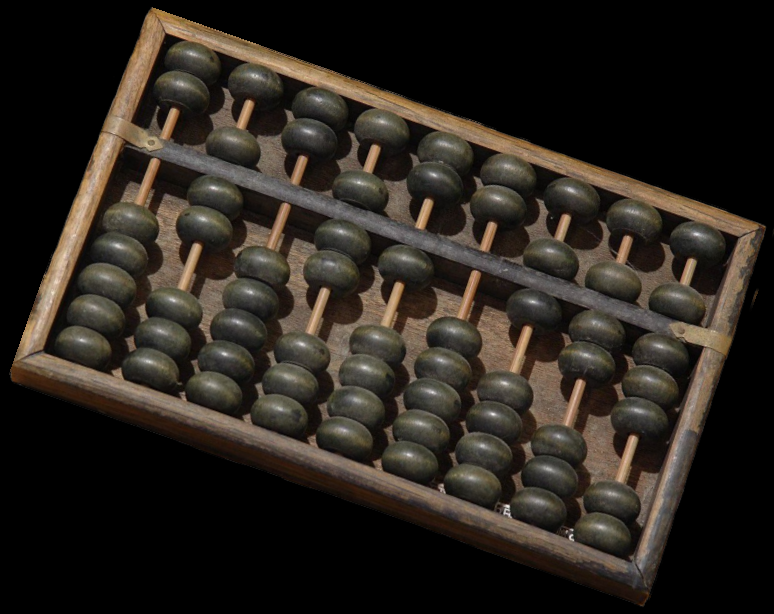
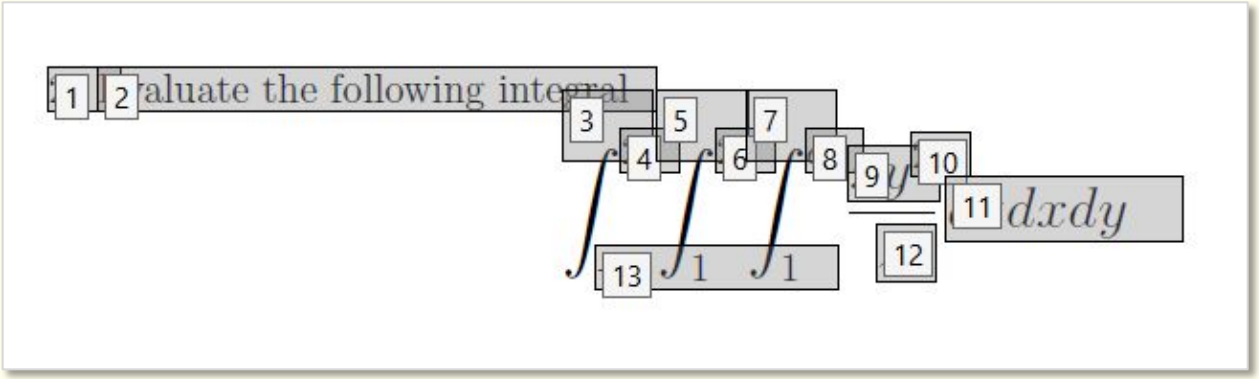


# Accessibility for Special Materials: Math

# Problem: PDFs Do Not Encode Math Accessibly

PDFs have no practical means of presenting accessible math:




Mathematical expressions become a series of glyphs that are meaningless to assistive technologies.

# Problem: Simple Formulas as Text Will Not Work

- What's wrong with entering simple equations as text, "2 - 3 = -1"?
- Screen-reading software will not "know" the text is math. A screen reader will speak the numbers as numbers and some of the operators as ASCII characters:

2 to 3 equals dash 1

- By default, the verbosity settings in most screen-reading software will simply ignore many symbols
- The JAWS screen reader speaks "$(x + 2)^3 = 8$" as:

X 2 3 equals 8

# Problem: Text Formatting Does Not Work Either

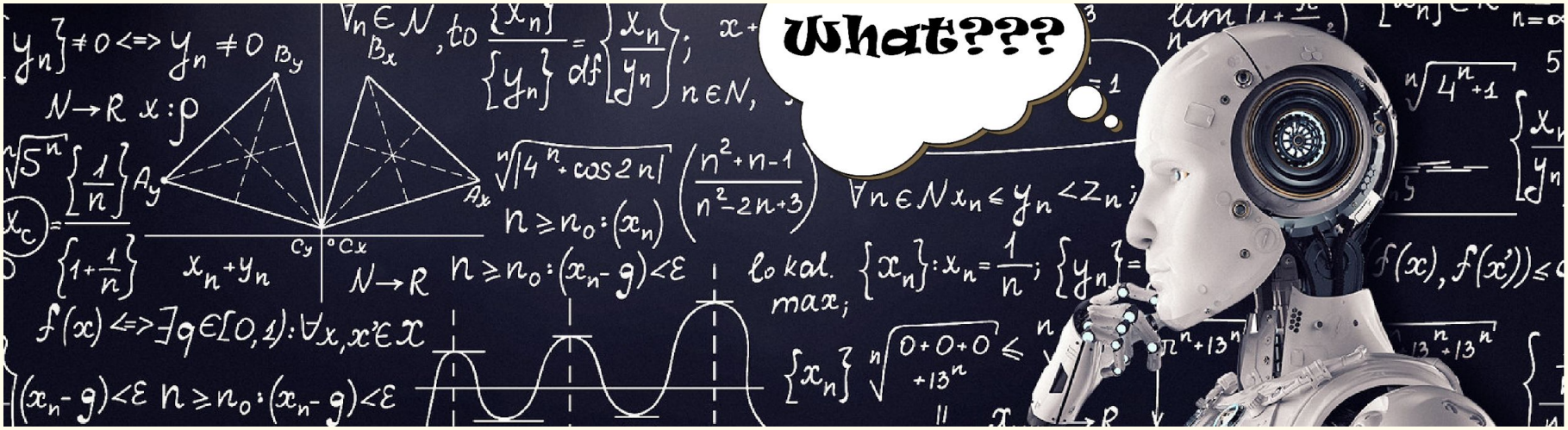
- Superscripts and subscripts in text are not supported either, “ $x^n$ ” will be spoken as:

x n

**The takeaway:** Common symbols, superscripts, subscripts, etc. in text will not be treated as math, may be ignored, or misinterpreted by assistive technologies

# Problem: Math Content is Often Published as Images

- Images are only effective for readers with normal vision and decoding capabilities
- Assistive Technology **will not** recognize math in images and speak it effectively any more than it will correctly describe images that are missing alt-text

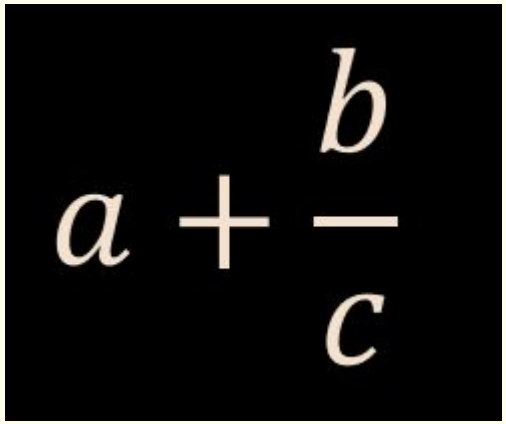


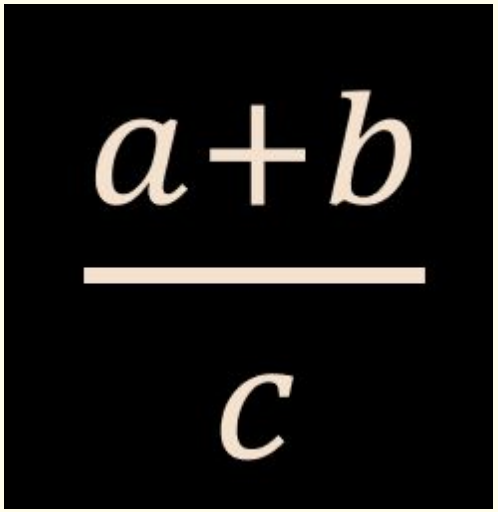
# How Should Math Be Spoken?

$$a + \frac{b}{c}$$

# How Should a Screen-Reader Speak Math?

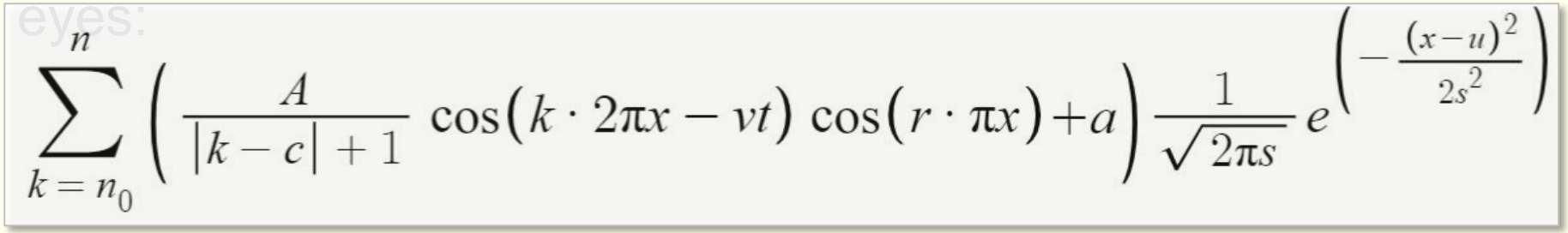
What phrasing or sonification needs to be added to “a plus b over c” to make these two examples unambiguous?



# Problem: Image Alt-Text Is Not Suitable

What would you prefer? Exploring this equation with your eyes:



$$\sum_{k=n_0}^{n} \left( \frac{A}{|k-c|+1} \cos(k \cdot 2\pi x - vt) \cos(r \cdot \pi x) + a \right) \frac{1}{\sqrt{2\pi s}} e^{\left( -\frac{(x-u)^2}{2s^2} \right)}$$

or hearing:

> "the sum from k is equal to n sub 0 to n of; open paren; the fraction with numerator A; and denominator the absolute value of k minus c, end absolute value; plus 1; end fraction; cosine of; open paren; k times 2 pi x; minus v t; close paren; cosine of, open paren, r times pi x, close paren; plus a; close paren; times; the fraction with numerator 1; and denominator the square root of 2 pi s, end root; end fraction; e superscript open paren; minus; the fraction with numerator; open paren x minus u, close paren squared; and denominator 2 s squared; end fraction; close paren"

Navigating forward and back through the words of the linearized speech text would not be equivalent to how an individual with sight examines it.

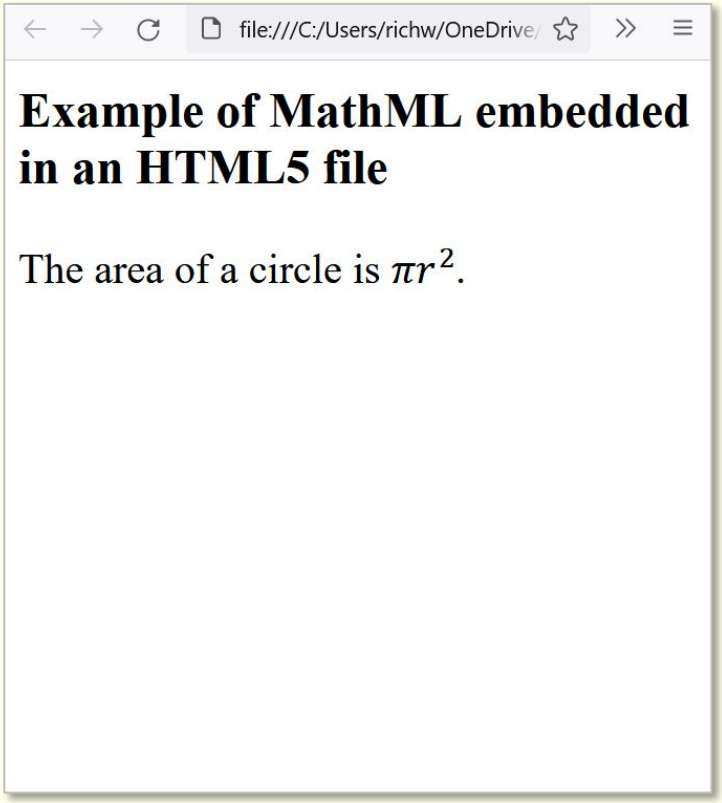
# Happily, the W3C Has the MathML Standard

The World Wide Web Consortium (W3C) oversees the development of key standards that help make web pages and electronic documents accessible, including math:

- **MathML** = A low-level specification for marking up mathematical and scientific content as XML in web pages and other digital documents
- Often used “under the cover”
- MathML 1.0 was released in April 1998
- MathML 3.0 (current) was released April 2014
- https://www.w3.org/Math/

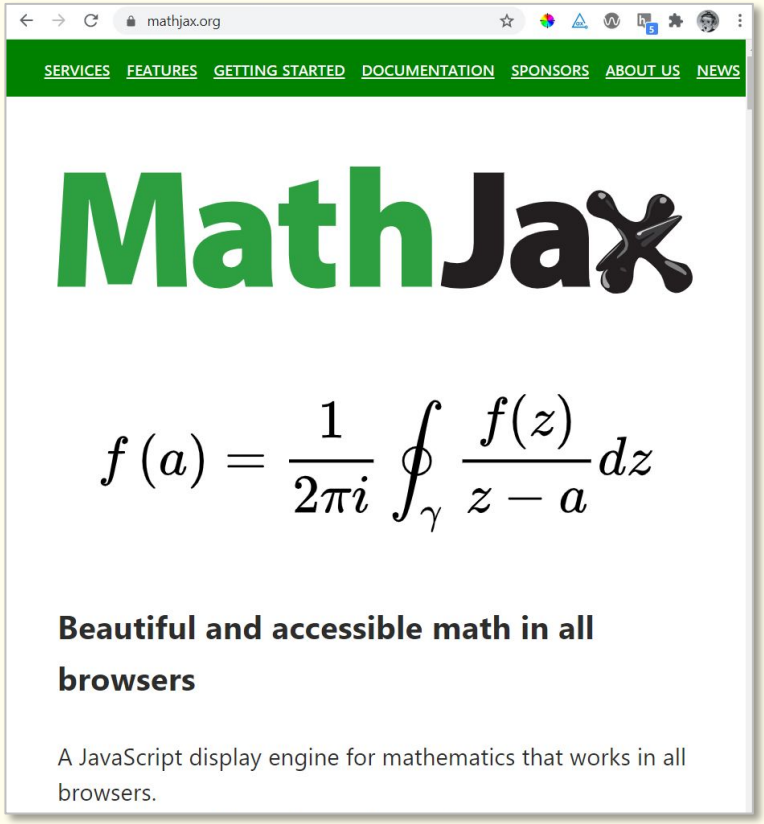
# MathML Renders in HTML Technologies

```
<h1>Example of MathML
embedded in an HTML5
file</h1>
<p>The area of a circle is
  <math>
    <mi>&pi;</mi>
    <mo>&InvisibleTimes;</mo>
    <msup>
      <mi>r</mi>
      <mn>2</mn>
    </msup>
  </math>.
</p>
```



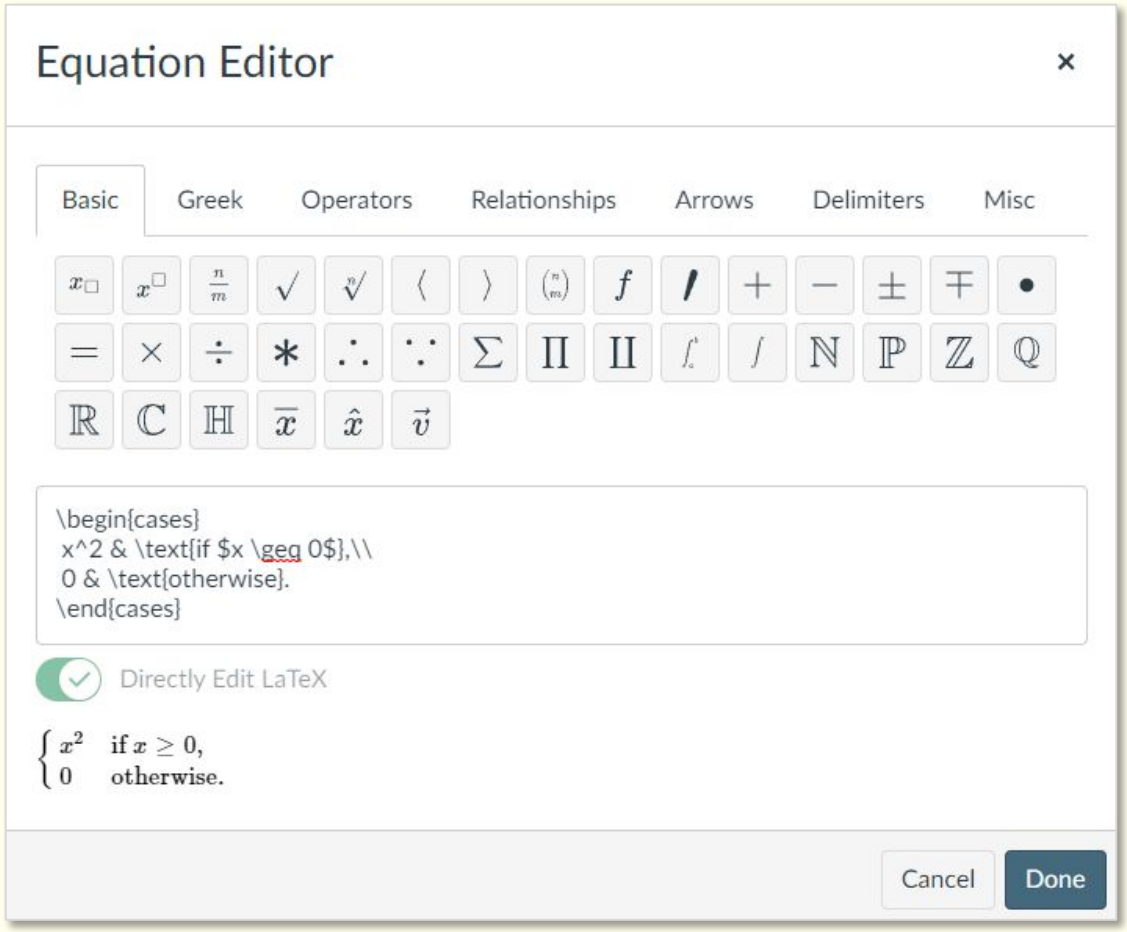
# Many Websites Use the MathJax Display Engine

- MathJax is an open-source JavaScript library.
- MathJax will find math content in an HTML document and render it reliably and accessibly.
- Generates speech text, braille, is zoomable, and has an interactive expression explorer.
- https://www.mathjax.org/



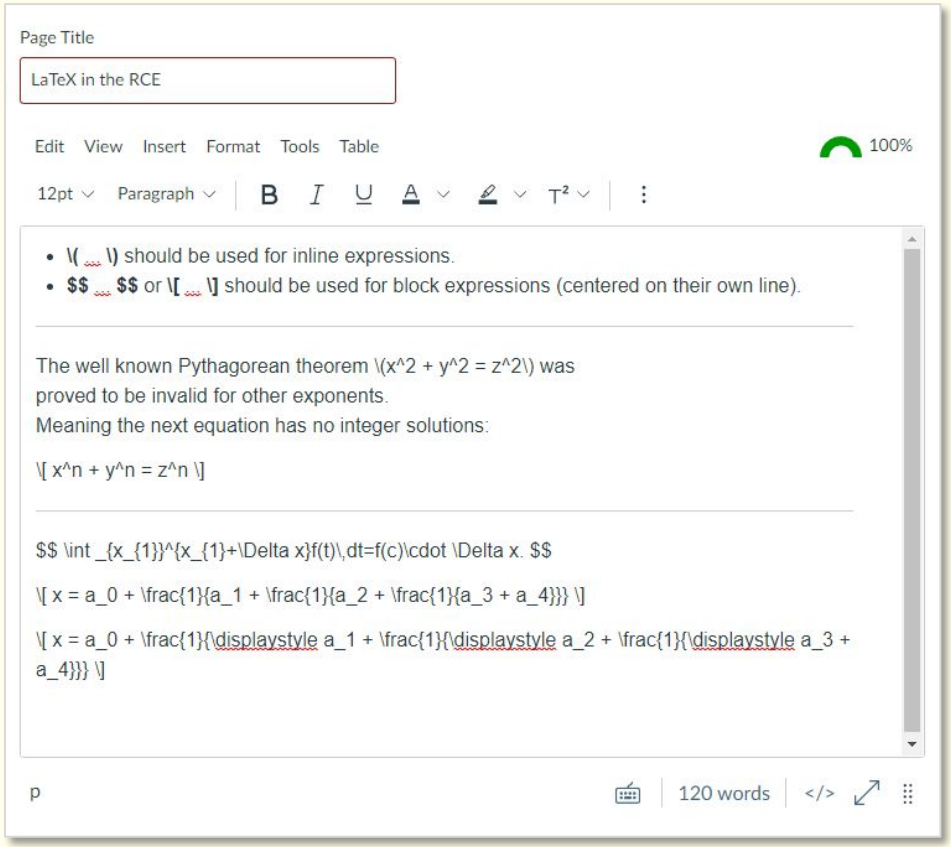
# Equation Editor in the Canvas LMS's RCE

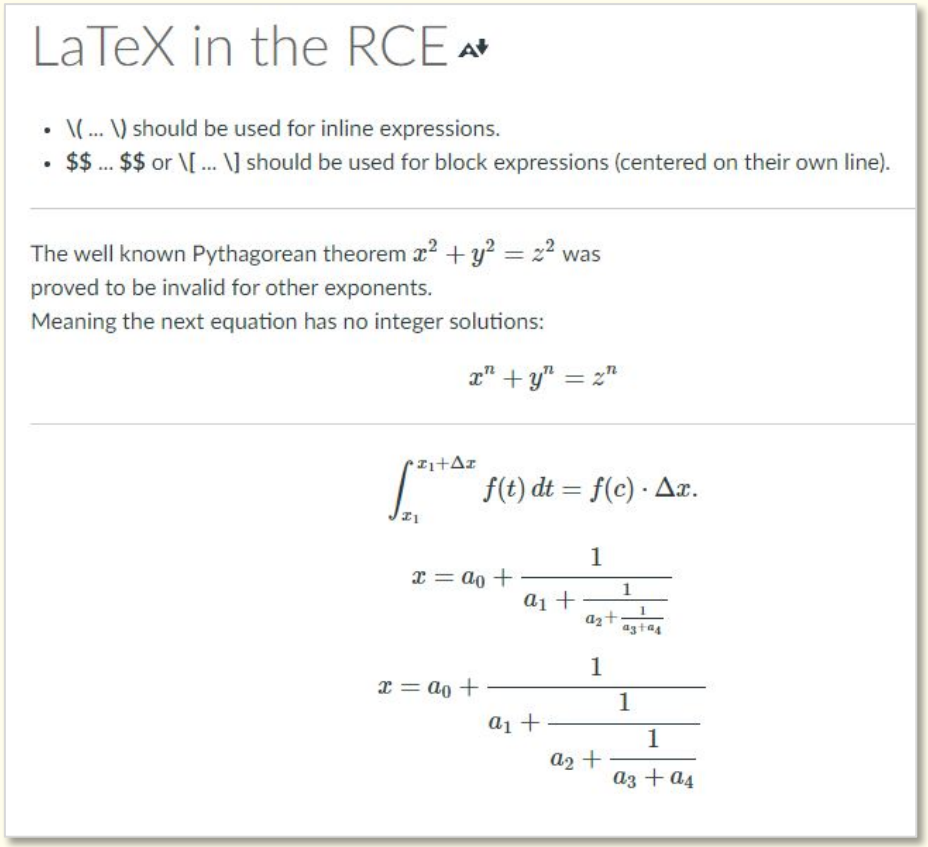
The Canvas Rich Content Editor's Equation Editor creates accessible math objects:



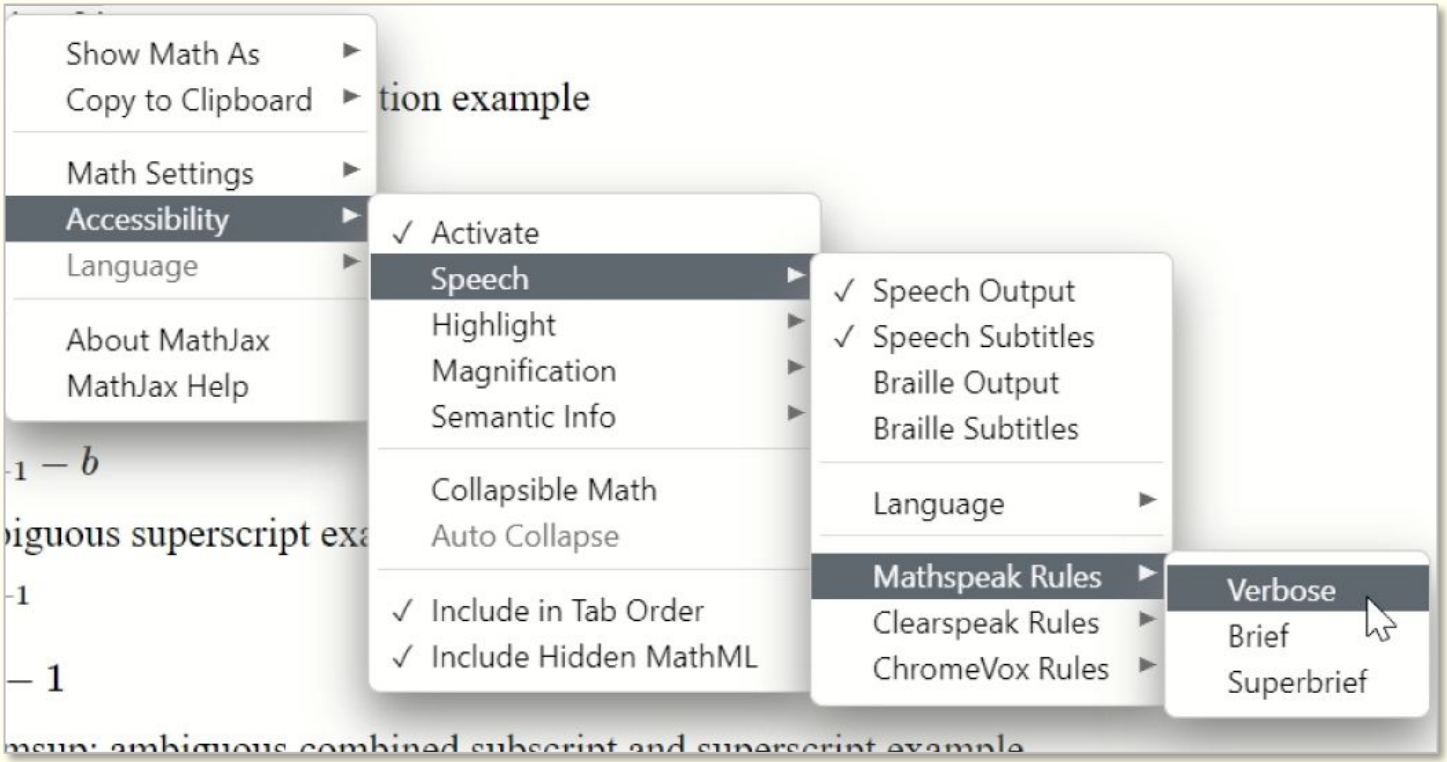
# LaTeX Entered Directly into the Canvas RCE

LaTeX can be entered between delimiters in the body text of the RCE



# MathJax Provides Grammars for Speaking Math




Many assistive technologies use one or more established grammars like ClearSpeak, MathSpeak and SimpleSpeak to speak math.

# Example: Math Linearized into Speech Text

x equals StartFraction
negative b plus-or-minus
StartRoot b squared minus 4 a
c EndRoot Over
2 a EndFraction

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

# Example of a Matrix

$$\begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

ClearSpeak (Medium verbosity):

```
the 3 by 3 matrix; row 1; 1, 0, 0; row 2; 0,
1, 0; row 3; 0, 0, 1;
```

# Example of a Conditional

$$f(x) = \begin{cases} x^2 + 3, & x < 0 \\ x^2 - 3, & x \geq 0 \end{cases}$$

ClearSpeak (Medium verbosity):

f of x equals; 2 cases, case 1; x squared plus 3, comma, x is less than 0; case 2; x squared minus 3, comma, x is greater than or equal to 0;

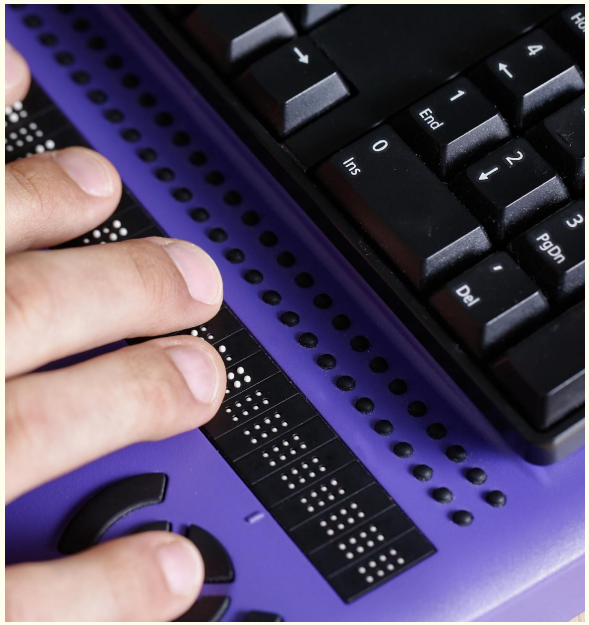
# Many AT Tools Provide Braille Output

**The Cauchy-Schwarz Inequality**

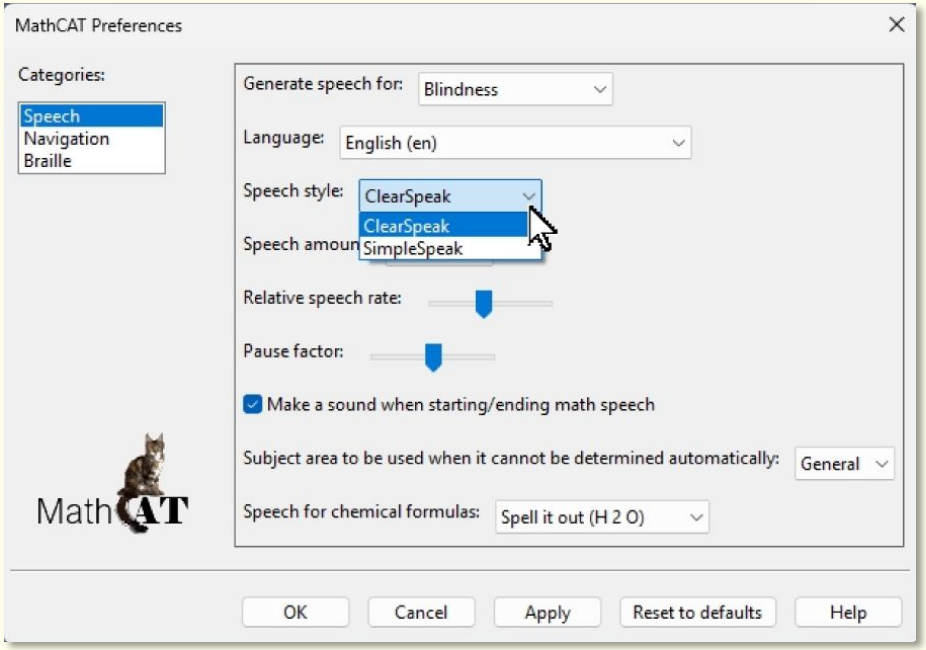
$$\left(\sum_{k=1}^{n} a_k b_k\right)^2 \leq \left(\sum_{k=1}^{n} a_k^2\right)\left(\sum_{k=1}^{n} b_k^2\right)$$

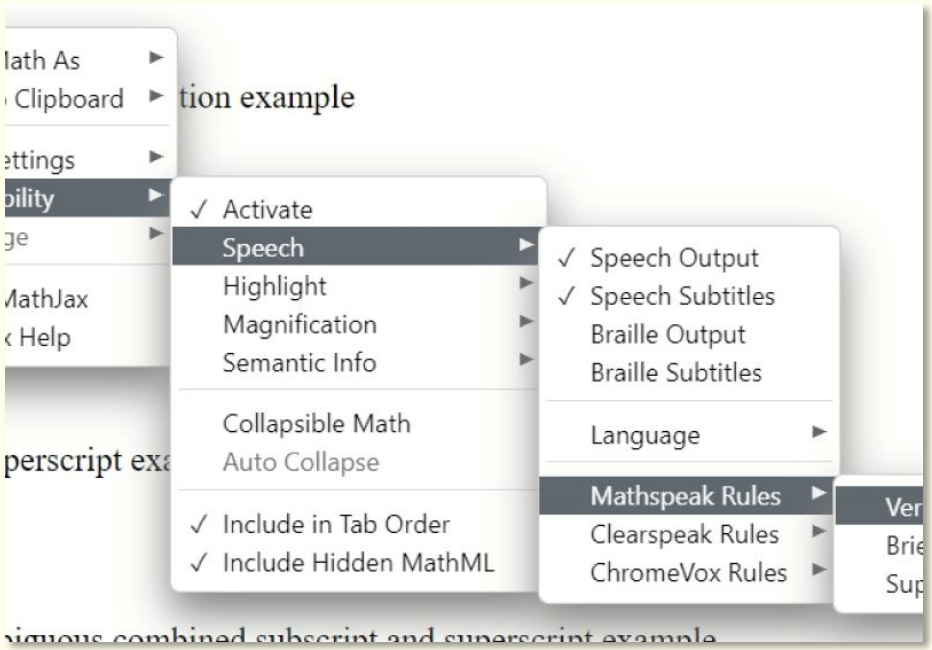
left parenthesis sigma summation Underscript k equals 1 Overscript n Endscripts a Subscript k Baseline b Subscript k Baseline right parenthesis squared less than or equals left parenthesis sigma summation Underscript k equals 1 Overscript n Endscripts a Subscript k Superscript 2 Baseline right parenthesis left parenthesis sigma summation Underscript k equals 1 Overscript n Endscripts b Subscript k Superscript 2 Baseline right parenthesis

$$\mathbf{V}_1 \times \mathbf{V}_2 = \begin{vmatrix} \frac{\partial X}{\partial u} & \frac{\partial Y}{\partial u} & 0 \\ \frac{\partial X}{\partial v} & \frac{\partial Y}{\partial v} & 0 \end{vmatrix}$$



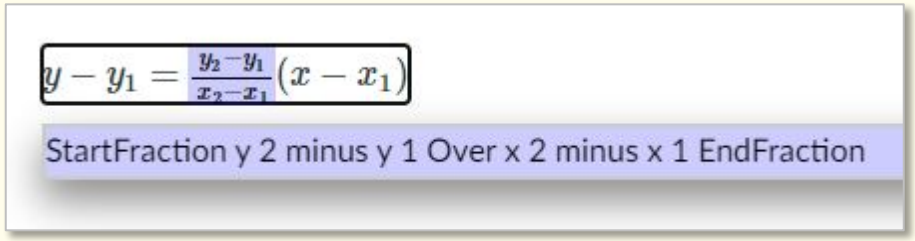
# Grammars for Speaking Math




Many assistive technologies use one or more established grammars like ClearSpeak, MathSpeak and SimpleSpeak (along with preference settings) to speak math.

# AT Users Can Navigate Using Expression Explorers




- Help pages for various equation explorers:
  - MathCAT Navigation Commands and their Key Bindings
  - MathJax: Key Bindings for the Math Explorer
  - JAWS: Accessing Math Content with JAWS and Fusion
  - VoiceOver iOS: Read Math Equations

# PDF/UA-2 Was Recently Released with Support for MathML


## ISO 14289-2 (PDF/UA-2), the "gold standard" for accessibility in PDF 2.0, has arrived

PDF association

PDF Association staff
March 15, 2024
Announcement

Based on WTPDF, ISO 14289-2 serves to assure institutions that the PDF Association's requirements for creating and validating accessible PDF 2.0 files are now ISO-standardized.

**About the author:** The PDF Association staff delivers a vendor-neutral platform for PDF's stakeholders, facilitating the development of open specifications and ISO standards for PDF technology. Staff members include: Alexandra Oettler (Editor), Betsy Fanning ... Read more

# Along with the Well-Tagged PDF Guidance

RESOURCE

## Well-Tagged PDF (WTPDF)

### Using Tagged PDF for Accessibility and Reuse in PDF 2.0

The primary purpose of this specification is to define how to represent electronic documents in PDF 2.0 files in a manner that allows the file to be reusable and accessible across a wide spectrum of possible use-cases.

There is a large overlap between the requirements for reuse and accessibility. However, some requirements are critical for reuse whereas others are critical for accessibility. This document clearly identifies the requirements for each use-case via a conformance level mechanism.

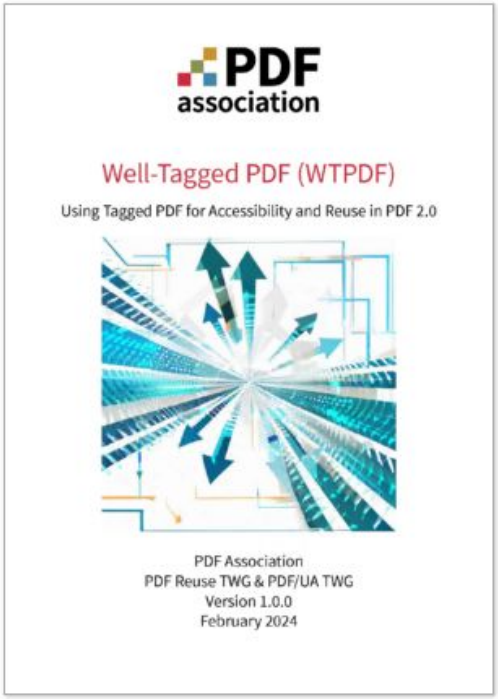
WTPDF identifies the components that shall, should or may be used in these contexts, as well as restrictions on their use. It includes a conformance level mechanism to empower software and document authors to target these use cases.

The specification is fully compatible with ISO 14289-2 (PDF/UA-2), so a file that conforms to the accessibility conformance level defined in this specification also conforms to the latest ISO standard for accessible PDF, and may be marked as such.

Both this document and PDF/UA-2 provide numerous improvements on PDF/UA-1, including:

- comprehensive requirements for the new structure element types introduced in PDF 2.0
- comprehensive requirements for structure element attributes;

RESOURCE INFO




Download WTPDF

Well-Tagged PDF (WTPDF) provides developers with comprehensive requirements for software that seeks to create fully reusable and accessible PDF 2.0 files in an interoperable manner.

# Adobe Funded LaTeX Project Support for PDF/UA-2



**Report on the LaTeX Tagged PDF workshop, TUG 2023**

David Carlisle, Ulrike Fischer,
Frank Mittelbach

**Contents**



they are needed. It also requires more compilations to build the correct tagging structure.

Other workflows such XeLaTeX or LaTeX–dvips are not recommended as real space characters can't be inserted in these cases. In order for accessibility tools to distinguish inter-word spaces from inter-letter kerns and other spacing adjustments, words need to be separated by space characters (U+0020) even if the spacing is further adjusted. It is not feasible to add these space characters just using the macro layer, and currently only pdfLaTeX and luaLaTeX have engine-level support to add them.

When developing or updating packages or classes for tagging, one always needs to test tagging with at least pdfLaTeX *and* luaLaTeX. They use different methods to create the basic MC-chunks (called "marked-content sequences" in PDF reference manuals) and create the structure tree (namely, PDF literals in pdfTeX and luaTeX node attributes in luaTeX).

### 1.2 Tagging commands and Tagging activation

# Test Versions of LaTeX -> Tagged PDFs w/MathML Are Available Now

## Automated tagging of PDF documents

We have now enabled new automatic tagging functionality for additional LaTeX elements, among them most display environments, standard sectioning commands and content, figure and table listings.

This can be activated through

```
\DocumentMetadata{testphase=phase-III}
\documentclass{...}                    % article, book or report
```

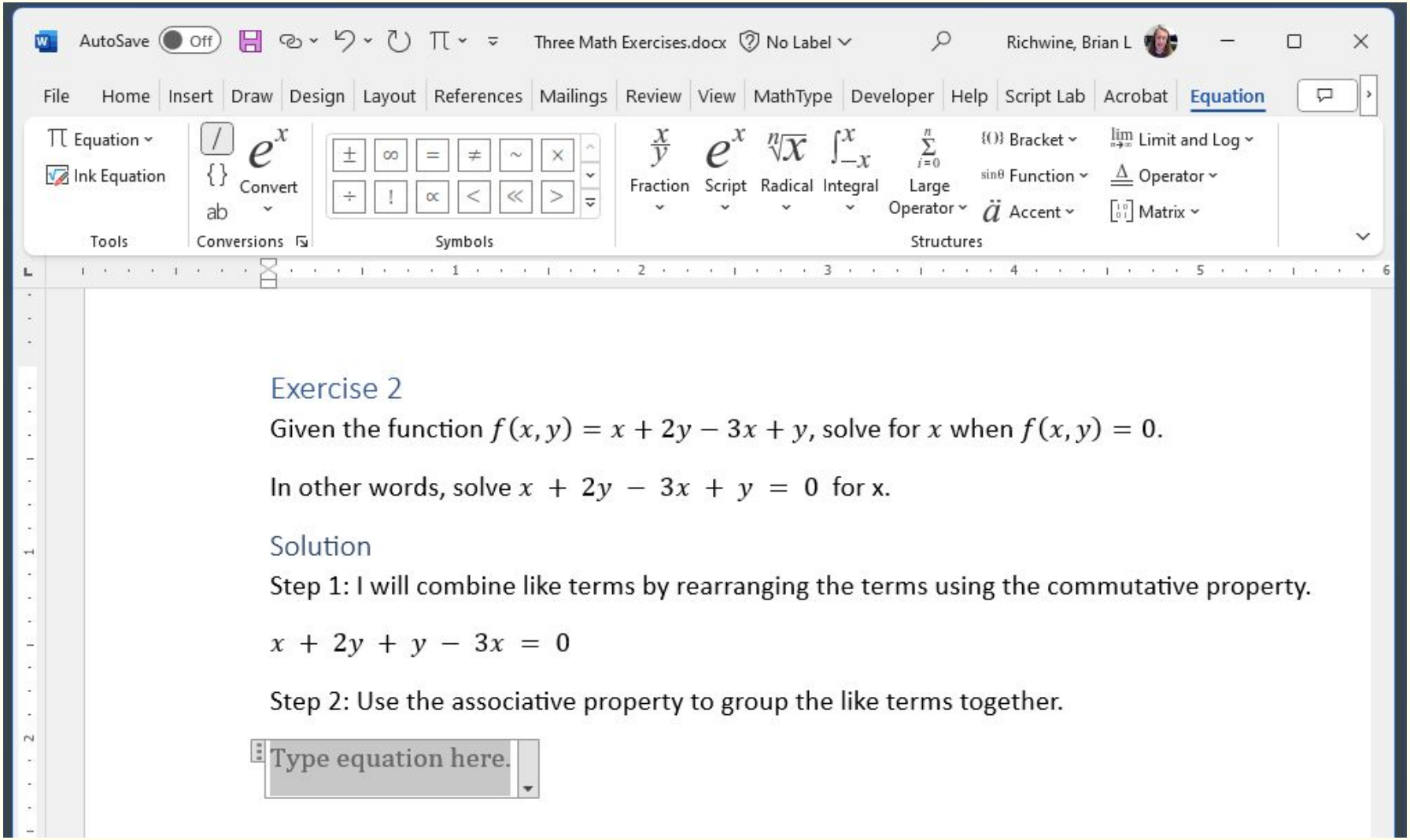
In addition there is also a (very early) prototype for tagging formulas, which can be activated through

```
\DocumentMetadata{testphase={phase-III,math}}
\documentclass{...}
```

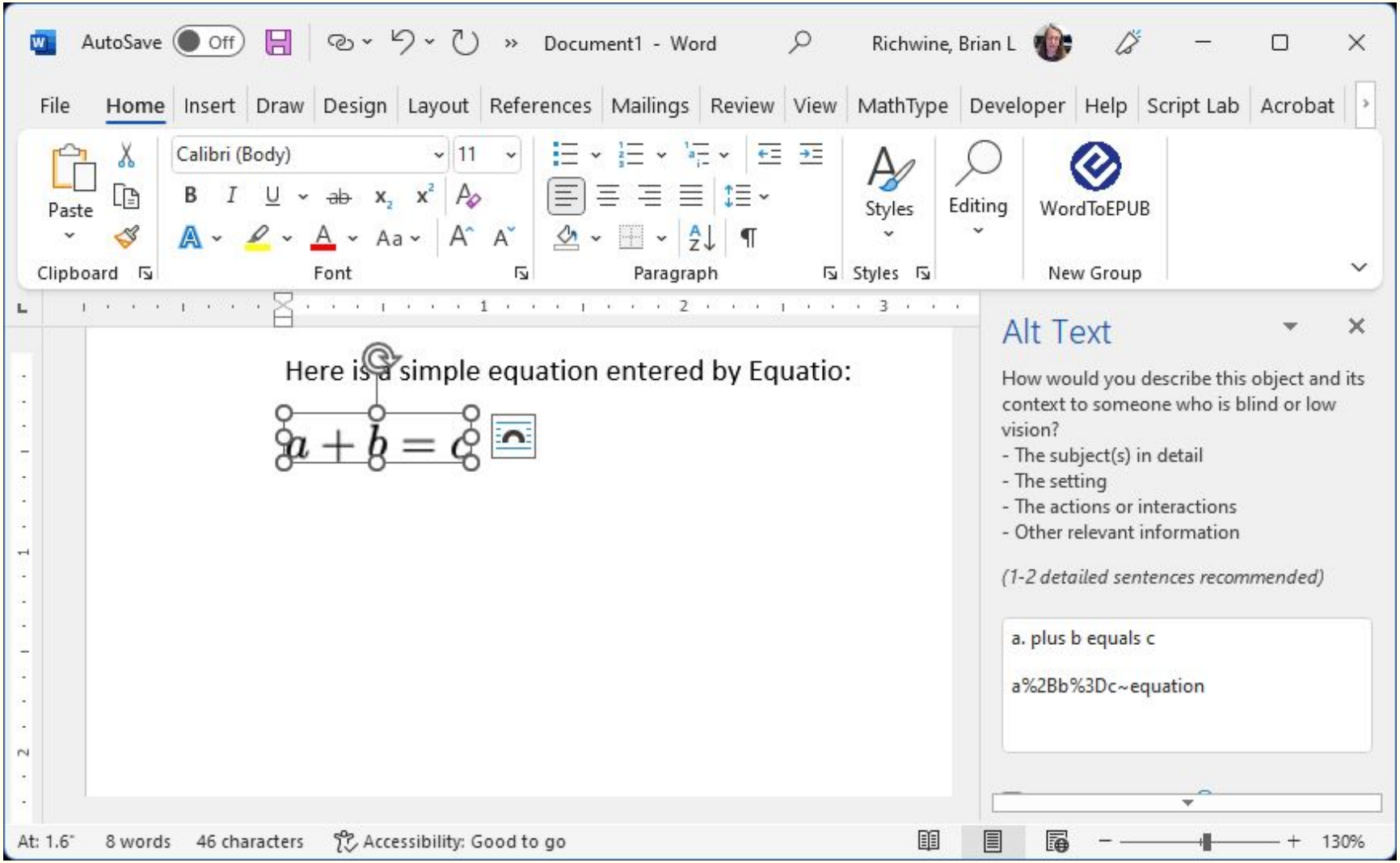
It offers support for LaTeX's standard math environments but also for all environments provided through the `amsmath` package.

All of this automation is currently in a prototype state and restricted to the use of standard classes ( `article` , `report` , and `book` ) and it supports only a limited number of add-on package. See the draft version of the LaTeX2e News Issue 37 newsletter for further details. It provides information how to submit feedback on the new functionality.

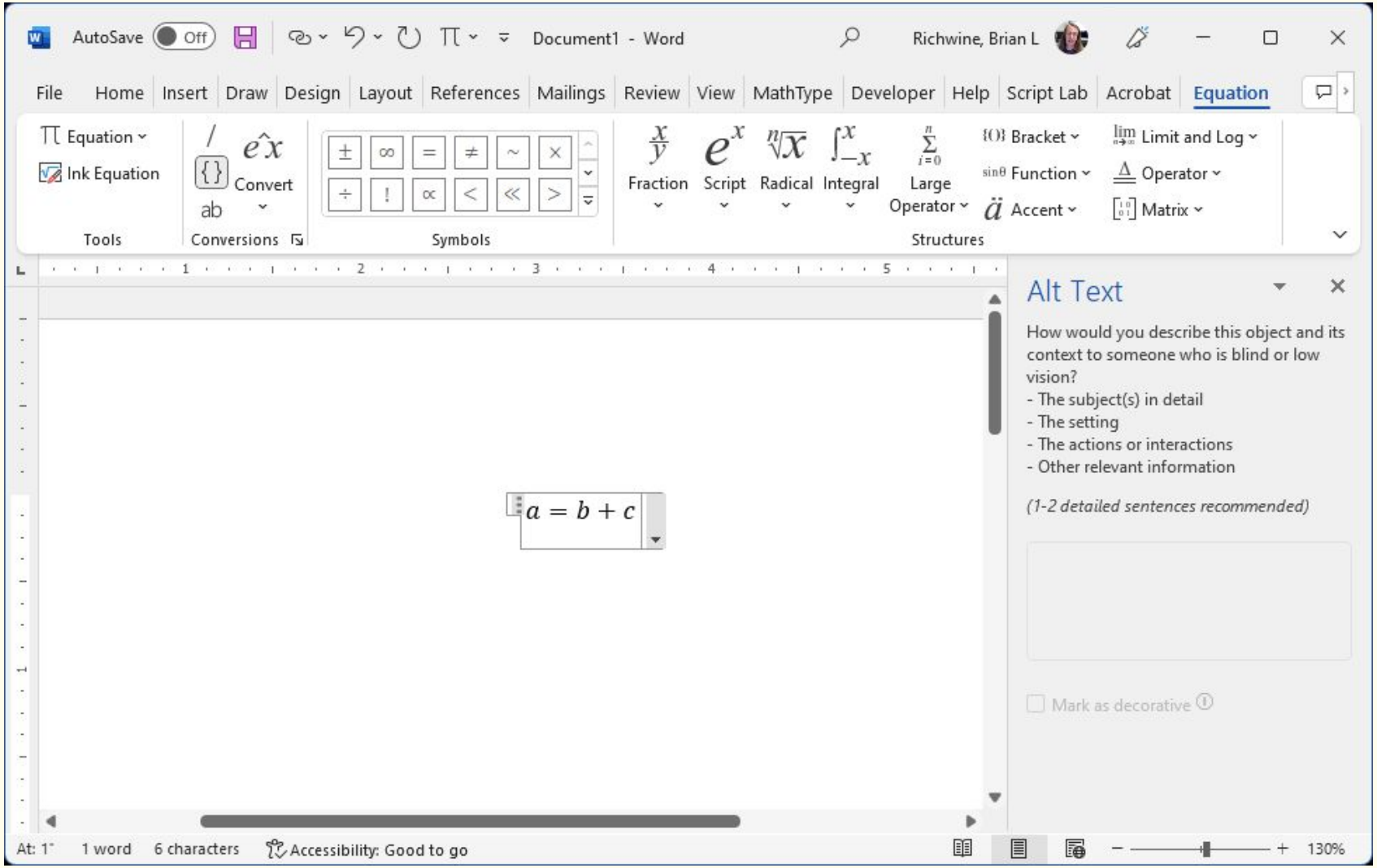
# Listening Isn't Just for Reading: Create and Edit Math Using Microsoft Word Equations



# Check Math in Word: Images



# Check Math in Word: Built-in Math Object



# AI-Powered Tools for Converting PDFs with Math into Other Formats (Word, HTML, etc.)