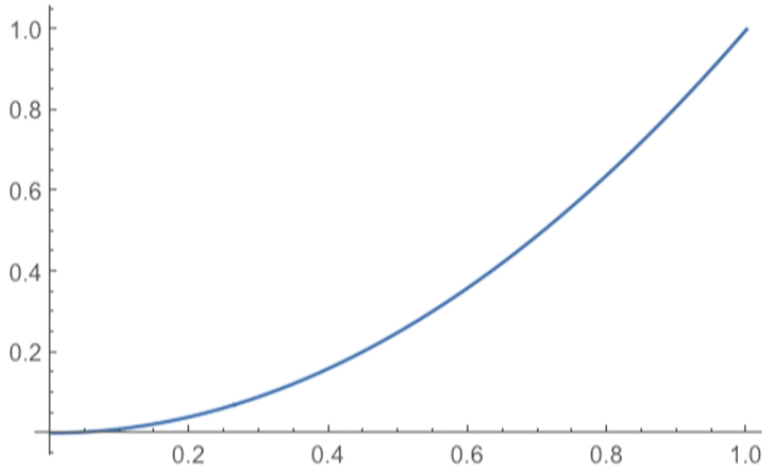
Notebook Interface

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.

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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

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Untitled-6

My plan to conqure the World!

Startup Phase

Implementation Phase

Implementation Phase

Resolution Phase

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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 menus

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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

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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.

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```
Cos[a] - Cos[b]
```

In[18]:= $\Gamma(a)$

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)

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

Out[19]//TraditionalForm=

B_n

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

Out[20]//TraditionalForm=

B_n

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

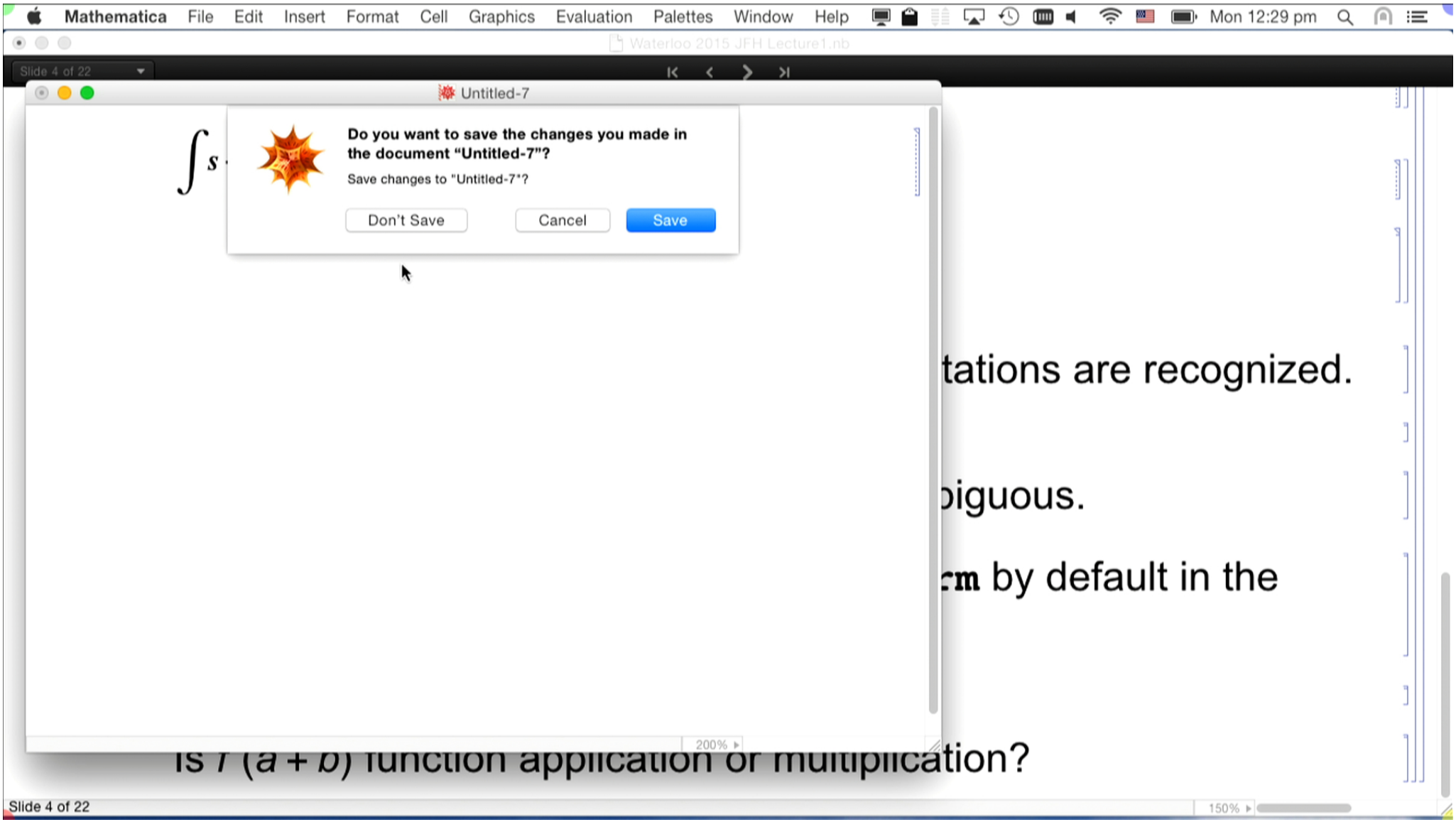
Out[23]=

↓

`BernoulliB[n]`

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

Slide 4 of 22 150%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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.
cm by default in the
is f (a + b) function application or multiplication?
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Palettes and 2D Input

Open the classroom assistant, do integral

$$\int_a^b e^{-x^2}\, dl\, var$$

How does one enter some 2D typeset following?

$$\int_a^b e^{-x^2}\, dl\, x$$

$$\partial_x \mathrm{Sin}[x]$$

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%

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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

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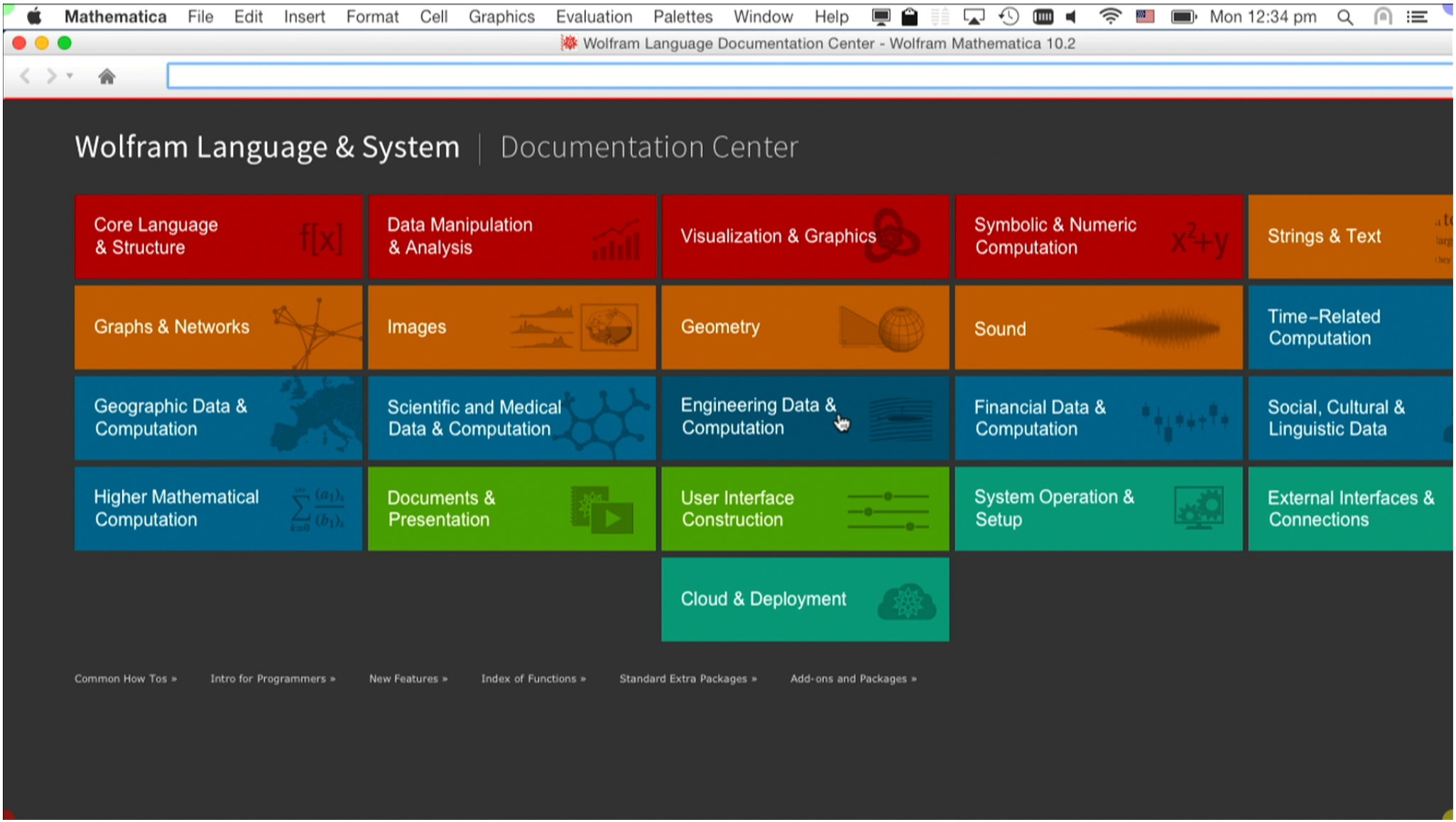
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Mon 12:34 pm
Wolfram Language Documentation Center - Wolfram Mathematica 10.2
Wolfram Language & System | Documentation Center
Core Language & Structure
Data Manipulation & Analysis
Visualization & Graphics
Symbolic & Numeric Computation
Strings & 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 »

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Navigating Help

https://www.wolfram.com/language/fast-introduction-for-programmers/

Plot

Find Selected Function

Documentation Center

Context Sensitive Help

Perdective Interface

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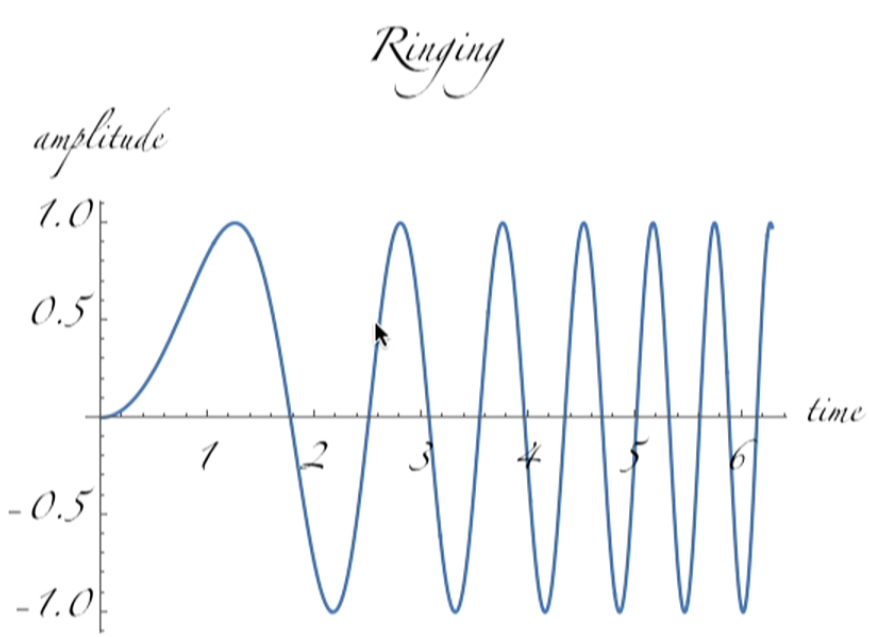
Untitled-9

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

Out[32]=



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

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

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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```
{{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

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$$\{x \to \text{Root}[c + b\,\#1 + a\,\#1^5\,\&,\ 5]\}\}$$

Solve quadratic

Reduce

```
Reduce[x^2 + b x + c > 0, x]
```

Out[39]=

$$x \in \text{Reals}\ \&\&\ \left(\left(c < 0\ \&\&\ \left(\left(b < 0\ \&\&\ \left(\left(\frac{b^2}{4\,c} < a < 0\ \&\&\ -\frac{b}{2\,a} - \frac{1}{2}\sqrt{\frac{b^2 - 4\,a\,c}{a^2}} < x < -\frac{b}{2\,a} + \frac{1}{2}\right.\right.\right.\right.\right.\right.$$

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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 %

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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
```

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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}]
```

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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 arg**)

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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

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Calculator like Usage

- Integrate

$$\text{Assuming}\left[\frac{h}{k\,T} > 0,\ \int_0^\infty \frac{(2\,\pi\,\nu^2)\sum_{n=0}^{\infty} h\,n\,\nu\,e^{-\frac{h\,n\,\nu}{k\,T}}}{c^3\sum_{n=0}^{\infty} e^{-\frac{h\,n\,\nu}{k\,T}}}\,d\nu\right]$$

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Part

expr[[*i*]] yields the ith 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

We can use extract to Extract multiple parts out of an expression

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Part

expr⟦*i*⟧ yields the ith 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 %

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```
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]
```

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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 @@@

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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

$$\text{Plus @@ Table}\left[\frac{i^2}{\sqrt{j}}, \{i, 1, 5\}, \{j, 1, 5\}\right]$$

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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]

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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

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Out[6]= False

In[8]:= $\frac{q}{w}$ // FullForm

```
Times[_, Power[_, -1]]
```

In[7]:= $\frac{1}{2}$ // FullForm

Out[7]//FullForm=

```
Rational[1, 2]
```

Do MatchQ[$\frac{1}{4}$, $\frac{a\_}{b\_}$]

Pattern matching is a **structural** matching and not a **semantic** matching.

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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 →

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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

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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

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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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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]
```

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