

# **Generating Correct Mathematical Documents**

**William F. Hammond**

**September, 2001**

# Mathematical Articles

# Mathematical Articles

- Contain ordinary text and mathematical content.

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- Contain ordinary text and mathematical content.
- Need realization on paper and on computer networks.

## A Segment of an Article

The *gamma function* may be defined in a suitable right-half plane by an integral, which essentially amounts to Fourier transform relative to the multiplicative group of positive real numbers of the reciprocal exponential function, and then extended to a meromorphic function in the complex plane with entire reciprocal. The following formula represents a variant of its Weierstrass product expansion:

## A Segment of an Article

The *gamma function* may be defined in a suitable right-half plane by an integral, which essentially amounts to Fourier transform relative to the multiplicative group of positive real numbers of the reciprocal exponential function, and then extended to a meromorphic function in the complex plane with entire reciprocal. The following formula represents a variant of its Weierstrass product expansion:

$$\int_0^{\infty} t^x e^{-t} \frac{dt}{t} = \frac{1}{x} \prod_{k=1}^{\infty} \frac{\left(1 + \frac{1}{k}\right)^x}{\left(1 + \frac{x}{k}\right)} .$$

The product manifests simple poles at zero and each of the negative integers.

# Goals

**From a Single Source:**

# Goals

## From a Single Source:

1. A typeset version of high quality for paper preprints.



# Goals

## From a Single Source:

1. A typeset version of high quality for paper preprints.
2. An online version for a web preprint.

# Goals

## From a Single Source:

1. A typeset version of high quality for paper preprints.
2. An online version for a web preprint.
3. A typeset version of high quality meeting the requirements of a journal chosen after the time of writing.

# Goals for Online Versions

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1. catalogable.

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1. catalogable.
2. universally accessible.

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1. catalogable.
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3. re-scalable and re-sizable.

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4. searchable for mathematical content.

# Goals for Online Versions

1. catalogable.
2. universally accessible.
3. re-scalable and re-sizable.
4. searchable for mathematical content.
5. “clippable” for mathematical content.



# **Mathematical Mainstream 1980–2000**

# Mathematical Mainstream 1980–2000

Donald Knuth's T<sub>E</sub>X

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Donald Knuth's  $\text{T}_{\text{E}}\text{X}$

$\text{L}_{\text{A}}\text{T}_{\text{E}}\text{X}$

# Mathematical Mainstream 1980–2000

Donald Knuth's  $\text{T}_{\text{E}}\text{X}$

$\text{\LaTeX}$

Plain  $\text{T}_{\text{E}}\text{X}$

# Mathematical Mainstream 1980–2000

Donald Knuth's T<sub>E</sub>X

L<sup>A</sup>T<sub>E</sub>X

Plain T<sub>E</sub>X

Other T<sub>E</sub>X Variants:

AMST<sub>E</sub>X, ConT<sub>E</sub>Xt, *Omega*, *Texinfo*

**How May One Provide Multiple  
Formattings?**

# How May One Provide Multiple Formattings?

Early Ideas:

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## Early Ideas:

1. Intuitive Authoring Systems: the WYSIWYG Idea



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## Early Ideas:

1. Intuitive Authoring Systems: the WYSIWYG Idea
2. Write HTML and Translate From There.

# How May One Provide Multiple Formattings?

## Early Ideas:

1. Intuitive Authoring Systems: the WYSIWYG Idea
2. Write HTML and Translate From There.
3. Write  $\text{\LaTeX}$  and Translate From There.

# **WYSIWYG: The Good News**

# WYSIWYG: The Good News

- Standard with Common “Word Processors”

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- Standard with Common “Word Processors”
- Available for  $\text{\LaTeX}$ .

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- Easy for Easy Tasks.

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- Available for  $\text{\LaTeX}$ .
- Available for SGML Systems.
- Easy for Easy Tasks.
- OK for Very Simple Documents.



# **WYSIWYG: The Bad News**

# WYSIWYG: The Bad News

- Hard for Hard Tasks.

# WYSIWYG: The Bad News

- Hard for Hard Tasks.
- Slow for Those Who Write Frequently.

# WYSIWYG: The Bad News

- Hard for Hard Tasks.
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- Hard for Hard Tasks.
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- Inapplicable to Multiple Formattings.

# WYSIWYG: The Bad News

- Hard for Hard Tasks.
- Slow for Those Who Write Frequently.
- Insufficiently Rich for Mathematics.
- Insufficiently Abstract.
- Inapplicable to Multiple Formattings.
- Some say WYSIAYG: “what you see is **all** you get”.

# **WYSIWYG vs. Structured Markup**



# WYSIWYG vs. Structured Markup

- Format-specific hanging indentation commands.

# WYSIWYG vs. Structured Markup

- Format-specific hanging indentation commands.
- Use of abstract list structures.

# Translating HTML

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- Reliable

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- Reliable
- But:

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- But:

1. No Math in HTML

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  2. HTML Generally Less Rich Than  $\text{\LaTeX}$

# Translating HTML

- Reliable
- But:
  1. No Math in HTML
  2. HTML Generally Less Rich Than  $\text{\LaTeX}$
  3. Special characters are translation headaches.  
Examples: # \$ % & ~ \_ ^ \ { } < >



# Translating $\text{L}^{\text{A}}\text{T}_{\text{E}}\text{X}$

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- Almost Impossible

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- Need to Proof Read Twice

# Translating L<sup>A</sup>T<sub>E</sub>X

- Almost Impossible
- Good Structure a Help
- May Require Human Intervention
- Need to Proof Read Twice
- *htlatex* in the T<sub>E</sub>XLive 6 distribution is remarkably good.

**XML**

**XML**

**eXtensible Markup Language**



# XML

## eXtensible Markup Language

- Data Under a **Template for Translation.**

# XML

## eXtensible Markup Language

- Data Under a **Template for Translation**.
- Enforced Separation of Content and Presentation.

# XML

## eXtensible Markup Language

- Data Under a **Template for Translation**.
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- Universal Exchange.

# XML

## eXtensible Markup Language

- Data Under a **Template for Translation**.
- Enforced Separation of Content and Presentation.
- Universal Exchange.
- Originated by
  - World Wide Web Consortium (W3C)
  - Sun Microsystems

**XML**

# XML

- Many Templates

# XML

- Many Templates
- Synonym for XML Template:  
*Document Type*

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Examples: HTML, *Docbook*, TEI, ...

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- Synonym for XML Template:  
*Document Type*
- Two worlds
  1. Classical Documents:  
Examples: HTML, *Docbook*, TEI, ...
  2. Electronic Data Interchange (EDI)  
Example: Graham William's T<sub>E</sub>X Catalogue found on CTAN  
[help/Catalogue/catalogue.html](http://help/Catalogue/catalogue.html)

# The GELLMU Project

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  - ★ No present full realization of online version goals.



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- Superseded my earlier ideas:
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  - ★ Adapting Texinfo (already suitable for multiple formattings).
- Relation to the Goals:
  - ★ No present full realization of online version goals.
  - ★ Proof that full realization of all goals and more is possible.

**GELLMU**

# GELLMU

Generalized Extensible  $\text{\LaTeX}$ -Like Markup

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Generalized **E**xtensible  $\text{\LaTeX}$ -Like **M**ark**U**p

- A markup interface for writing (SGML or) XML.

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- $\text{\LaTeX}$ -like notation more succinct than that of XML.

# GELLMU

Generalized **E**xtensible  $\text{\LaTeX}$ -Like **M**ark**U**p

- A markup interface for writing (SGML or) XML.
- $\text{\LaTeX}$ -like notation more succinct than that of XML.
- Extensible using GELLMU's  $\backslash newcommand$  with arguments. (SGML has no analogue of macros with arguments.)

# Difference Between $\text{L}^{\text{A}}\text{T}_{\text{E}}\text{X}$ Source and GELLMU Source

# Difference Between $\text{L}^{\text{A}}\text{T}_{\text{E}}\text{X}$ Source and GELLMU Source

- Article prepared under a template for processing by *latex*, the Program.



# Difference Between $\text{\LaTeX}$ Source and GELLMU Source

- Article prepared under a template for processing by *latex*, the Program.
- Article prepared under a template for processing by many programs.

It is a small step from  $\text{\LaTeX}$  source to GELLMU source.

# The Idea of $\text{\LaTeX}$ -Like Markup

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- Text + Commands

# The Idea of L<sup>A</sup>T<sub>E</sub>X-Like Markup

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- A *command* is a function that operates on text.

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- Text + Commands
- A *command* is a function that operates on text.
- A command may take a non-negative number of arguments.

# Examples of L<sup>A</sup>T<sub>E</sub>X-Like Commands

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Example of a command taking no argument:

```
\latex
```

```
LATEX
```

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this is \emph{emphasized} text  
this is emphasized text
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Example of a command (for math) taking two arguments:

```
\[ \frac{a z + b}{c z + d} \]
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Example of a command (for math) taking two arguments:

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```

$$\frac{az + b}{cz + d}$$

# **GELLMU Modes**

# GELLMU Modes

1. Basic

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1. Basic

2. Advanced

# GELLMU Modes

1. Basic

2. Advanced

(a) Regular

# GELLMU Modes

1. Basic

2. Advanced

(a) Regular

(b) Other (less fully developed)

# Regular GELLMU: System Stages



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1. L<sup>A</sup>T<sub>E</sub>X-Like Source.

# Regular GELLMU: System Stages

1. L<sup>A</sup>T<sub>E</sub>X-Like Source.
2. Syntactic Translation to SGML.

# Regular GELLMU: System Stages

1.  $\text{\LaTeX}$ -Like Source.
2. Syntactic Translation to SGML.
3. Translation of SGML to Enriched XML.

# Regular GELLMU: System Stages

1. L<sup>A</sup>T<sub>E</sub>X-Like Source.
2. Syntactic Translation to SGML.
3. Translation of SGML to Enriched XML.
4. Various Formattings of Enriched XML.

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- Each output format is the result of successive transforms.
- Additional intermediate transforms can be provided.
- These slides were prepared using a special formatting of regular GELLMU's *article*.
- The [source markup](#)\* for these slides is as readable as ordinary  $\text{\LaTeX}$  source.

\*URI: `correct.glm`

# The Syntactic Translator

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source markup → XML or SGML

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<code>\foo{ ... }</code>	→	<code>&lt;foo&gt; . . . &lt;/foo&gt;</code>
<code>\foo;</code>	→	<code>&lt;foo/&gt;</code>
<code>\foo</code>	→	<code>&lt;foo&gt;</code>
<code>\foo:</code>	→	<code>&lt;/foo&gt;</code>
<code>\foo[a="x" ...]</code>	→	<code>&lt;foo a="x" ...&gt;</code>

# Syntactic Differences from L<sup>A</sup>T<sub>E</sub>X

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- No white space between command name and first argument delimiter.
- No white space between delimiters of successive arguments.
- Bracketed arguments may not be optional.

# Use of GELLMU in Basic Mode for XHTML

Write:

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Write:

```
the WWW \a[href="http://www.w3.org/"  
{Consortium} site
```

for generating the XML:

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the WWW \a[href="http://www.w3.org/"  
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to produce:

the WWW [Consortium\\*](http://www.w3.org/) site

\*URI: <http://www.w3.org/>



**\newcommand with XHTML**

# `\newcommand` with XHTML

## Definitions

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```
\newcommand{\emph}[1]{\em{#1}}
```

```
\newcommand{\w3ref}[2] []{%
```

```
\a[href="http://www.w3.org/#1"]{#2}}
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# `\newcommand` with XHTML

## Definitions

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## Invocations

# `\newcommand` with XHTML

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## Invocations

Using GELLMU's `\emph{newcommand}`  
one can reduce the markup required  
for an anchor to `\w3ref{W3C}`'s  
`\w3ref{Math/}`{MathML} site.

# `\newcommand` with XHTML

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`\w3ref{Math/}`{MathML} site.

**Rendering:** Using GELLMU's *newcommand* one can reduce the markup required for an anchor to [W3C's MathML](#) site.

**Why is GELLMU's article "Didactic" ?**

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- Intended as a first XML document type for  $\text{\LaTeX}$  authors



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  2. What high end XML people think is needed.

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  1. What  $\text{\LaTeX}$  authors are accustomed to.
  2. What high end XML people think is needed.
- Room to adjust and expand.

# The Gamma Function: Its Weierstrass Product

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$$\int_0^{\infty} t^x e^{-t} \frac{dt}{t} = \frac{1}{x} \prod_{k=1}^{\infty} \frac{\left(1 + \frac{1}{k}\right)^x}{\left(1 + \frac{x}{k}\right)}$$

# Markup for the Gamma Identity

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Regular GELLMU source for the identity:



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Regular GELLMU source for the identity:

```
\[ \int_{0}^{\infty}
    t^x e^{-t} \frac{d t}{t}
\int:
= \frac{1}{x}
\prod_{k=1}^{\infty}
    \frac{
        \bal{1 + \frac{1}{k}}^x
    }{
        \bal{1 + \frac{x}{k}}
    }
\prod: \]
```

# **Gamma: Derived XML Markup**

# Gamma: Derived XML Markup

```
<displaymath>
<int>
  <msub>0</msub>
  <msup><infty/></msup>
  t<pow>x</pow> e<pow><minus/>t</pow>
  <frac>
    <numr>d t</numr>
    <denm>t</denm>
  </frac>
</int>
<equals/>
<frac><numr>1</numr><denm>x</denm></frac>
<prod>
  <msub>k<equals/>1</msub>
  <msup><infty/></msup>
  <frac>
    <numr>
      <bal>1<plus/>
      <frac>
        <numr>1</numr>
        <denm>k</denm>
      </frac>
    </numr>
  </frac>
</prod>
</displaymath>
```

```
</bal><pow>x</pow>
</numr>
<denm>
  <bal>1 <plus/>
    <frac>
      <numr>x</numr>
      <denm>k</denm>
    </frac>
  </bal>
</denm>
</frac>
</prod>
</displaymath>
```

**Gamma: in MathML**

# Gamma: in MathML

(not by automatic translation)

# Gamma: in MathML

(not by automatic translation)

```
<math
  xmlns="http://www.w3.org/1998/Math/MathML"
  class="display" mode="display">
<mrow>
  <mrow>
    <msubsup>
      <mo>&Integral;</mo>
      <mrow><mn>0</mn></mrow>
      <mi>&infin;</mi>
    </msubsup>
    <mrow>
      <msup>
        <mrow><mi>t</mi></mrow>
        <mrow><mi>x</mi></mrow>
      </msup>
      <mo> </mo>
    </mrow>
    <msup>
      <mrow><mi>e</mi></mrow>
      <mrow><mi>-t</mi></mrow>
    </msup>
  </mrow>
  <mo> </mo>
  <mfrac>
    <mrow><mi>dt</mi></mrow>
```

```

    <mi>t</mi>
  </mfrac>
</mrow>
</mrow>
<mo>=</mo>
<mrow>
  <mfrac>
    <mrow><mn>1</mn></mrow>
    <mi>x</mi>
  </mfrac>
<mo> </mo>
<msubsup>
  <mo>&Product;</mo>
  <mrow><mi>k</mi><mo>=</mo><mn>1</mn></mrow>
  <mi>&infin;</mi>
</msubsup>
<mrow>
  <mrow>
    <mfrac>
      <mrow>
        <msup>
          <mrow><mfenced>
            <mrow>
              <mn>1</mn><mo>+</mo>
              <mfrac><mn>1</mn><mi>k</mi></mfrac>
            </mrow>
          </mfenced></mrow>
          <mrow><mi>x</mi></mrow>
        </msup>
      </mrow>
    </mfrac>
  </mrow>

```



```
</mrow>
<mrow><mfenced>
  <mrow>
    <mn>1</mn><mo>+</mo>
    <mfrac><mi>x</mi><mi>k</mi></mfrac>
  </mrow>
</mfenced></mrow>
</mfrac>
</mrow>
</mrow>
</mrow>
</math>
```

# Viewing MathML

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Viewing support for MathML in web pages is not yet widely available.  
The above item can be rendered by:

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- *Mozilla's* MathML development track: [wprod.xml](#) (only).

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- *W3C's Amaya*: [wprod.html](#) or [wprod.xml](#).
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- With special plugin for *MSIE*: [wprod.html](#) (only).

# Generating MathML from article

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- Ad hoc `wprod.html` was made from GELLMU source:  
[wprod.glm](#).



# Generating MathML from article

- Ad hoc `wprod.html` was made from GELLMU source:  
[wprod.glm](#).
- The short *article form* (slide 28) of GELLMU source above *could* be given automatic translation to MathML.

# Generating MathML from article

- Ad hoc `wprod.html` was made from GELLMU source:  
[wprod.glm](#).
- The short *article form* (slide 28) of GELLMU source above *could* be given automatic translation to MathML.
- An automatic translation should go through *content* MathML and from there to *presentation* MathML.

# Generating MathML from article

- Ad hoc `wprod.html` was made from GELLMU source:  
[wprod.glm](#).
- The short *article form* (slide 28) of GELLMU source above *could* be given automatic translation to MathML.
- An automatic translation should go through *content* MathML and from there to *presentation* MathML.
- An automatic translation would not be under the umbrella of general XML processing.

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1. Source markup labeling of math symbols.
2. Source markup typing of math symbols.

# MathML Generation Issues

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- Will authors cooperate?

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- Will **standard** web user agents cooperate?

# Two Final Notes

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- For more information: <http://www.albany.edu/~hammond/gellmu/>

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- For more information: <http://www.albany.edu/~hammond/gellmu/>
- GELLMU source for these slides is on the web:  
<http://math.albany.edu:8000/~hammond/Presen/Correct/correct.glm>