

Authoring Interactive Sage Worksheets

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Goals

- Write about using Sage, and relevant mathematics

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- Write about using mathematics, and relevant Sage

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(I won't talk much about this, but it should be obvious)
- Convert a Sage worksheet into a high-quality publishable print format
(Thursday night's idea)

Today's Talk

- \LaTeX
- Dan Drake's SageTeX
- Eitan Guiari's tex4ht
- Davide Cervone's jsMath
- Sage notebook and worksheets
- Sage @interact framework
- Taylor Series in the Classroom

L^AT_EX

- Well-known to many mathematicians
- Sources are long-lived (1980's for me)
- Widely available, many platforms
- Many add-on packages
- A comfortable place to write for many mathematicians, scientists
So a low barrier to getting started
- LaTeX Public Project License (LPPL)

SageTeX

- Designed to allow Sage commands to be placed inline with \LaTeX
- Creates `latex()` and `plot()` output “on-the-fly”
- GNU Public License (GPL)

Extensions?

- `\sageinline{}`
small amounts Sage code verbatim (syntax package)
- `\begin{sageverbatim}\end{sageverbatim}` environment
produces a Sage input cell
- `\begin{sagecell}[output]`
Sage input, optionally with computed output cell

Sample SageTeX Extensions

For example the code below will (1) create $\langle G \rangle$ as the symmetric group on five symbols, (2) specify $\langle \sigma \rangle$ as an element of $\langle G \rangle$, (3) use $\langle \sigma \rangle$ as the generator of a cyclic subgroup $\langle H \rangle$, (4) list all the elements of $\langle H \rangle$. In more mathematical notation, we might write $\langle \langle (1\ 2\ 3)(4\ 5) \rangle \rangle \subseteq G = S_5$.

```
%  
\begin{sageverbatim}  
G = SymmetricGroup(5)  
sigma = G("(1,2,3)(4,5)")  
H = G.subgroup([sigma])  
H.list()  
\end{sageverbatim}
```

Sample Input Cell

As a workbook

For example the code below will (1) create G as the symmetric group on five symbols, (2) specify σ as an element of G , (3) use σ as the generator of a cyclic subgroup H , (4) list all the elements of H . In more mathematical notation, we might write $\langle (1\ 2\ 3)(4\ 5) \rangle = H \subseteq G = S_5$.

```
G=SymmetricGroup(5)
sigma=G("(1,2,3)(4,5)")
H=G.subgroup([sigma])
H.list()
```

```
[(), (4,5), (1,2,3), (1,2,3)(4,5), (1,3,2), (1,3,2)(4,5)]
```

As a PDF

For example the code below will (1) create G as the symmetric group on five symbols, (2) specify σ as an element of G , (3) use σ as the generator of a cyclic subgroup H , (4) list all the elements of H . In more mathematical notation, we might write $\langle (123)(45) \rangle = H \subseteq G = S_5$.

```
G=SymmetricGroup(5)
sigma=G("(1,2,3)(4,5)")
H=G.subgroup([sigma])
H.list()
```

tex4ht

- Translator - “ TEX for HyperText”
- NSF funded project
- Creates HTML, XML/XHTML/MathML, JSMath, OpenOffice, DocBook, Text Encoding Initiative, JavaHelp, speech (!)
- Two small platform-specific binaries, compiles easily from source
- Three-pass operation, uses unmodified TEX to create DVI
- \LaTeX packages are modified for use, by request (very responsive)
- Fast and accurate
- More finicky than TEX , like unmatched (,) in text
- LaTeX Public Project License (LPPL)

jsMath

- Render a (large) subset of $\text{T}_{\text{E}}\text{X}$ in web browser
- Relies heavily on Javascript
- Scalable fonts. Locally, or from a server
- Well-integrated, tested in notebook
- Paste tex4ht-generated jsMath into a worksheet as text and it “just works”
- Apache 2.0 License

tex4ht Customization

A tex4ht “configuration” file

Tags Sage code blocks

```
\Preamble{xhtml , jsmath , info }
  \ScriptEnv{sageverbatim}
    {\ifvmode \IgnorePar \fi
      \EndP\HCode{<sage>}\NoFonts\break}
    {\ifvmode \IgnorePar \fi
      \EndP\HCode{</sage>}\EndNoFonts
      \csgname par\endcsgname\ShowPar}
\begin{document}
\EndPreamble
```


Worksheets and @interact

- Sage's framework for interactive demonstration
- @interact decorator on a function
- Function arguments create checkboxes, text input fields, sliders
- GNU Public License (GPL)

Sample Embedded Sage Interact

```
\begin{sageverbatim}
%auto
@interact
def _(n = input_box(default=12, label = "Cyclic_group_of_order:", type=Integer) ):
    cyclic = CyclicPermutationGroup(n)
    subgroups = cyclic.conjugacy_classes_subgroups()
    html( "All_subgroups_of_a_cyclic_group_of_order_$$$\\n" % latex(n) )
    table = "$\\begin{array}{ll}"
    for sg in subgroups:
        table = table + latex(sg.order()) + \
            "&\\left\\langle" + latex(sg.gens()[0]) + \
            "\\right\\rangle"
    table = table + "\\end{array}$"
    html(table)
    html("\\nHint: _$$$_factors_as_$$$" % ( latex(n), latex(factor(n)) ) )
\end{sageverbatim}
```

Sample Embedded Sage Interact

```
%auto
@interact
def _(n = input_box(default=12, label = "Cyclic group of order:", type=Integer) ):
    cyclic = CyclicPermutationGroup(n)
    subgroups = cyclic.conjugacy_classes_subgroups()
    html( "All subgroups of a cyclic group of order  ${}n$ " % latex(n) )
    table = "$\\begin{array}{l}"
    for sg in subgroups:
        table = table + latex(sg.order()) + \
            " & \\left\\langle" + latex(sg.gens()[0]) + \
            "\\right\\rangle\\\\"
    table = table + "\\end{array}$"
    html(table)
    html("\\nHint:  ${}s$  factors as  ${}s$ " % ( latex(n), latex(factor(n)) ) )
```

Cyclic
group of
order:

All subgroups of a cyclic group of order 12

- 1 $\langle () \rangle$
- 2 $\langle (1, 7)(2, 8)(3, 9)(4, 10)(5, 11)(6, 12) \rangle$
- 3 $\langle (1, 5, 9)(2, 6, 10)(3, 7, 11)(4, 8, 12) \rangle$
- 4 $\langle (1, 4, 7, 10)(2, 5, 8, 11)(3, 6, 9, 12) \rangle$
- 6 $\langle (1, 3, 5, 7, 9, 11)(2, 4, 6, 8, 10, 12) \rangle$
- 12 $\langle (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12) \rangle$

Hint: 12 factors as $2^2 \cdot 3$

Putting it All Together

- “Regular” \LaTeX
for narrative, mathematics, references, sectioning, etc
- SageTeX for inline Sage code, Sage cells (input/output)
do the right thing for print AND for worksheet as targets
- @interact for interactive functionality

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Workflow

- Process with `tex4ht`
- Cut/paste into a worksheet, or automate `*.sws` creation

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Wish List

- Extensions to SageTeX
- Cross-worksheet links in notebook

Final Example - Taylor Series in the Classroom

- A Sage worksheet designed to include interact
- PDF version for students as well