



Texas School for the Blind and Visually Impaired

Presents

Accessible Mathematics for Students with a Visual Impairment and/or Additional Disabilities

AccessU 2019

May 16, 2019

Austin, Texas



Presented by
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birdm@tsbvi.edu

www.tsbvi.edu/math

www.tsbvi.edu/videos-webinars/mathematics



Agenda

- Math Materials (Including Graphics)
 - Braille Reader
 - Low Vision Student
- Accessible Math Tools and Technology
 - Number and Quantity
 - Algebra and Statistics and Probability
 - Geometry
 - Measurement
- What's New in Research Regarding Accessible Mathematics?



Early Childhood: Where Learning Mathematics Begins

The Multi-Sensory Approach



Toys Count in Pre-School



- Braille Math Blocks from <https://unclegoose.com/product/braille-math-blocks-2/>



Elementary School

Never too
young!!

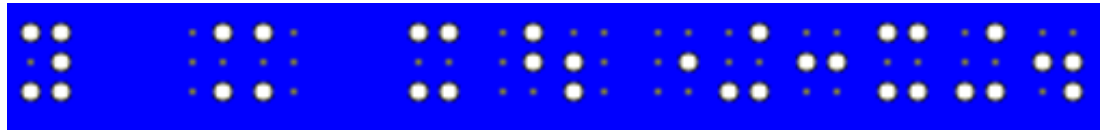


Brailled Math Materials

- High Quality Braille Textbooks & Assessments (Released Tests)

- Nemeth Code

- Tactile Graphics

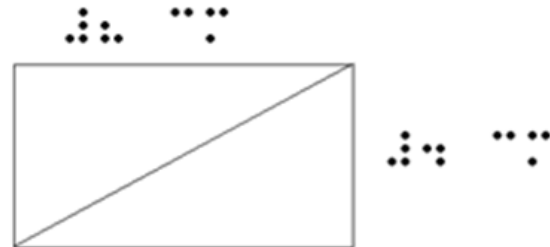


- Teacher-Made Materials

- Worksheets

- Quizzes

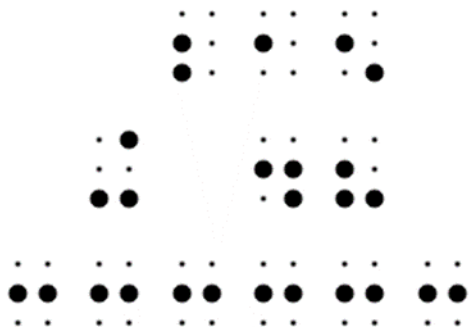
- Tests



Examples of the Nemeth Code

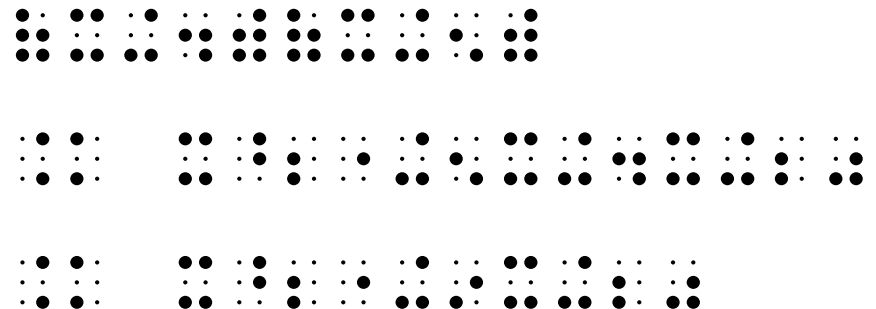
Spatial Arrangement

$$\begin{array}{r} 215 \\ + 48 \\ \hline \end{array}$$



Horizontal Arrangement

$$\begin{aligned} &(x + 4)(x + 5) \\ &= x^2 + 5x + 4x + 20 \\ &= x^2 + 9x + 20 \end{aligned}$$



Nemeth Translation Packages

- Duxbury: \geq DBT WIN 10.3

www.duxburysystems.com



- MacKichan: Scientific Notebook

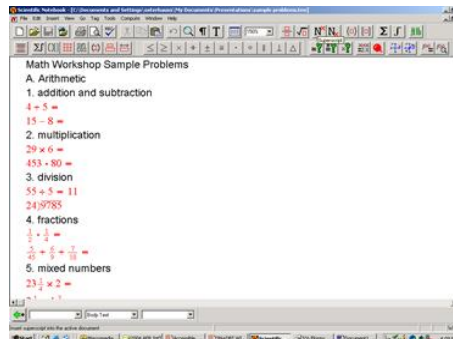
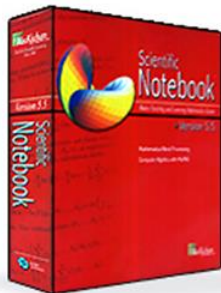
www.mackichan.com



**Design
Science**

- Design Science: MathType

www.dessci.com



Advancements in Technology

- Translation software capable of converting print math to braille math and vice versa
- Affordable refreshable braille displays



Writing Math Using Notetakers

➤ HIMS

- Braille Sense U2 (Word processor: print to Nemeth/Nemeth to print & scientific calculator)
- Braille Sense Polaris (Word processor: print to Nemeth/Nemeth to print & graphing/scientific calculators)

➤ Humanware

- BrailleNote Apex (Word processor: print to Nemeth/Nemeth to descriptive math print & scientific calculator)
- BrailleNote Touch (Word processor: print to Nemeth/Nemeth to print & graphing/scientific calculators)

Resources available from sara.larkin@iaedb.org



Resources for Learning Nemeth Code

- **Publications Available to Learn Nemeth Code**
www.tsbvi.edu/component/content/article/1523-publications-available-to-learn-nemeth-code
- **Other Ways to Learn Nemeth Code**
www.tsbvi.edu/component/content/article/1522-other-ways-to-learn-nemeth-code
- **Nemeth Code Reference Sheets**
www.tsbvi.edu/resources-math/1524-nemeth-code-reference-sheets
- **Nemeth Updates**
<http://www.brailleauthority.org/mathscience/math-science.html>



What's New with Learning Nemeth!

- *Guidance for Transcription Using the Nemeth Code within UEB Contexts*
- *Graphing Calculator Guidelines*
www.brailleauthority.org/mathscience/math-science.html
- *Nemeth at a Glance: A Math Resource, Grade Level Chart, and Evaluation Tool*
<http://www.tsbvi.edu/store/ecom/index.php?action=ecom.pdetails&mode=nemeth>



Online Nemeth

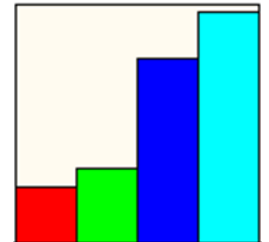
- *APH Nemeth Tutorial* <https://tech.aph.org/nemeth/>
- *Nemeth Braille Searchable Database*
<http://accessibility.pearson.com/nemethdatabase>
- *Nemeth Braille Code for Instructors and Paraeducators* (PreK/1 and Grades 2/3 available now; Grades 4/5/6, Grades 7/8, Algebra, Geometry, and Algebra II & PreCal/Calculus all coming soon) www.tsbvi.edu/courses/course-listing#nemethdescription



Math Materials

Large Print Reader

- Large Print Textbook
- Enlarged Materials
- Regular Print with Magnification
- Be Alert for Color-Keyed Graphics



Accessible Math Graphics

- Tactile Graphics
- Large Print Graphics
- Universally Designed Math Graphics for both the Student Who is Blind or Who Has Low Vision



Thoughts on Visual vs Tactual Perception

1. Visual impairment is not an isolated condition; it affects the whole process of information-gathering.
2. Vision enables a person to simultaneously perceive all parts of an object in its totality and in its relationship to other objects.
3. The learner who is visually impaired has to rely on sequential observations (only part of an object can be seen or felt at a time), and the entire image has to be "built-up" out of the components. Relationships with other objects can be lost entirely.
4. The level of cognition needed for integration of sequential information is higher than that needed for concept formation through immediate visual perception.
5. If you have vision, you can experience this way of processing information by looking at a drawing through a very small hole in a piece of card held over the drawing; I think that you will find that it's hard for you to "get the picture."



Guidelines and Standards for Tactile Graphics, 2010

from the Braille Authority of North America
(BANA) and Canadian Braille Authority (CBA)

www.brailleauthority.org/

Available for purchase from APH...

Print: 7-35935-00 Braille: 5-35935-00



Guidelines and Standards for Tactile Graphics

Supplement: Examples 1 - 35

The tactile graphics examples illustrated in this supplement have been designed to accompany the *Guidelines and Standards for Tactile Graphics 2010*. Each tactile graphic is preceded by a brief summary of the important design techniques and braille formats used in each example.

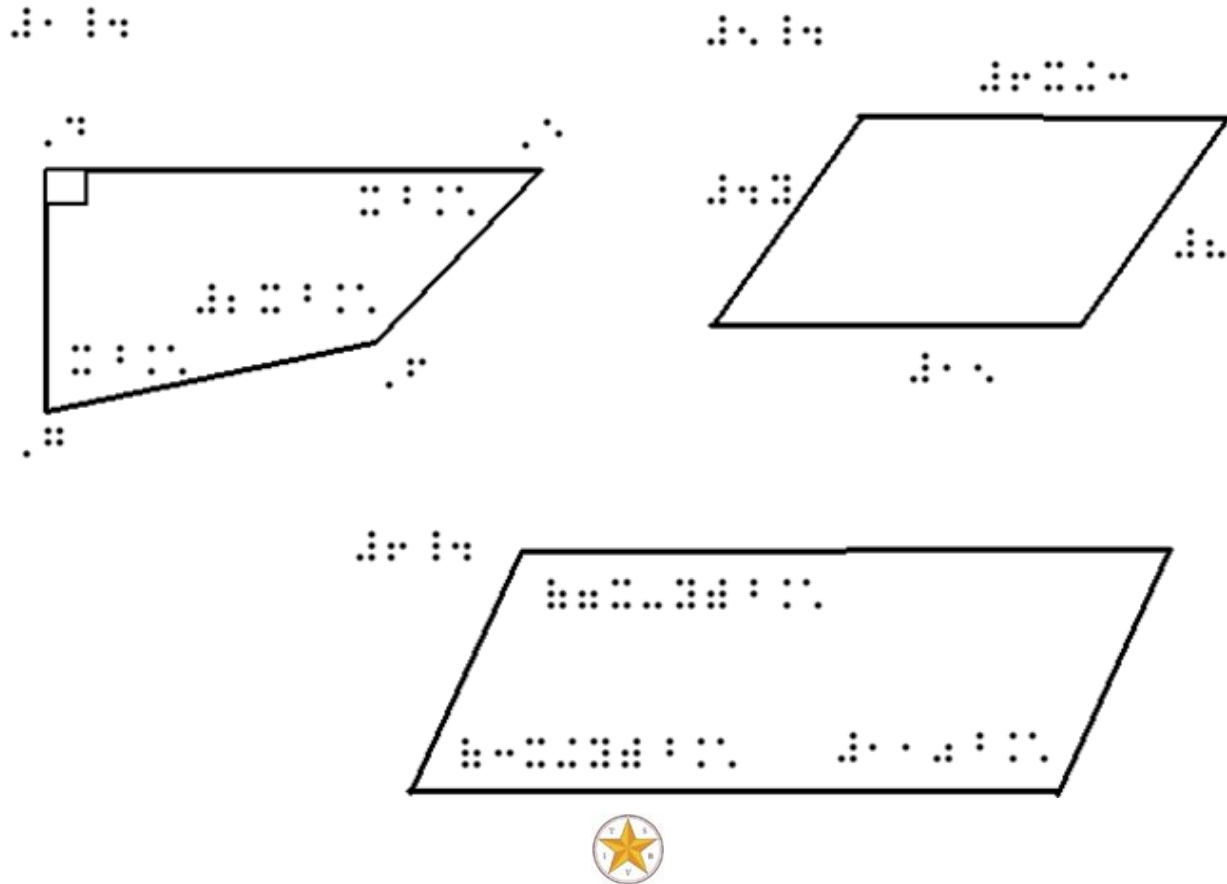
Available for purchase from APH...

Print: 7-35936-00

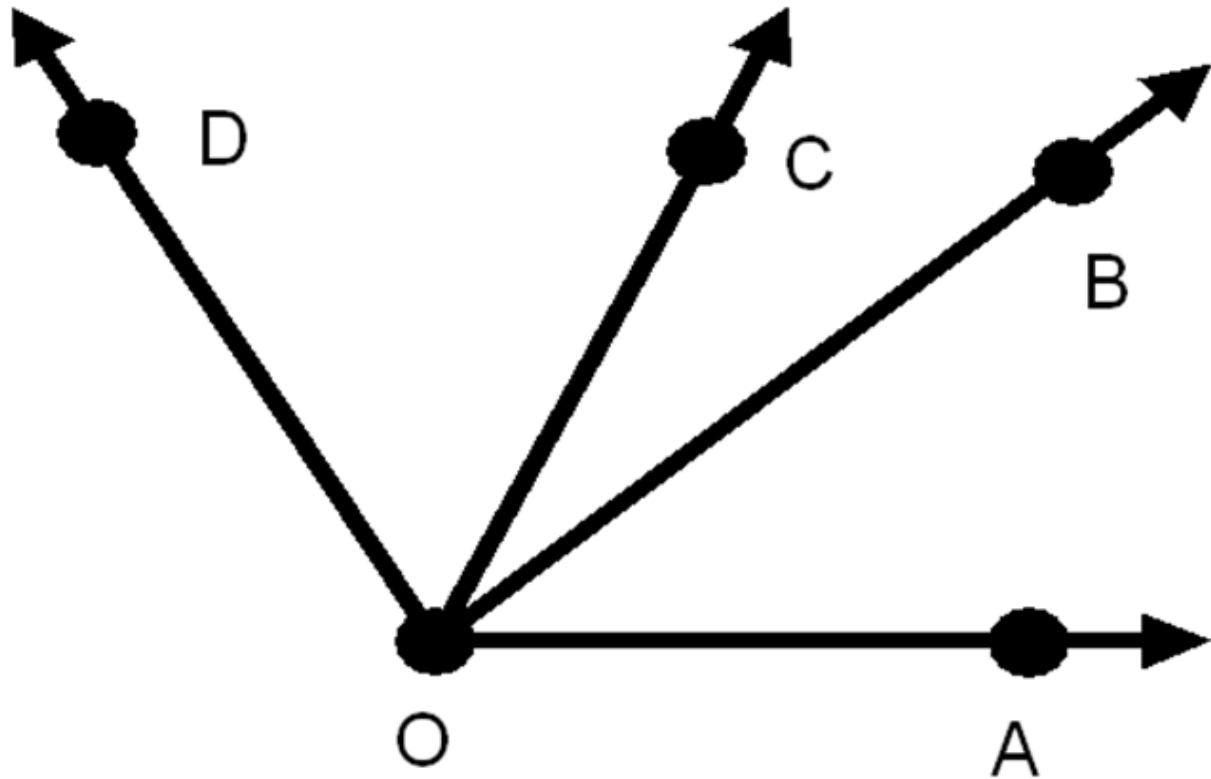
Braille: 5-35936-00



Creating Graphics Using the Microsoft Word Drawing Toolbar (Quadrilaterals)

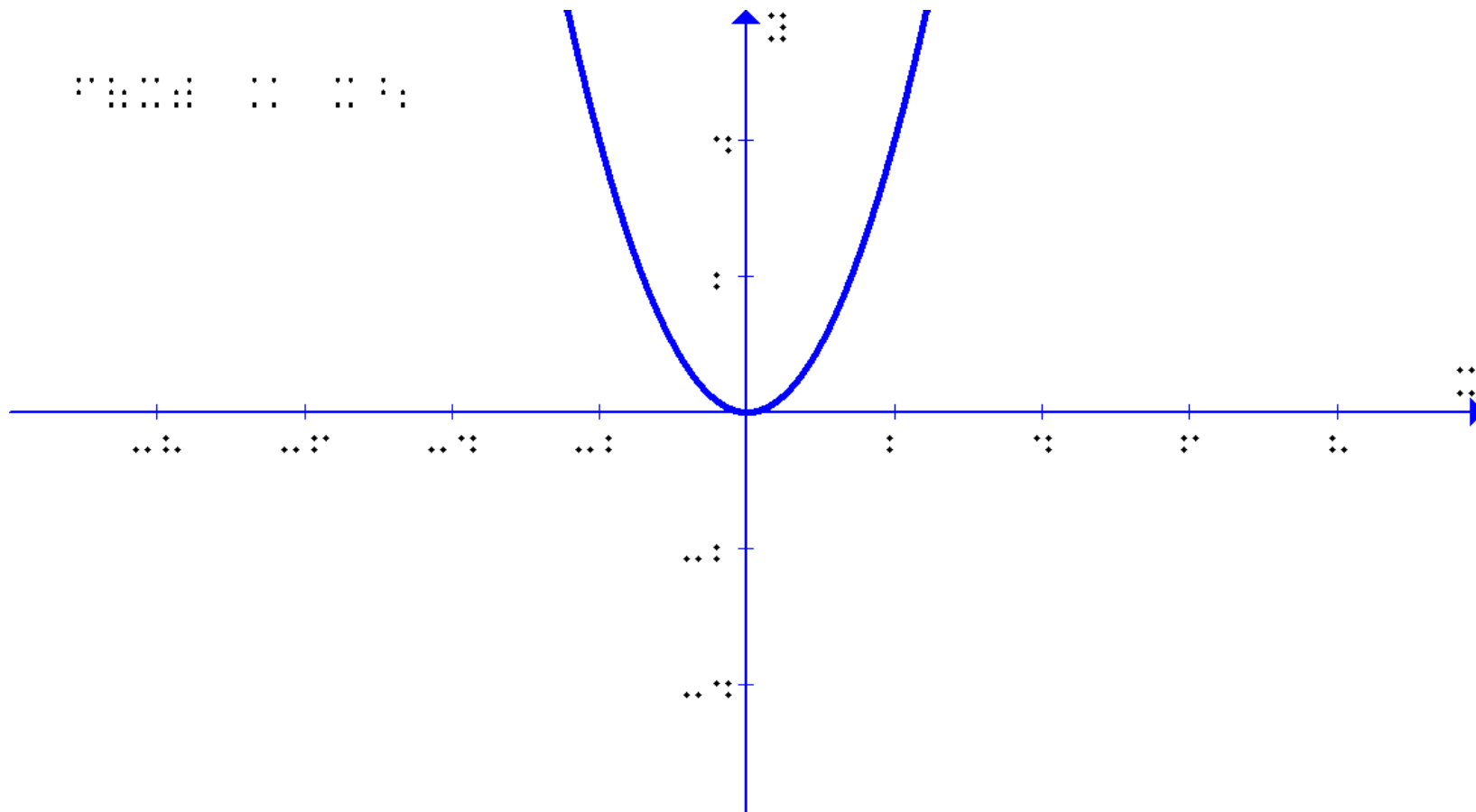


Creating Graphs Using the Microsoft Word Drawing Toolbar



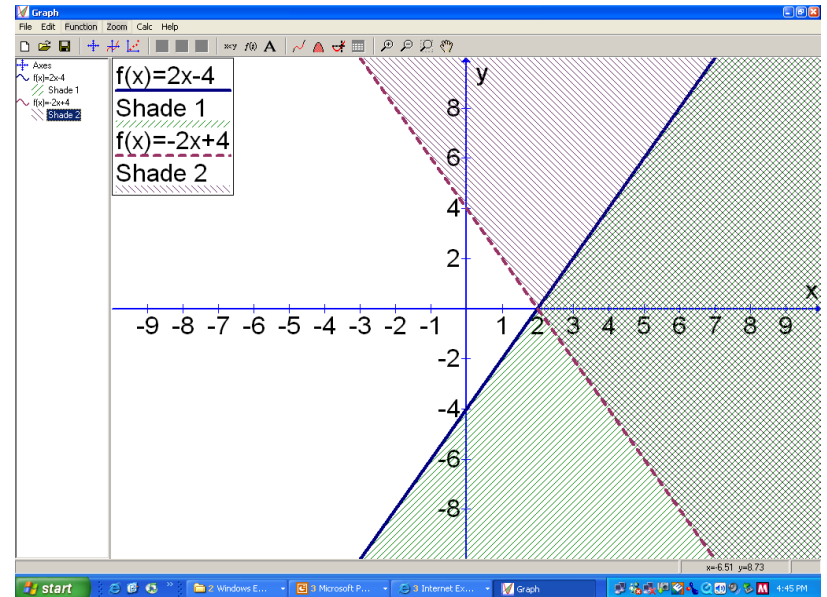
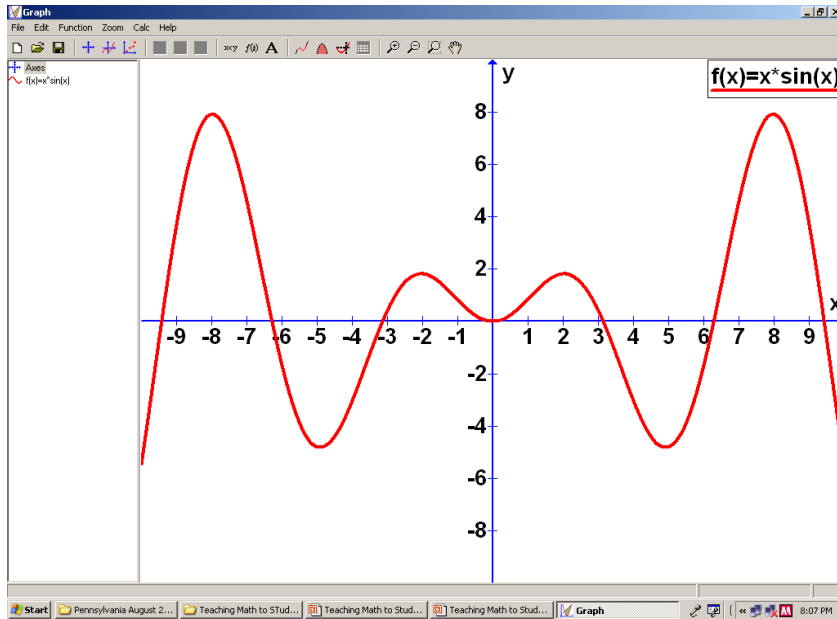
Creating Graphics Using *Graph*

www.padowan.dk



Large Print Graphs by *Graph*

www.padowan.dk

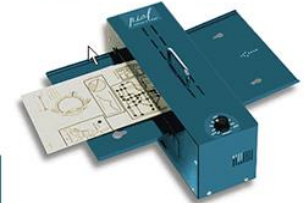


Tactile Imaging Machine and Swell Touch Paper

- Pictures in a Flash (PIAF)
www.humanware.com

PIAF - Pictures In A Flash

Tactile graphics made 1-2-3 easy!



A Simple and Fast Way to Produce Tactile Graphics

- Swell-Form Graphics Machine
www.americanthermoform.com



ViewPlus Braille Embossers are all Powered by Tiger®



www.viewplus.com



- **Braille production made flexible and easy:**
Braille is translated and embossed from MS Word in one touch and graphics are produced from any PC software including Illustrator & CorelDraw.
- **Braille and Ink:**
Prints Braille and ink on the same page in a single pass.
- **Tactile graphics embossed in fine detail:**
Tiger tactile graphics are the highest-resolution of any embosser.
- **Braille & graphics software included:**
TSS incorporates braille software, tactile graphic studio, and more. It is also compatible with Duxbury and other braille software.



Phoenix Braille and Tactile Graphics Embosser

<http://brailleur.com/phoenix.php>



- Introducing Phoenix, the World's first multi-function Braille and Tactile Graphics System.
- Imagine the ability to scan your pictures, graphs and charts into your computer and with a few clicks of the mouse, emboss those images in high definition tactile graphics without compromising the quality of your Braille text.

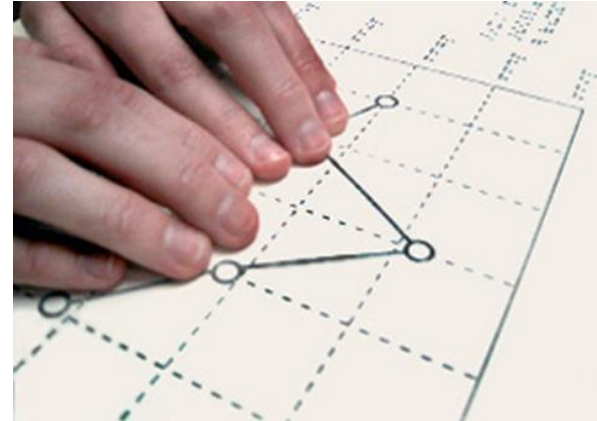


Math Graphics Made to Order by Others

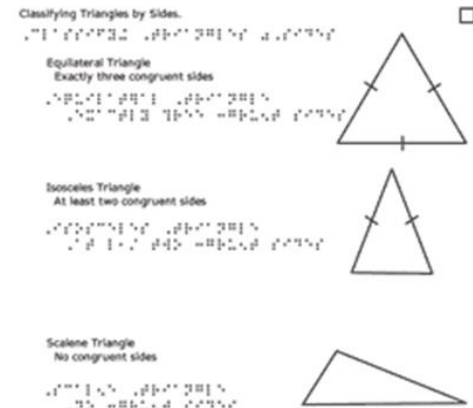
- gh, LLC

LaserLine™ Graphics

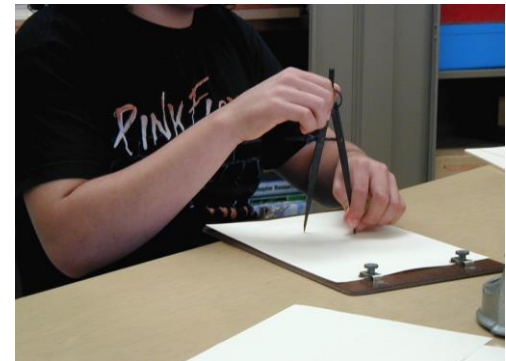
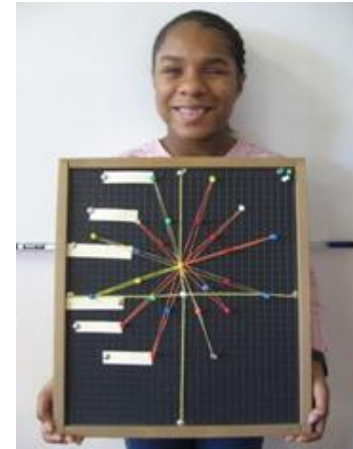
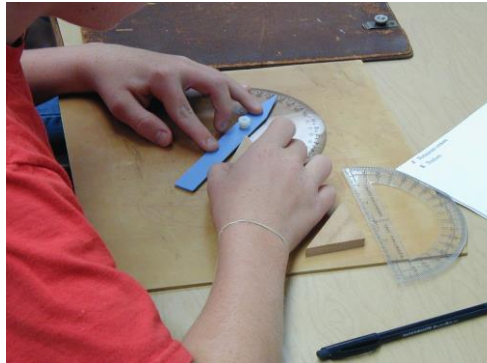
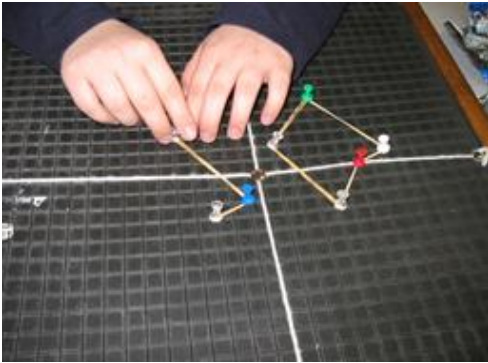
www.gh-accessibility.com



- Tactile Vision Graphics
<http://tactilevisiongraphics.com>



Accessible Math Tools and Technology



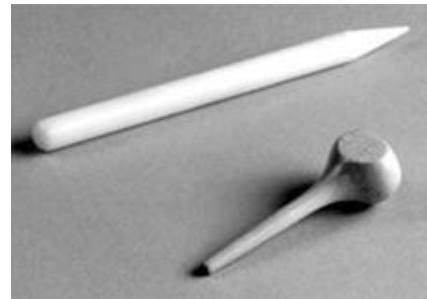
Basic Math Tools

Braille Reader

- Braillewriter
- Braille Paper



- Braille Eraser



Basic Math Tools

Large Print Reader

- Appropriate Paper
 - Bold line paper
 - Unlined paper
- Proper Writing Implement
 - Sharpie
 - 20/20
 - Flair
 - Staedtler Mars Technico Mechanical Pencil



Basic Math Technology

Braille Reader

- Refreshable Braille
 - Braille Notetaker
 - Refreshable Braille Display
- Laptop
- iPhone
- iPad



Basic Math Technology

Large Print Reader

- Laptop
- iPhone
- iPad



- Magnification Software



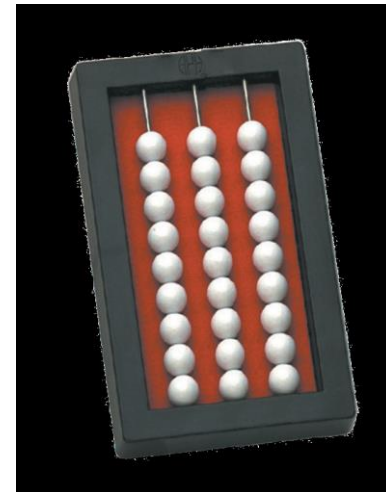
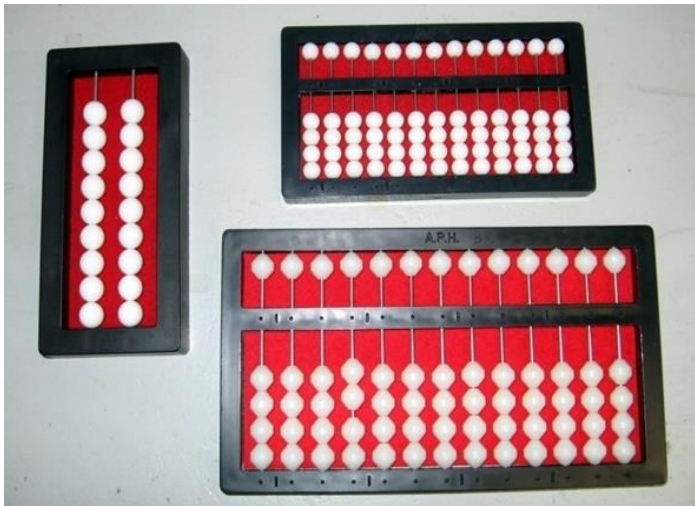
Number and Quantity



Abaci from APH www.aph.org

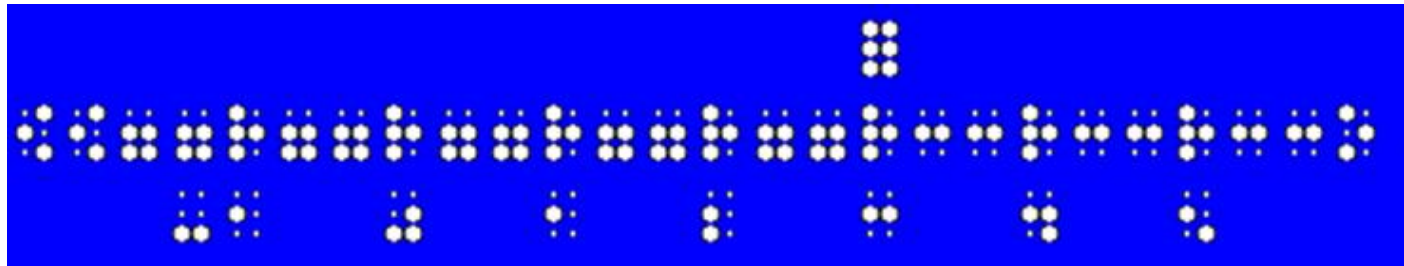
www.tsbvi.edu/videos-webinars/mathematics

- Cranmer Abacus
- Beginner's Abacus Kit
- Expanded Beginner's Abacus Kit

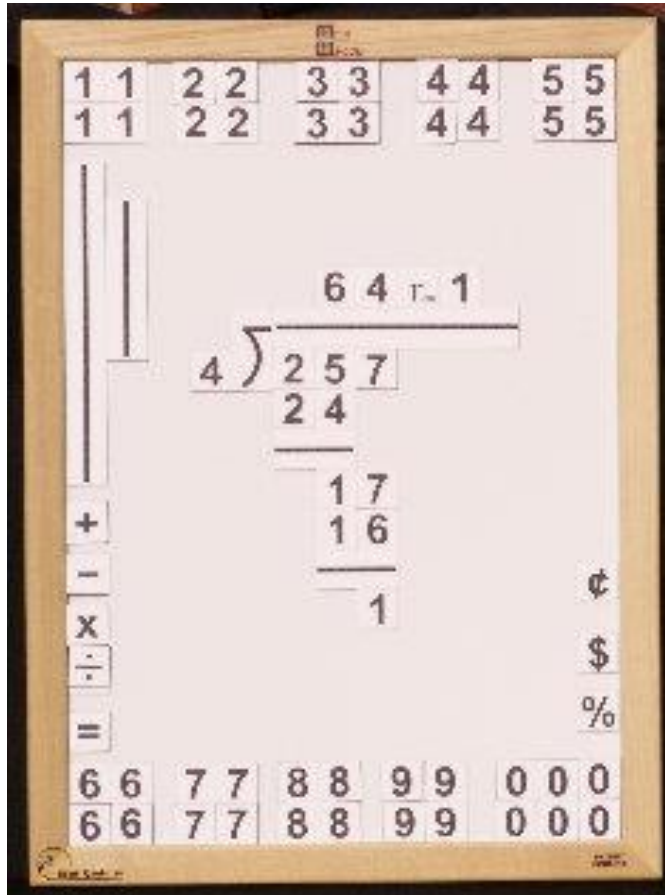


Student-Generated Graphics on a Number Line

- APH Number Line Device
- APH Consumable Number Lines
- Desktop Stick-On Number Lines
- Student-Made Number Lines



Hands-On Computation Tool



Math Window in Braille
and Large Print

www.mathwindow.com



APH Math Apps

<http://www.aph.org/products/mobile-apps/>



- Math Flash (Action for Google Home/Google Assistant) Based on APH's popular Math Flash™ software that combines math flash cards with fun audio feedback and animated characters!



- Slapstack Math (for iOS devices) Slapstack Math™ is an action and memory game that uses math flash cards instead of playing cards. The goal is to collect the most points by pulling in the most cards.

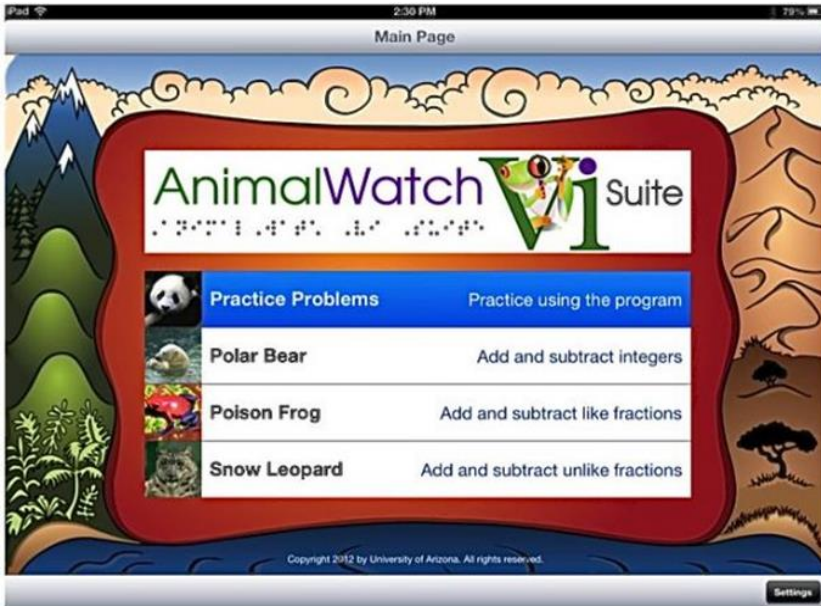


Math Robot™ from APH

<https://itunes.apple.com/app/math-robot/id704570512>

- Math Robot iOS App
 - Works with your iPad or iPad mini running iOS 7 or later!
 - Use with a refreshable braille display





- <http://awvis.arizona.edu>
- www.aph.org



AnimalWatch Vi Building Graphics Literacy

- <http://awvibgl.coe.arizona.edu/>



Home

For Teachers in Our Study

Forms and Information for
Teachers in Our 2018-2019
National Pilot Study
[More Information](#)

Be Part of Our 2018-2019 Study!

70 students with visual
impairments doing math at the
6th-7th-grade level and their TVs
are invited to be part of our 2018-
2019 team! Learn more on our FOR
TEACHERS page.

[Download the PDF Flyer](#)

Materials Available

The AnimalWatch Vi Suite app and
materials developed under our
previous IES project are available
for FREE from the American
Printing House for the Blind.
Learn more by downloading our
flyer!

[Download the Flyer](#)



Project Team



Current Research



For Teachers



News & Photos



Previous Work

Welcome to the *AnimalWatch Vi: Building Graphics Literacy* web site. Our project's aim is to support students with visual impairments in building their pre-algebra skills and ability to interpret information presented in graphics (e.g., bar graphs, scatterplots, maps). Research shows that if a student is not successful in pre-algebra he or she is less likely to succeed in higher level math. By pairing instruction in how to approach graphics with engaging content about environmental science issues, we will increase the math word problem solving skills of students with visual impairments.

Please contact Project Director L. Penny Rosenblum at rosenblu@email.arizona.edu or 520-621-1223 for more information.



Publications and Videos

- Abacus: Getting Started with the Counting Method
- Prime Factorization on the Abacus
www.tsbvi.edu/videos-webinars/mathematics
- Osterhaus, S.A. (2003). *Susan's Math Technology Corner: Standardized Braille Number Lines*. *Division on Visual Impairments Quarterly*, 48(2), 9-11
www.tsbvi.edu/resources/2316-susans-math-technology-corner-standardized-braille-number-lines

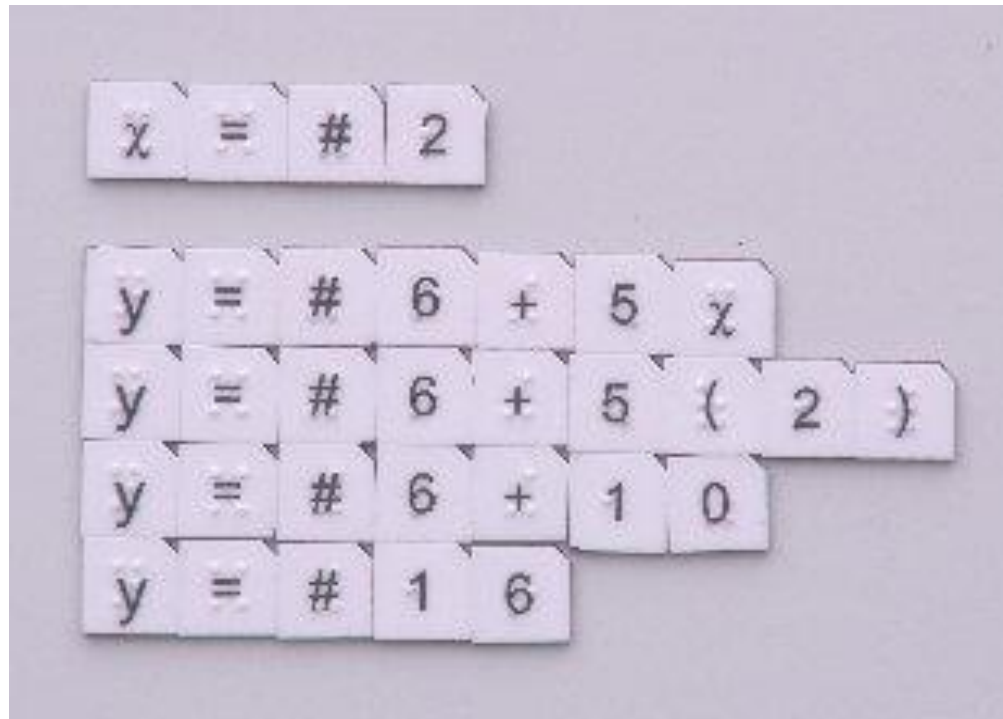


Algebra and Statistics and Probability



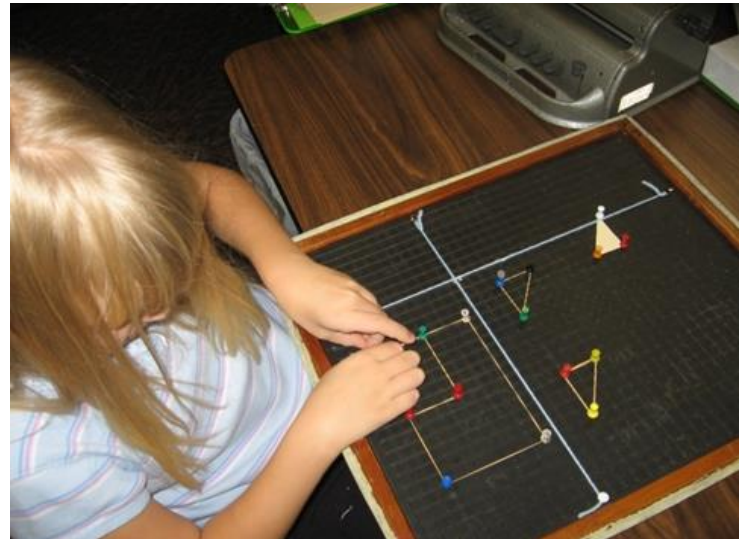
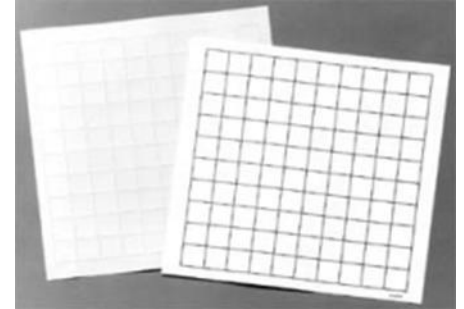
Math Window Algebra Add-On

www.mathwindow.com

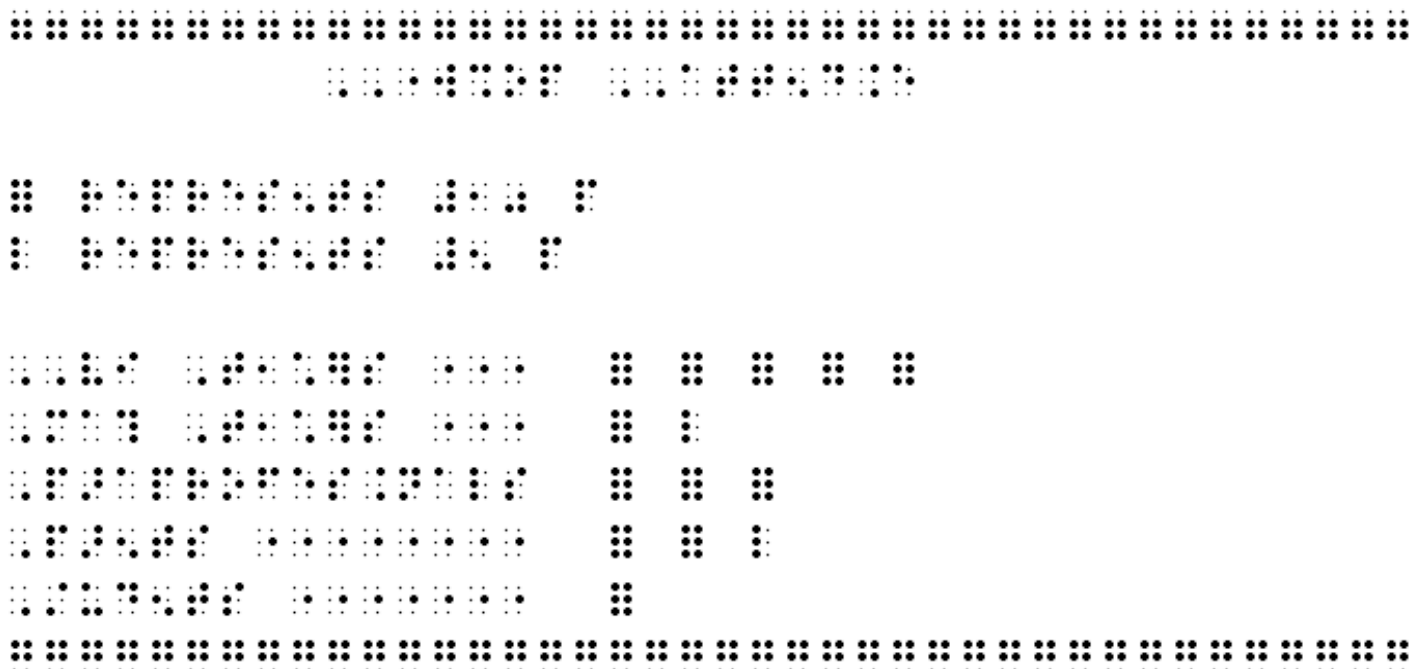


Student-Generated Graphics on a Coordinate Plane

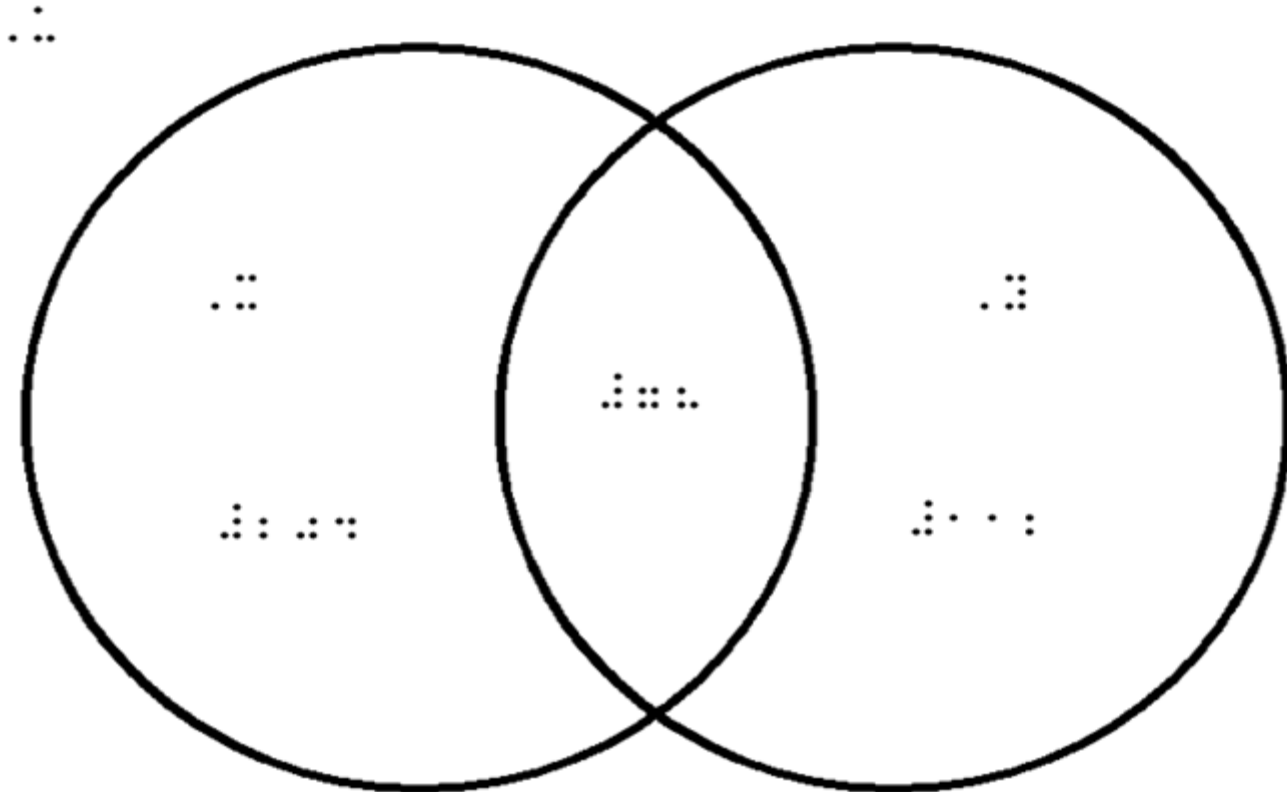
- **APH Graphic Aid for Mathematics**
- **Graph Paper**



Student- or Teacher-Generated Braillewriter Pictograph



Student- or Teacher-Generated Venn Diagram



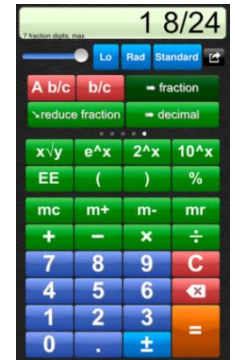
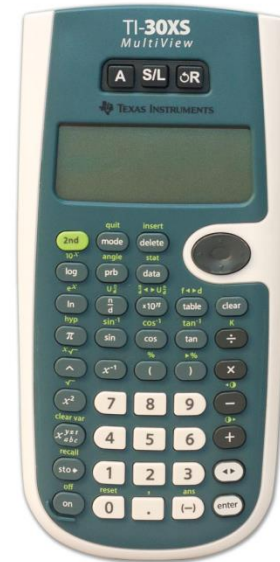
Talking Scientific Calculators

- ORION TI-30XS

www.aph.org (available on federal quota money)

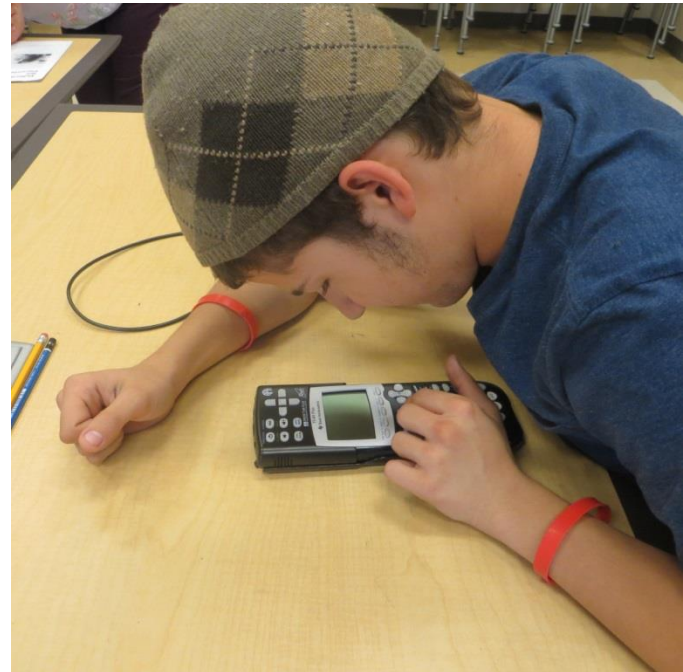
- Talking Scientific Calculator
By Adam Croser

<https://itunes.apple.com/us/app/talking-scientific-calculator/id411433609?mt=8>



ORION TI-84+ Talking Graphing Calculator

- Available from APH with federal quota money www.aph.org/



DESMOS

www.desmos.com/accessibility

Desmos | Accessibility

Secure | <https://www.desmos.com/accessibility>

What is Desmos? Desmos is the next generation of graphing calculator: in-browser, beautiful, and free! [Try it out >](#)

desmos

About Partnerships Classroom Activities We're Hiring!

Why Accessibility is Important

Supported Browsers

Configuring Your Screen Reader

Expression Entry

Typing Symbols

Table Entry

Sliders

Audio Tracing

Slider Trace

Common Actions

Mobile App

We Would Love Your Feedback

Desmos Graphing Calculator

Untitled Graph Save

desmos

Audio trace on

$y = x^2 - \frac{1}{2}$

$y = \cos(x)$

Playing audio 2:11 / 2:53

Why Accessibility is Important

Our mission at Desmos is to help every student learn math and love learning math. Our graphing calculator is used by millions of students all around the world, and we'd like to see that use expand



Desmos <https://www.desmos.com/>

- All of the information around accessibility for their calculators <https://www.desmos.com/accessibility>
- Webinar <https://youtu.be/IaTAC35b72c>
- All of their recordings on accessibility <https://learn.desmos.com/accessibility>
- Calculators
 - <https://www.desmos.com/scientific?braille>
 - <https://www.desmos.com/calculator> (*Graphing*)
 - <https://www.desmos.com/fourfunction?braille>
- Braille Demo
 - <https://www.desmos.com/braille-demo/index.html>

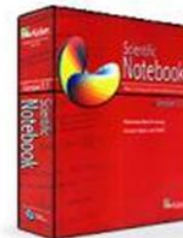
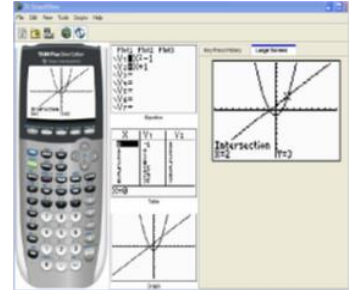


Large Display Scientific/ Graphing Calculator Solutions

- TI-Smart View 2.0
The Emulator Software
Package for the TI-84+
- TI-NSpire (or TI-NSpire
CAS+)

[https://education.ti.com/en/
us/home](https://education.ti.com/en/us/home)

- Scientific Notebook
www.mackichan.com



Large Display Graphing Calculator Solutions on a Tablet

- Desmos Graphing Calculator (available for iPad and Android)
- Free Graphing Calculator by William Jockusch (available for iPad and Android)



Publications and Videos (Algebra)

- Osterhaus, S.A. (2002). Susan's Math Technology Corner: Teaching A Blind Student How to Graph on a Coordinate Plane: No Tech, Low Tech, and High Tech Tools. *Division on Visual Impairments Quarterly*, 47(3), 23-26
www.tsbvi.edu/index.php?option=com_content&view=article&id=3619:coordinate-plane&catid=54
www.tsbvi.edu/videos-webinars/mathematics
- Solving Quadratic Equations Graphically, by Factoring, and by Using the Quadratic Formula
www.tsbvi.edu/resources-math/3237-teaching-strategies#Quadratic



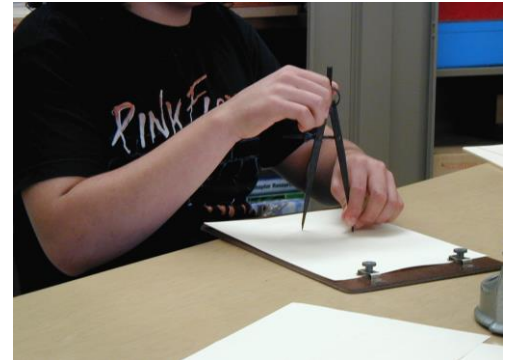
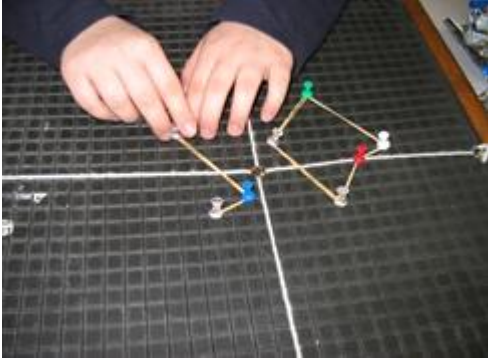
Videos

www.tsbvi.edu/videos-webinars/mathematics

- Orion TI-84 Tutorials
 - Graphing Simple Functions and Gathering Information
 - Plotting Points and the Line of Best Fit
 - Working with Matrices
- Using the Orion TI-84 Plus in the Classroom
- Multiplication of Polynomials



Geometry



MathBuilders, Unit 6: Geometry

K-3 www.aph.org



Hands-on System for Learning Three-Dimensional Geometry www.geometro.net



Geometro Sets Available from APH

www.aph.org

Mini



Medium

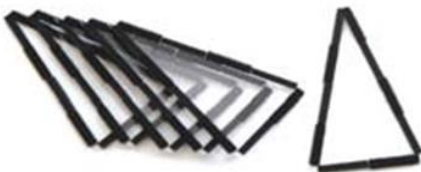
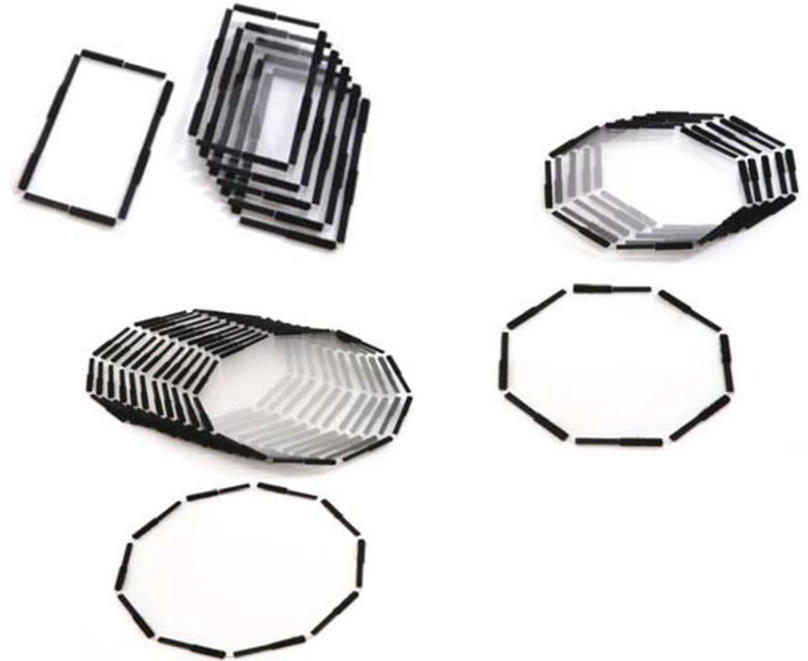


Large



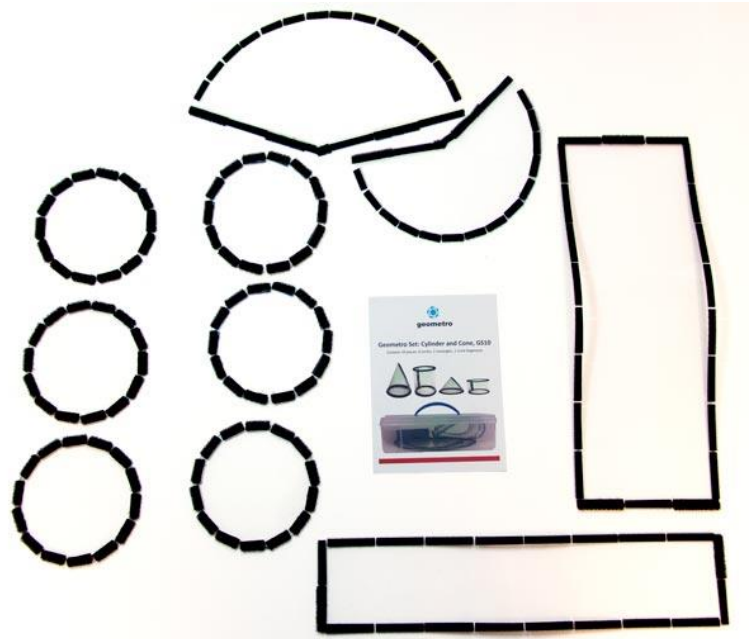
More Geometro Shapes

- Rectangles
- Octagons
- Decagons
- Isoceles Triangles
- Hook Material Rods



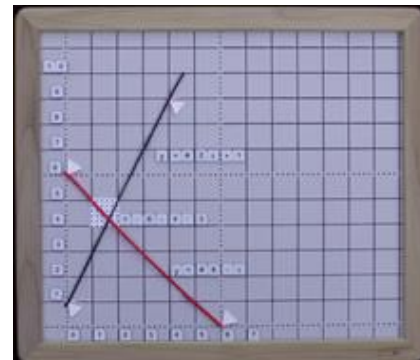
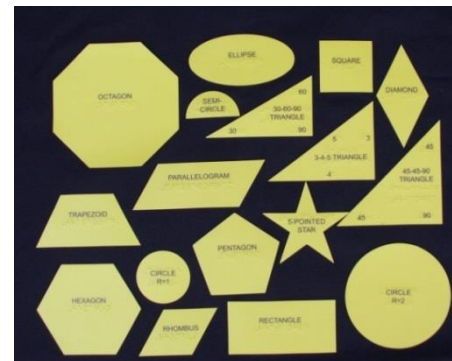
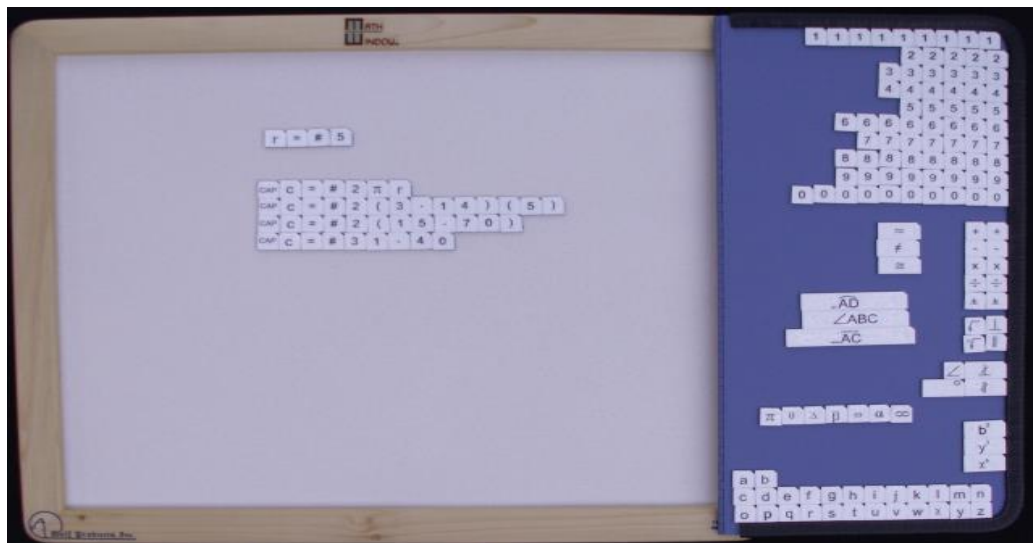
Geometro GS10 Cylinder and Cone

- Provides students with flat plastic shapes (six circles, two rectangles, and two circle sectors) that can be readily joined to form two cylinders and two cones. Each have the same base, but different heights.

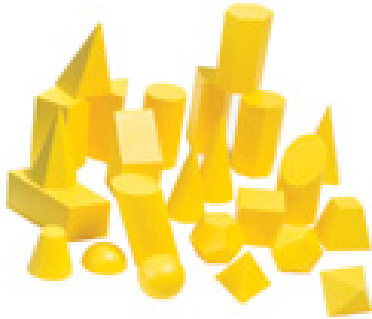


Math Window Geometry Kit

www.mathwindow.com



Geometric Manipulatives



- Didax Plastic Geometric Models 25 shapes
- Discovery Toys Playful Patterns Design
- Didax 4 Geometric Templates



Drawing/Construction Tools

- Drawing Board
- Compass

www.maxiaids.com

www.fiskars.com

www.APH.org

www.staedtler.us/en/

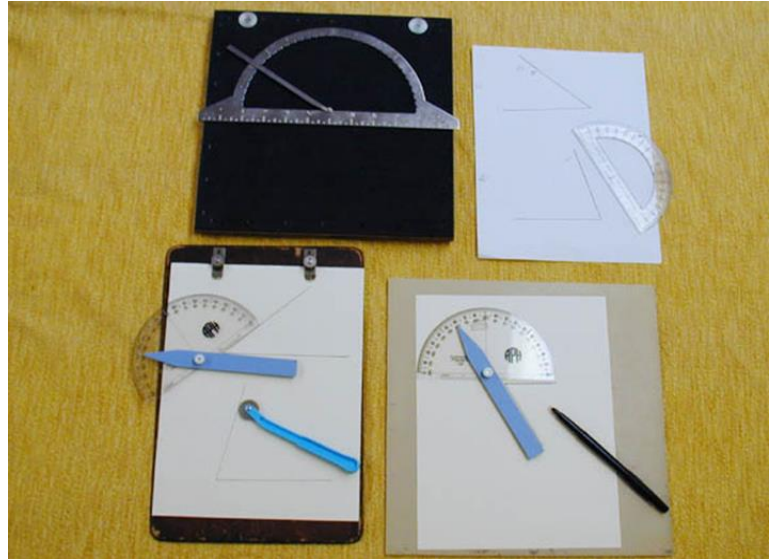
www.easytactilegraphics.com/



Drawing/Construction Tools (cont.)

- Protractor
- Straightedge
- Tracing Wheel
- Stylus and/or Pen
- Drawing Board

www.APH.org/



Students at Work Drawing



Publications and Videos (Geometry)

- Geometric Constructions
www.tsbvi.edu/resources-math/3237-teaching-strategies#Geometric
www.tsbvi.edu/videos-webinars/mathematics
- Transformations, Line Symmetry, and Tessellations
www.tsbvi.edu/resources-math/3237-teaching-strategies#Transformations
- APH Braille/Print Protractor
www.tsbvi.edu/videos-webinars/mathematics



New Geometry Videos

www.tsbvi.edu/videos-webinars/mathematics

Videos for regular education math teachers that demonstrates teaching parallel lines, perpendicular lines, and skew lines to a student who is blind or visually impaired; strategies, tools, and materials.

- Parallel Lines
- Perpendicular Lines
- Skew Lines



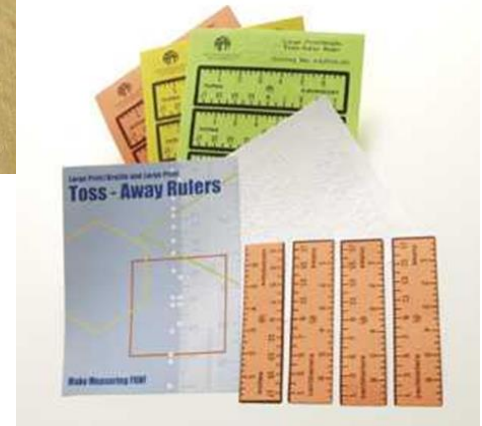
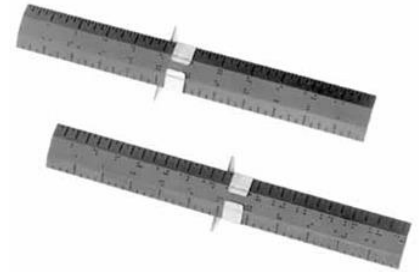
Measurement



Linear and Angle Measurement

www.tsbvi.edu/tools/2181-math-tools#equipment

- Ruler
- Yardstick and Meter Stick
- Toss-Away Rulers
- Protractor

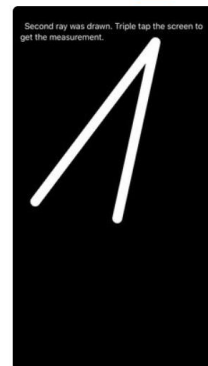


Draw2Measure Protractor App

<http://www.aph.org/products/mobile-apps/>

- Draw2Measure Protractor App for iOS® devices allows blind and visually impaired students to measure angles in two ways!

First, students can place an angle over the screen of a device, such as a phone or tablet, and trace along the sides of the angle with a fingertip or stylus. The app records the locations of the sides and then calculates the angle.



Tactile Caliper – 1/16 inch precision

www.squirreldevices.com

www.youtube.com/watch?v=JOi8zTI9TwY

- The caliper is accurate to 1/16". There are subtle audible cues when it is operating. The caliper is 12 inches long, the size of a standard ruler. The caliper's design allows for small objects to be inserted into the caliper's opening. This eliminates some common problems for students including holding the ruler steady and lining up the ruler to begin measuring.



The caliper is available from the online store at National Braille Press.

www.nbp.org/ic/nbp/CALIPER.html



Tactile Caliper – 1 mm Precision

- This metric caliper is brand new and currently being field tested by APH.
- Should be available soon, along with the English measurement tactile caliper, from APH on federal quota funds.



Temperature



Tactile Demonstration
Thermometer

www.aph.org



Talking Lab Quest

<http://www.independencescience.com>



Students at Work Measuring



Measurement Resources

- Linear Measure, Perimeter, Area
www.tsbvi.edu/resources-math/3237-teaching-strategies#Linear
- APH Braille/Print Protractor
www.tsbvi.edu/videos-webinars/mathematics
- Perkins School for the Blind
www.perkinselearning.org/accessible-science
- Independence Science
www.independencescience.com



What's New in Research Regarding Accessible Mathematics?



Math Speech and Braille Display

- Math Player + MathType + NVDA

www.dessci.com/en/reference/ies-ets/instructional_material/default.htm#navigation_guide

- JAWS

www.freedomscientific.com/JAWSHQ/JAWSHeadquarters01

www.freedomscientific.com/content/html/jawshq/MathML-Samples.html

http://podcast.freedomscientific.com/FSCast/episodes/FSCast128-Conference_Specials,MathML,Mike_Wood.mp3



Accessible Equation Editor

<http://accessibility.pearson.com/mathex-app/>

The screenshot displays the Accessible Equation Editor interface. At the top is a toolbar with icons for basic arithmetic (+, -, ×, ÷), fractions, powers (y^x), square roots ($\sqrt{\quad}$), equals (=), approximate (≈), undo, redo, delete, and a clear button. Below the toolbar is a large equation input field containing the equation $x^2 + y^2 = 4$. To the right of the input field is a vertical menu with categories: Numbers, Constants, Symbols, Arithmetic, Fractions, Groups, Relations, Radicals, Scripts, Functions, Trigonometry, Hyperbolic, and Omissions. At the bottom of the interface is a Braille display showing the Braille representation of the equation $x^2 + y^2 = 4$.



DESMOS

<https://www.desmos.com/accessibility>

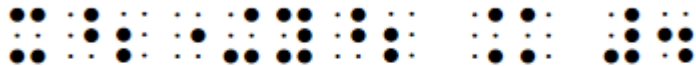
<https://www.desmos.com/braille-demo/index.html>

<https://www.desmos.com/scientific?braille>

Braille

Nemeth

UEB



Formatted Math

$$x^2 + y^2 = 4$$

The screenshot shows the Desmos Scientific Calculator interface. At the top right, there is a settings gear icon. Below it, a settings panel is open, showing the following options:

- Projector Mode: A button.
- Braille Mode: A section with three buttons: Off, Nemeth (selected), and UEB.
- Reverse Contrast: A checkbox that is currently unchecked.

Below the settings panel, the calculator display shows the equation $x^2 + y^2 = 4$ in Braille. To the right of the display, there is a yellow warning triangle icon and the text "This calculator does not support this type of equation...".

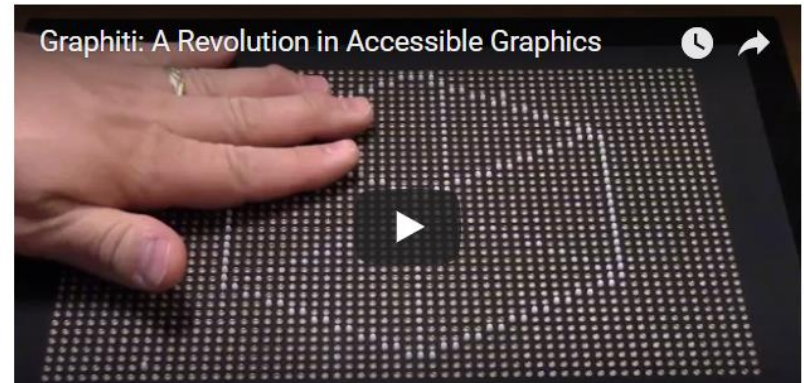
At the bottom of the calculator, there is a row of buttons: "main", "abc", "func", "DEG" (with a dropdown arrow), a left arrow, a right arrow, and "clear all".

Below the buttons, a large grey box contains the text "Braille Mode Is On!" and "Try hooking up a Refreshable Braille display, or just type with a keyboard."



Graphiti www.aph.org

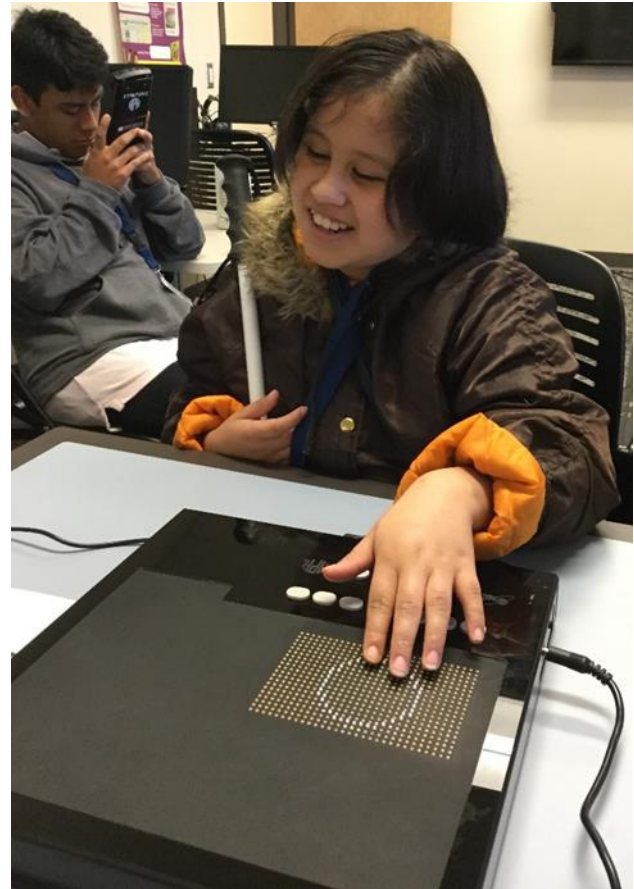
- **Graphiti is a dynamic multilevel tactile touch display** developed by [Orbit Research](http://OrbitResearch.com) and the American Printing House for the Blind. Graphiti allows students and adults to access a wide variety of on-screen graphics by touch.



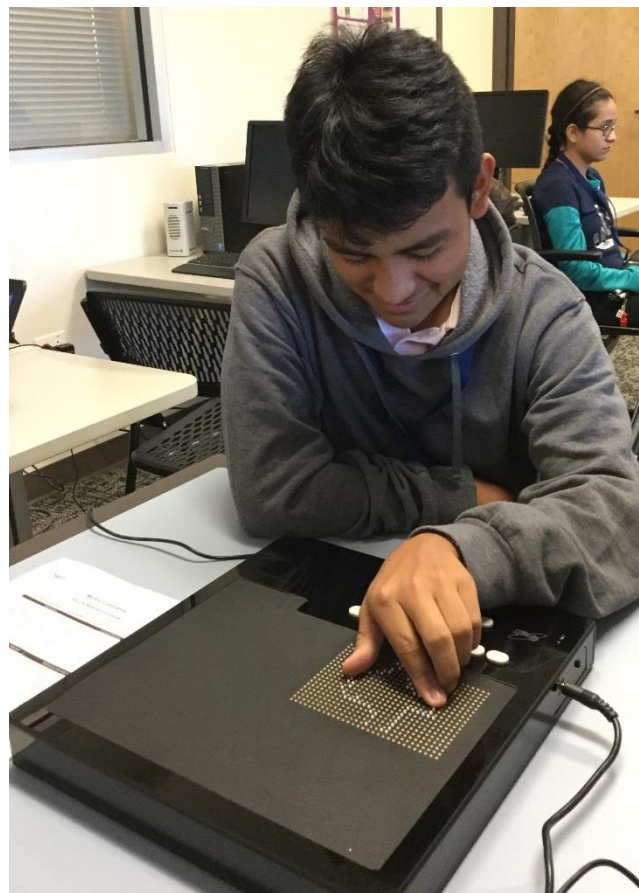
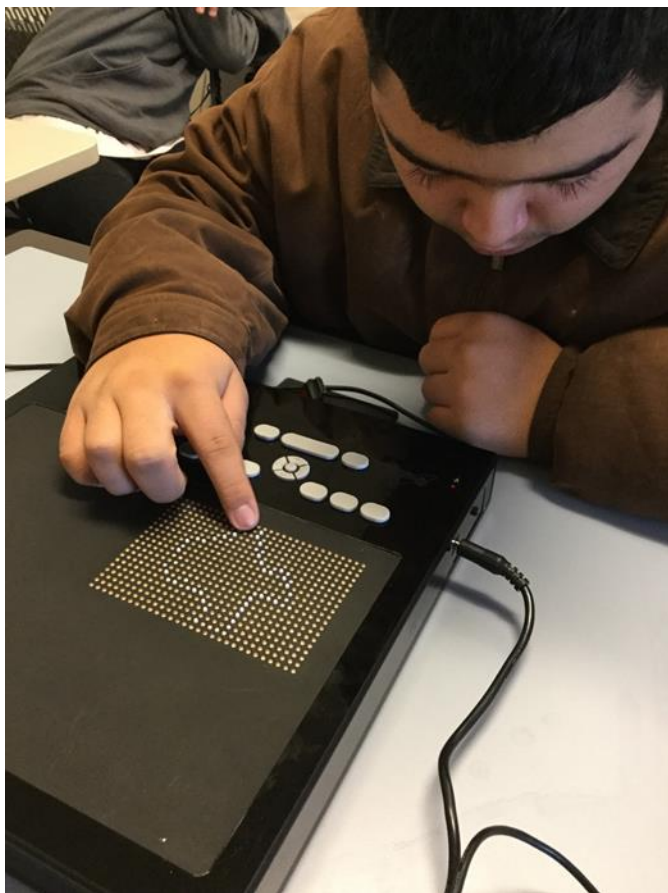
Graphiti – Short Term Programs' Math Tools Class - Guess the Shape



Graphiti – Triangle and Circle



Graphiti – Is that Texas?



Graphiti with the Orion TI-84+ Talking Graphing Calculator



Up and Coming Technology

- Drawing with the Graphiti™
- Bristol Braille Canute: Multi-line refreshable braille



Other Math Resources

- Delta www.delta-education.com
- Didax www.didax.com
- ETA Hand2Mind www.hand2mind.com
- Math Forum www.mathforum.org
- Nasco www.enasco.com/math
- Online Math Tutorial Videos
www.tsbvi.edu/videos-webinars/mathematics



Texas School for the Blind & Visually Impaired

- Thank you for your kind attention.
- Now, it's time for questions...

