

# The Centroid

*The Journal of the North Carolina Council of Teachers of Mathematics*

## **In this issue:**

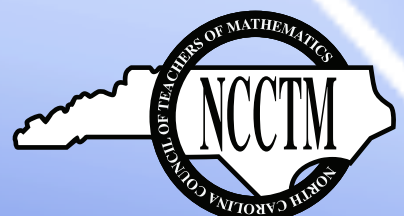
***NCCTM's State Math Conference has Gone Virtual!***

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***Santa to the Rescue: Exploring the Use of Slope and the Pythagorean Theorem***

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**Volume 46, Issue 1 • Fall 2020**

**The Centroid** is the official journal of the North Carolina Council of Teachers of Mathematics (NCCTM). Its aim is to provide information and ideas for teachers of mathematics—pre-kindergarten through college levels. *The Centroid* is published each year with issues in Fall and Spring.

Subscribe by joining NCCTM. For more information go to <http://www.ncctm.org>.

#### Submission of News and Announcements

We invite the submission of news and announcements of interest to school mathematics teachers or mathematics teacher educators. For inclusion in the Fall issue, submit by August 1. For inclusion in the Spring issue, submit by January 1.

#### Submission of Manuscripts

We invite submission of articles useful to school mathematics teachers or mathematics teacher educators. In particular, K-12 teachers are encouraged to submit articles describing teaching mathematical content in innovative ways. Articles may be submitted at any time; date of publication will depend on the length of time needed for peer review.

General articles and teacher activities are welcome, as are the following special categories of articles:

- *A Teacher's Story,*
- *History Corner,*
- *Teaching with Technology,*
- *It's Elementary!*
- *Math in the Middle,* and
- *Algebra for Everyone.*

#### Guidelines for Authors

Articles that have not been published before and are not under review elsewhere may be submitted at any time to Dr. Debbie Crocker, [CrockerDA@appstate.edu](mailto:CrockerDA@appstate.edu). Persons who do not have access to email for submission should contact Dr. Crocker for further instructions at the Department of Mathematics at Appalachian State, 828-262-3050.

Submit one electronic copy via e-mail attachment in *Microsoft Word* or rich text file format. To allow for blind review, the author's name and contact information should appear *only* on a separate title page.

#### Formatting Requirements

- Manuscripts should be double-spaced with one-inch margins and should not exceed 10 pages.
- Tables, figures, and other pictures should be included in the document in line with the text (not as floating objects).
- Photos are acceptable and should be minimum 300 dpi tiff, png, or jpg files emailed to the editor. Proof of the photographer's permission is required. For photos of students, parent or guardian permission is required.
- Manuscripts should follow APA style guidelines from the most recent edition of the *Publication Manual of the American Psychological Association*.
- All sources should be cited and references should be listed in alphabetical order in a section entitled "References" at the end of the article following APA style. Examples:

##### Books and reports:

Bruner, J. S. (1977). *The process of education* (2nd ed.). Cambridge, MA: Harvard University Press.  
National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics*. Reston, VA: Author.

##### Journal articles:

Perry, B. K. (2000). Patterns for giving change and using mental mathematics. *Teaching Children Mathematics*, 7, 196–199.

##### Chapters or sections of books:

Ron, P. (1998). My family taught me this way. In L. J. Morrow & M. J. Kenney (Eds.), *The teaching and learning of algorithms in school mathematics: 1998 yearbook* (pp. 115–119). Reston, VA: National Council of Teachers of Mathematics.

##### Websites:

North Carolina Department of Public Instruction. (1999). *North Carolina standard course of study: Mathematics, grade 3*. Retrieved from [http://www.ncpublicschools.org/curriculum/mathematics/grade\\_3.html](http://www.ncpublicschools.org/curriculum/mathematics/grade_3.html)

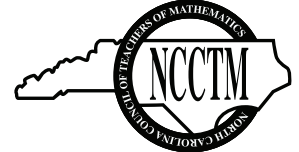
# The Centroid

The Journal of the North Carolina Council of Teachers of Mathematics

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Volume 46, Issue 1 – Fall 2020

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**Celebrate 50 Years of NCCTM  
And 100 Years of NCTM!  
Virtual Annual Conferences!**

### NCCTM

We were pleased to be able to offer some great sessions on August 4 and 5! See page 3 for more information on the virtual conference!

### NCTM

The NCTM Centennial Meeting and Exposition Has gone virtual as well: November 11, 12, 13, and 14. For more information, check out:

<https://www.nctm.org/virtual2020/>

# President's Message

State President Kathy Jaqua  
Western Carolina University, Cullowhee, NC  
kjaqua@email.wcu.edu

## *The Single Most Important Math Skill...*

Every time I'm standing in line at the grocery checkout, I see a magazine advertising an article based on a version of "If you could ask (fill in the blank here with some historical or religious name) just one question, what would it be?" I think about that question for a few minutes, and then the line moves, and I go on with the rest of my day. I rarely think about that question again. I do, however, have one of those questions of my own that is not about a person and that I think about regularly. My question is "If you could teach every child one math skill, what would it be?"

I've posed this question to groups of teachers, to groups of students, and to individuals. I get lots of different answers. Some people choose a specific skill such as knowing the multiplication tables; others choose a general answer such as solving algebraic equations. I answer that question with a math skill that may not sound like a skill at all. I want to teach every child the **skill of asking why**.

We teach children many different math skills every day, and generally **we ask them why** many times a day. I do believe that it is important for students to be able to do particular tasks in math and to understand why the techniques that they use work; so those tasks and questions are critical. But the skill that I want to teach children is the **skill of asking why themselves**. It is no coincidence that one of the first questions that young children ask is why. "Why is the sky blue? Why do puppies bark? Why is rain wet?" The wonder of the world is new to them, and they want to know everything. They see, touch, hear, smell and taste everything that they can, and then they want to know why. Imagine a classroom where children do those same things with mathematical ideas.

The skill of asking why is the heart of mathematics. What connects the ideas of whole number arithmetic to algebraic manipulations to calculus is the underlying question of why math works. Understanding why means that students don't have to relearn a particular concept each time they encounter a new content area. A student asking why leads to a depth of knowledge that moves with them from one content area to the next.

How do we help students develop the skill of asking why for themselves? The NC Standards for Mathematical Practice are certainly a beginning, as each of the Practices encourages children to approach mathematics from a thinking point of view. Developing students' skill of asking why, however, requires more. 1) Skills have to be modeled authentically. That means as teachers we have to ask ourselves why in ways that children can observe. These questions must be true questions rather than a rhetorical device. 2) Skills have to be practiced. That means that as teachers we must plan activities that push students to ask why.

Both of these tasks are challenging, and that is when we need to rely on each other. Participating in professional development opportunities such as those sponsored by the North Carolina Center for the Advancement of Teaching, working in PLCs in your school or district, attending conferences where teachers talk about what works in their own classrooms such as the Annual NCCTM conference are all ways to enhance our abilities to teach children to ask why. I offer another suggestion. Examine the content itself. Whatever level of mathematics that you teach, you can always learn something new about mathematical content. By looking at mathematics itself, you can find something that makes you ask why—something that strikes that chord of wonder that the young child has for everything. If you want a group to do math with, look around your area for a Math Teachers Circle. You can find a group of teachers from kindergarten through university who get together regularly to do math that they don't necessarily teach and just to practice asking why for themselves.

The next time you are in the checkout line, ignore the magazines, and ask yourself why about some mathematical idea. It won't cost as much as any of the magazines on display, and you can share your wonder with your students, encouraging them to ask their own questions. You will be teaching them the single most important math skill: asking why for yourself.

# NCCTM's State Math Conference Goes Virtual!



To ensure that our members stay safe, we have moved the state conference online. Our first sessions were very successful.

eLearning Session Presenters	
k-5	<b>Dawne Coker:</b> math facilitator in Cumberland County and an adjunct distance education instructor for East Carolina University
6-8	<b>Janna Sells:</b> Vice President of i-LEADR, INC.
9-12	<b>Juliette Kuhn:</b> Digital Learning Coordinator for Wake County Public School System <b>Allison McCulloch:</b> Associate Professor in the Department of Mathematics and Statistics at UNC Charlotte
Equity Session Presenters	
k-5	<b>Deborah Peart:</b> Illustrative Mathematics Elementary Math Curriculum project and the founder of My Mathematical Mind L.L.C.
6-8	<b>Jonee Wilson:</b> Assistant professor of mathematics education in the Dept of Teacher Education and Learning Sciences at NC State <b>Valerie Faulkner:</b> Associate Teaching Professor in the Teacher Education and Learning Sciences department at NC State
9-12	<b>Ebony Jason:</b> Teacher and Instructional Coach in Winston-Salem/Forsyth County Schools <b>Matthew Owens:</b> A high school math teacher and Master Teacher for New York City's Dept of Ed AP for All Program in Brooklyn, NY

Here are a few of the comments from participants:

- Loved it. Learned a lot about virtual learning and things that I could use in my classroom. I wanted to see how other teachers set up expectations as well as other tools that I could use, and I got that from this video.
- Another great session! It was good to hear how someone can implement Number Talks with online instruction. Also hearing ideas/ resources from peers from different parts of the state was helpful as well.
- I enjoyed the opportunity to listen, converse and troubleshoot ideas with other math educators.
- I love how we are able to share so many resources and classroom management suggestions with each other! I have many ideas that I'm able to take with me going into this school year.

Watch the website for upcoming sessions!

<https://www.ncctm.org/conferences/state-mathematics-conference/>

## Thank You to Our Virtual Conference Sponsors!



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# **NCTM Statement on Equitable Access to Quality Mathematics Instruction**

As we mourn the unjust deaths of George Floyd, Breonna Taylor, and Ahmaud Arbery, the North Carolina Council of Teachers of Mathematics renews its commitment to promoting equitable access to quality mathematics instruction for the children of North Carolina. Students need to experience mathematics in ways that allow them to be successful and that give them the power to change the world. This experience needs to be delivered with both excellence and equality while resonating with the lives of Black, Latinx, Indigenous, Asian, and all marginalized peoples. Racism cannot be tolerated, and we as teachers must be vigilant that we do not tolerate nor contribute to racism, bias, hate, or violence in our classrooms.

Although these beliefs are the foundation of the work of the organization, we also acknowledge that severe gaps in equity exist and that we must continue to strive to close these gaps. Acknowledgement of equity issues in content and access to quality mathematics education is an important first step, but real change will only occur with actions designed to bring about improvement. We cannot change the past, but we can and do change the future as we educate children. We can step forward to be part of a positive change to eliminate racism and bias as a part of everyday life for anyone.

As an organization of educators, the North Carolina Council of Teachers of Mathematics will contribute to that change by providing pertinent professional development that helps us grow as teachers in our knowledge and skills for creating classrooms where every child can learn in a safe environment free from racism, bias, and oppression. We commit to increasing diversity in our leadership, in our speakers, and in our work on behalf of the mathematics teachers and students of North Carolina. We will work to support the teachers of North Carolina in creating a mathematics environment where all students feel safe, valued as learners, and capable as mathematicians.

## **NCTM Statement on Equity**

Creating, supporting, and sustaining a culture of access and equity require being responsive to students' backgrounds, experiences, cultural perspectives, traditions, and knowledge when designing and implementing a mathematics program and assessing its effectiveness. Acknowledging and addressing factors that contribute to differential outcomes among groups of students are critical to ensuring that all students routinely have opportunities to experience high-quality mathematics instruction, learn challenging mathematics content, and receive the support necessary to be successful. Addressing equity and access includes both ensuring that all students attain mathematics proficiency and increasing the numbers of students from all racial, ethnic, linguistic, gender, and socioeconomic groups who attain the highest levels of mathematics achievement.

## **NCTM's 100 Days of Professional Learning**

Check out NCTM's Webinars! A few examples:

September 14: Building Students Mathematical Competence

September 16: What's the Point of Points? Rethinking the Assessment of Student Mathematics Work

September 22: Celebrating 100 Years of Big Beautiful Problems

For more information: <https://www.nctm.org/online-learning/Webinars/list?status=live>

# Santa to the Rescue: Exploring the Use of Slope and the Pythagorean Theorem

Ann Wheeler, Texas Woman's University, Denton, TX , &  
Diana De Santiago, Gainesville Junior High School, Gainesville, TX

Incorporating holiday-related themes into mathematics lessons can be an entertaining approach to enliven mathematical topics for students. We felt that utilizing the idea of Santa's reindeer being missing might be a fun way to introduce a Christmas-themed lesson pertaining to two mathematics standards from the Common Core:

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*The authors present holiday-themed activity that can be used to address 8<sup>th</sup> grade standards related to linear functions, slope, and the Pythagorean Theorem.*

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- 8.F.B.4: *Construct a function to model a linear relationship between two quantities. Determine the rate of change and initial value of the function from a description of a relationship or from two  $(x, y)$  values, including reading these from a table or from a graph. Interpret the rate of change and initial value of a linear function in terms of the situation it models, and in terms of its graph or a table of values; and*
- 8.G.B.7: *Apply the Pythagorean Theorem to determine unknown side lengths in right triangles in real-world and mathematical problems in two and three dimensions.* This activity also incorporates a problem-based challenge that should be a theme in any good mathematical task. (National Governors Association Center for Best Practices and the Council of Chief State School Officers, 2010).

This article describes an activity designed to meet these two objectives. We used the activity with 30 preservice teachers (PSTs) enrolled in a middle school mathematics methods and content course, who worked in groups of up to four. The first task required the PSTs to create linear functions. For the second task, the PSTs tested their knowledge of using the Pythagorean Theorem. A full-sized version of the provided worksheet follows this article.

## **Problem #1: Oh, no! Santa is going to be mad!**

*Help! The elves left the reindeer pen open overnight and four reindeer got out! Can you help the elves get them back before Santa comes home? On the graph paper (Fig. 1), write the equation of the line segment that the elves would need to reach each reindeer. The line segment should start from the square-shaped pen on the left and go diagonally to each reindeer. The elves can only carry one reindeer at a time.*

The PSTs used the provided grid paper (Fig. 1) that shows the reindeer pen, as well as Vixen, Rudolph, Dasher, and Dancer placed strategically throughout the first quadrant of the coordinate system. Two of the reindeer were below the pen, whereas the other two were placed above the pen. This allowed for PSTs to determine two negative and two positive slopes with a fixed  $y$ -intercept at the location of the pen,  $(0,11)$ .



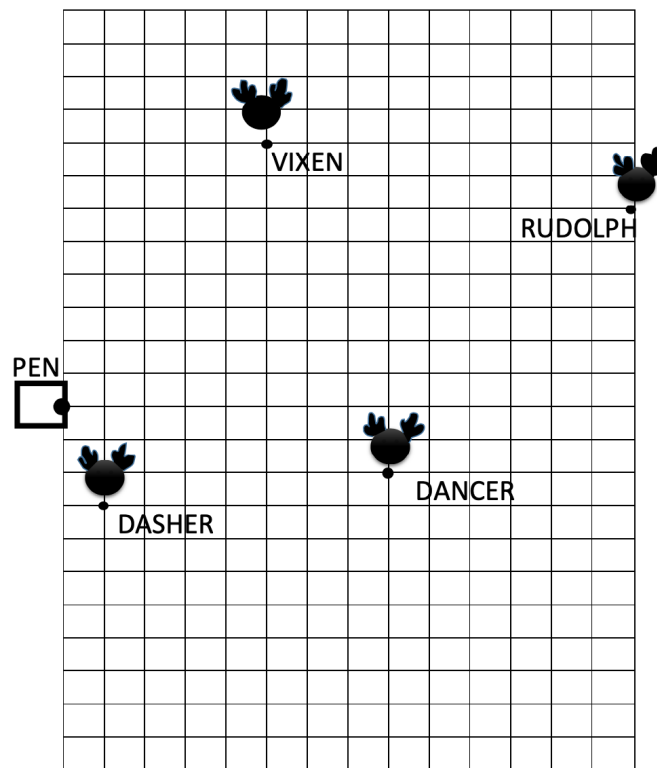


Figure 1. The grid showing the position of the reindeer.

### Sample Work for Problem #1

Most PSTs correctly calculated the slopes of the line segments created between the pen and each reindeer. See Figure 2 for an example of work where PSTs created the triangular regions between the pen (at the far left) and each reindeer, as well as their corresponding equations.

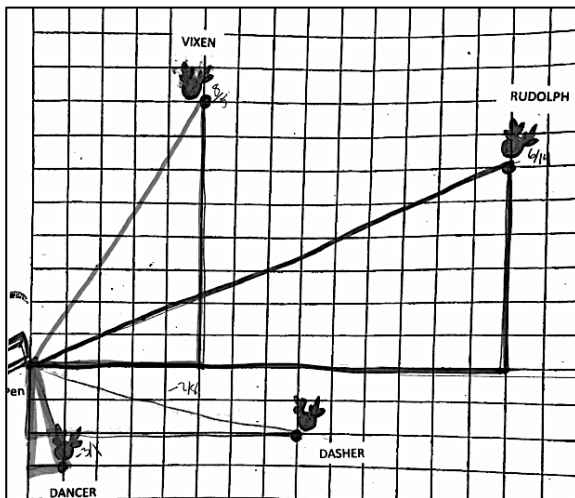


Figure 2. Sample PST work for problem #1.

Directions: Help! The elves left the reindeer pen open overnight and 4 reindeer got out!! Can you help the elves get them back before Santa comes home? On the attached graph paper, write the equation of the line that the elves would need to reach each reindeer. The equation should start from the pen and go diagonally to each reindeer. The elves can only carry one reindeer at a time.

1. Vixen  $y = \frac{8}{9}x + 11$
2. Rudolph  $y = \frac{7}{9}x + 11$
3. Dancer  $y = -3x + 11$
4. Dasher  $y = -\frac{1}{4}x + 11$

All but one PST stated the correct y-intercept, but some PSTs had problems with correctly writing the slope. The most common errors were counting the number of units incorrectly, such as stating -4 for the slope for Dancer when it should have been -3 and stating the slope upside down, such as stating the slope for Dasher as -4 instead of  $-\frac{1}{4}$ .



## Problem #2: Did the elves get all their steps in?

The elves are exhausted! Santa wants to know the total distance the elves traveled to get the reindeer. Using the Pythagorean Theorem, calculate the total distance the elves traveled.

PSTs used their provided grid paper to create triangles to calculate the distance each reindeer traveled, as well as the cumulative distance the elves traveled to collect all the reindeer.

### Sample Work for Problem #2

Twenty-six of the 30 PSTs correctly calculated the total distance the reindeer's traveled. Figure 3 shows a representative example of work from a PST who did the work correctly.

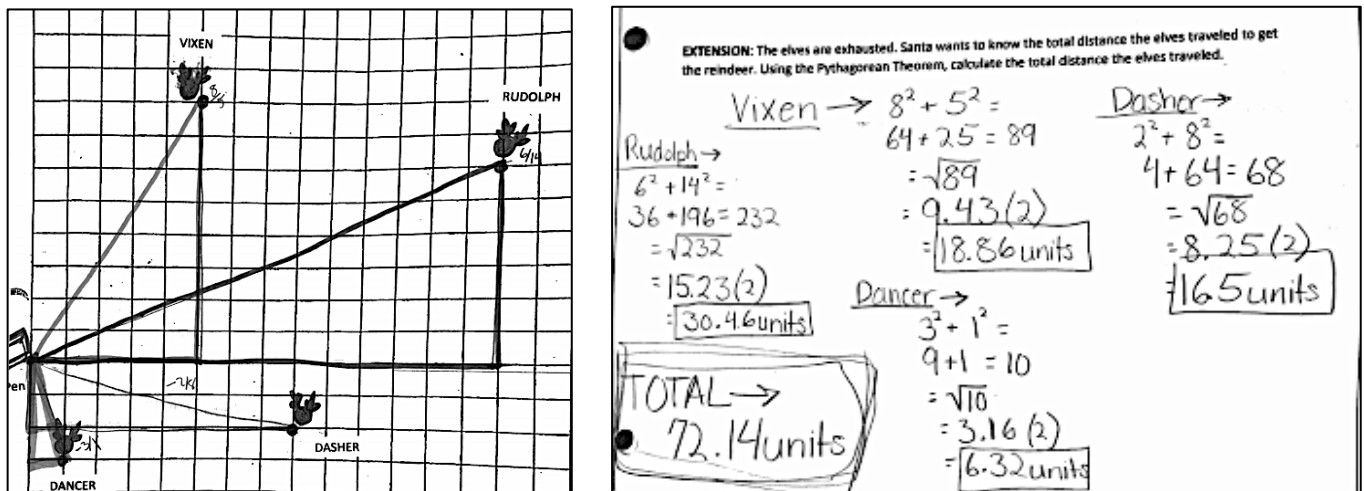


Figure 3. Sample Pythagorean theorem PST work.

Two of the four PSTs who incorrectly answered the problem did not double the length of each hypotenuse found. There was a discussion by the teacher and the class about how to calculate the total distance to help PSTs not make this error. The other two incorrect answers were from PSTs who did not find the total distance but did correctly calculate the distance that each reindeer individually traveled.

### Conclusion

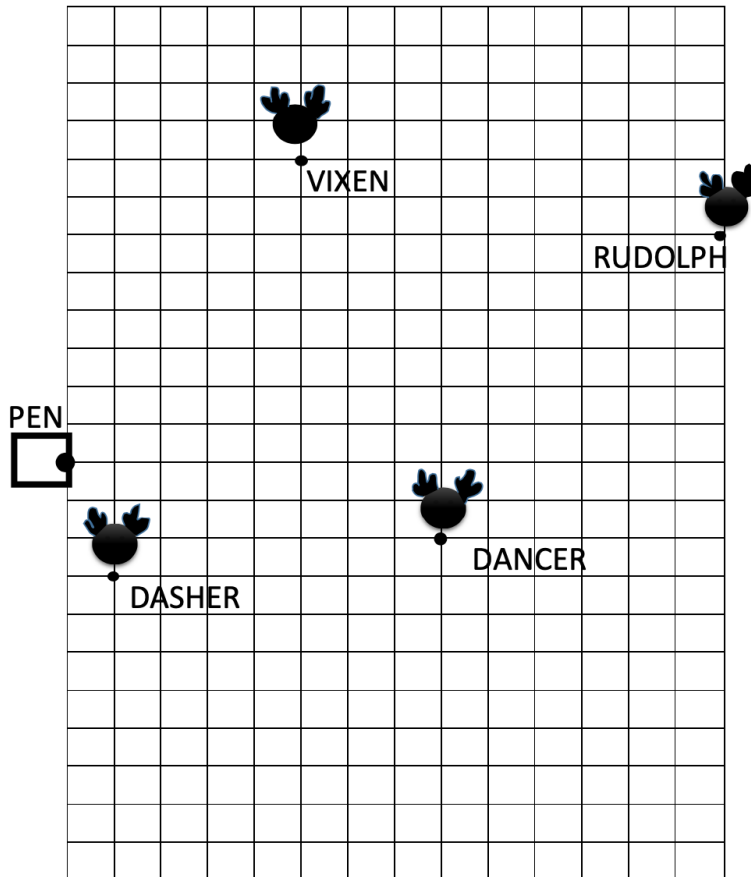
Using holiday-themed mathematics lessons can be a fun and engaging exercise for students. During this activity, PSTs wrote the equations of line segments that represent the paths elves would take to reach the reindeer, as well as utilized the Pythagorean Theorem to calculate the distances Santa's elves traveled to retrieve the reindeer. The PSTs enjoyed being able to take often procedurally-taught topics and work through an activity that involved an interesting scenario to solve.

### Reference

National Governors Association Center for Best Practices and the Council of Chief State School Officers. (2010). *Common core state standards for mathematics*. Washington, DC: Author. Retrieved from <http://www.corestandards.org>

# Activity: The Reindeer are Missing!

**Directions:** Help! The elves left the reindeer pen open overnight, and four reindeer got out! Can you help the elves get them back before Santa comes home? Write the equation of the line segment that the elves would need to reach each reindeer. The line segment should start from the pen and go diagonally to each reindeer. The elves can carry only one reindeer at a time.



Vixen: \_\_\_\_\_ Rudolph: \_\_\_\_\_

Dasher: \_\_\_\_\_ Dancer: \_\_\_\_\_

**Extension:** The elves are exhausted! Santa wants to know the total distance the elves traveled to get the reindeer. Using the Pythagorean Theorem, calculate the total distance the elves traveled.

# A Visual Proof of the Pythagorean Theorem

Betty B. Long & Deborah A. Crocker, Appalachian State University, Boone, NC

There are a number of visual or informal proofs of the Pythagorean Theorem. These types of proofs are often called “proofs without words.” They are used to help students see how the Pythagorean Theorem works and why it is true. There are many such proofs. Veljan (2000) attributes the approach used in this patty paper activity to Chou-pei Suan-ching of China (ca. 250 BC). It involves cutting a larger square into four right triangles and a smaller square. Using algebra, students can discover the Pythagorean Theorem and develop a little more understanding about it.

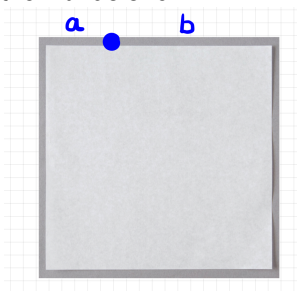
In the North Carolina Mathematics Standards for Middle Grades (North Carolina Department of Public Instruction, 2017), the following standard is listed:

Understand and apply the Pythagorean Theorem  
NC.8.G.6. Explain the Pythagorean Theorem and its converse.

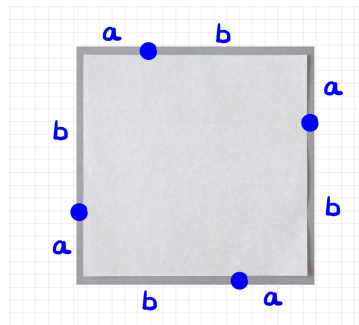
The proof provided below is one way to meet this standard. Since the algebra involved is high school level, this could be an activity to use as a review of the Pythagorean Theorem for high school students and for some practice of algebra skills. The algebra skills used for the activity include the distributing of a constant, multiplying linear expressions, and combining like terms. We provide instructions for the student and suggestions for the teacher below.

## Handout for the Students

1. Use one sheet of patty paper. Put a mark on one side. Label one part of the side “ $a$ ” and the other “ $b$ ” as shown:



2. Use the first sheet of patty paper to make a similar mark on all four sides of another sheet of patty paper, and label all of the lengths “ $a$ ” and “ $b$ ” as shown below.



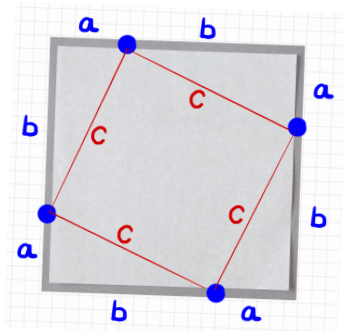
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*The authors present a hands-on, proof without words for students to investigate the Pythagorean Theorem.*

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Write a formula for the area of the sheet of patty paper using the letters  $a$  and  $b$ .

3. Fold from point to point on adjacent sides and label the hypotenuse “ $c$ ” on each right triangle you make, as shown below.



- a. Using the labels in the figure, write the area of one of the triangles.
  - b. Using the labels in the figure, write the area of the small interior square.
  - c. Using the four triangles and the small square, write the area of the original sheet of patty paper.
4. Since the area of the sheet of patty paper is the same no matter which way you write it, the two expressions for area must be equal. Write an equation setting them equal to each other. Simplify that equation. What do you see?

### Suggestions for teachers

The students will need two pieces of patty paper and a ruler. Once the students have selected the position for the point and copied that location to all four sides, they need to write the area of the patty paper in two different ways using the labels on the patty paper: (1) the area of the entire square of patty paper, and (2) the sum of the areas of the four triangles and the smaller square. The diagrams on the student handout can be used with the algebra shown below. You may have to encourage your students with a hint to get them started.

The area of the whole sheet of patty paper, with the labeling above:

$$(a + b)^2$$

The area of the whole sheet of patty paper using the square plus the area of the four right triangles:

$$c^2 + 4\left(\frac{1}{2}ab\right)$$

Since the area of the square piece of patty paper is equal to itself:

$$(a + b)^2 = c^2 + 4\left(\frac{1}{2}ab\right)$$

Simplify the previous equation as shown below:

$$(a + b)^2 = c^2 + 4\left(\frac{1}{2}ab\right)$$

$$a^2 + 2ab + b^2 = c^2 + 2ab$$

$$a^2 + b^2 = c^2$$

Now you have the Pythagorean Theorem. Students can see the connections between the areas created on the patty paper. An extension of this activity might be to investigate other visual or informal proofs of the Pythagorean

Theorem. For a project, have students find other approaches and share them in class, on a poster, or in a presentation.

## References

North Carolina Department of Public Instruction. (2017). *North Carolina K-8 math standards*. Retrieved from <https://www.dpi.nc.gov/teach-nc/curriculum-instruction/standard-course-study/mathematics>

Veljan, D. (2000). The 2500-year-old Pythagorean Theorem. *Mathematics Magazine*, 73(4), 259-272. Doi: 10.2307/2690973

## In Memoriam: Robert (Bob) Ralph Jones, Jr.

It is with great sadness that NCCTM has learned of the passing of one of our founders, Bob Jones. Bob played an instrumental role in working to organize a meeting that would give birth to NCCTM.

In 1970, as Supervisor of Mathematics for the State Department of Public Instruction, Bob—along with Bob Clary, Josie Thomson, and Hunter Ballew—started conversations about forming a new state organization for math teachers. A proposal was written to NCTM for funds to underwrite a meeting of mathematics leaders from across the state to plan the organization's structure.

NCTM funded this proposal and Bob, Josie Thompson, and Hunter Ballew organized the meeting and sent a letter of invitation to those identified as leaders in the North Carolina mathematics education community. A core group of 20 leaders from around the state attended a meeting in Bryson City in October to brainstorm—a gathering now considered to be the first meeting of NCCTM. The group felt strongly that this proposed organization could take on the responsibilities of sharing the content, pre-service, and in-service experiences in primary and secondary mathematics.

Through his career in education and administration and his involvement in NCCTM, Bob had a huge impact on mathematics education in North Carolina. We send our deepest sympathies to Bob's family at this sad time. He will be sorely missed!



## Rankin Award Nominations

The Rankin Award is designed to recognize and honor individuals for their outstanding contributions to NCCTM and to mathematics education in North Carolina. Presented in the fall at the State Mathematics Conference, the award, named in memory of W. W. Rankin, Professor of Mathematics at Duke University, is the highest honor NCCTM can bestow upon an individual.

The nomination form can be obtained from the “awards” area of the NCCTM Website, [www.ncctm.org](http://www.ncctm.org). More information can be obtained from Lee V. Stiff, [lee\\_stiff@ncsu.edu](mailto:lee_stiff@ncsu.edu).

# 2020 NCCTM Logo Contest Winners

Reported by Anthony Finlen, Asheboro, NC

The Mathematics Logo Contest is held each spring. The NCCTM Board selects the winning logo at its Spring meeting. The 2020 winning logo, pictured, will be available on shirts at the NCCTM State meeting in October.

State Winner:

Minseo Choi  
5th Grade Student at McAlpine Elementary  
Teacher: Sarah Koch

Other Finalists:

## Eastern

### Student - Grade - Teacher

Blayden Miller - 8 - Jenks Johnson  
Brantley Edwards - 10 - Peggy Walston  
Camryn Joyner - 10 - Peggy Walston  
Cartyr Kittrell - 4 - Tiffany Phillips  
Isabella Turner - 8 - Jenks Johnson  
Matthew David - 9 - Jenks Johnson  
Nacir Lewis - 7 - Jenks Johnson  
Tanner Williams - 4 - Tiffany Phillips  
Thomas Yoo - 11 - Cherry Devane  
Zanyah Barbour - 5 - Kimberly Lunde

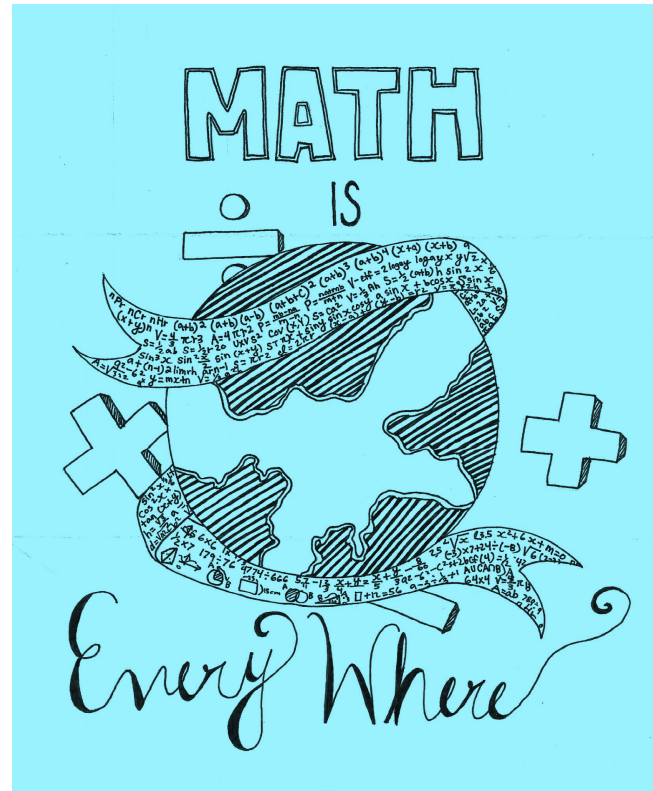
## Central

### Student - Grade - Teacher

Hailey - 2 - Miranda James  
Kenzie Edwards - 9 - Amy Owens  
Lilee - 2 - Miranda James  
Lydia Wisdom - 7 - Angela Short  
Mary Bun - 7 - Karen Pardo  
Riley Lawson - 5 - Christy Hutchins  
Skylar Schaal - 5 - Christy Hutchins

## Western

Savanah Wilcox - 11 - Carmen Wilson



## Innovator Award Nominations

The North Carolina Council of Teachers of Mathematics accepts nominations for the Innovator Award at any time. The Committee encourages the nomination of organizations as well as individuals. Any NCCTM member may submit nominations. The nomination form can be obtained from the "awards" area of the NCCTM Website, [www.ncctm.org](http://www.ncctm.org). More information can be obtained from: Dr. Ana Floyd, [afloyd@randolph.k12.nc.us](mailto:afloyd@randolph.k12.nc.us).

# Using RStudio Cloud with a High School Class

Alan T. Arnholt & Suzanne R. Arnholt, Appalachian State University, Boone, NC

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*The authors describe a real-world data-fitting activity using RStudio Cloud, along with directions for how to get started in the RStudio environment.*

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The study of statistics has changed drastically since the advent of the internet and the creation of incredibly fast computers. Data sets used in class have moved from a few values in one or two variables to hundreds of variables with thousands of cases. Calculators are insufficient to do modern statistics, yet they have been the tool of choice in elementary and high schools for years. With RStudio Cloud, elementary and high school teachers tasked with starting students' statistics education have access to a premier computing platform used by professionals worldwide. Assignments can be created and distributed electronically, which is much more sustainable than passing out papers with problems. A diverse student population can be served equitably, as all students will have access to the leading computational platform in the field. Using RStudio Cloud in the teaching of statistics at any level enhances students' understanding of modern statistics. This paper will detail how to get RStudio accounts for both teacher and students, describe how to create and distribute an assignment to a class, and provide a sample link to an assignment including a data set whose analysis should be of interest to present day students.

## Getting an Account

RStudio Cloud's login page can be found at <https://rstudio.cloud>. If you work at a school with Google accounts, it is advisable to have students (and the teacher) sign up with Google. At the time of publication of this article, the "sign up" link is on the top right of the main page or on the bottom right of the login page. You may also sign up with any valid e-mail address. Once you have signed up, you can log in. If you click "info," you can read an intro to RStudio Cloud as well as the User's Guide (RStudio Cloud, n.d.). The same process you use as a teacher can be used by your students to create their own accounts.

When you want a location for a particular class's assignments, you will create a Private New Space by clicking on New Space (Fig. 1).

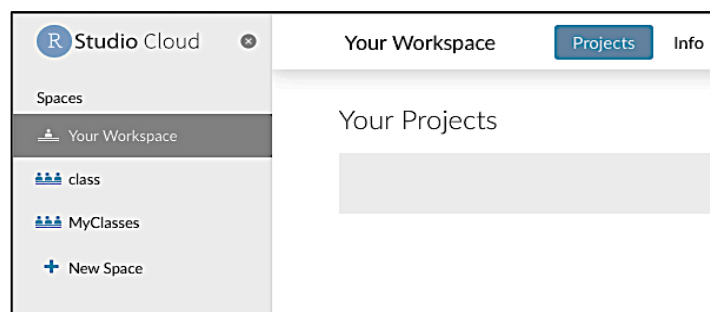


Figure 1. Top left corner of RStudio Cloud

The number of new private spaces is somewhat limited without an upgrade, so if you plan to use this system for many semesters or classes, asking for an upgrade is a good choice. Once the new private space is created, say "MyClasses," click on it. Near the top center of the screen is a list of "Members." Initially, you are the admin and the only member of your space.



You can “invite” your students to join your space with their e-mail addresses. Each student must be invited individually. You could also set the access to Shared, then distribute the Sharing Link (copy sharing link shows up as an option once you click shared) to your students. Once all the students have joined the space, you can then set Access to “Invitation Required” to ensure that nobody joins the class later without your permission. The latter method is easier. Again, you may need to request more members with the Capacity link at the bottom right screen

## Creating Assignments

A good way to create assignments for your students is to make a project for each assignment and populate it with the files, data sets, and packages you would like each student to have when they begin the assignment. It is also a good idea to create a base project that contains files and packages your students will typically use. Our students typically use *rmarkdown* (Allaire et al., 2019), a few of the packages from *tidyverse* (Wickham, 2017), and *bookdown* (Xie, 2020). Consequently our base project has the *rmarkdown*, *tidyverse*, and *bookdown* packages and all of their dependencies installed. To create a base project, click New Project. Deploying Project will appear as RStudio Cloud loads a basic distribution of R with commonly used packages. Name your base project by clicking on the Untitled Project to the right of your private space name (MyClasses in this example). Once the RStudio interface displays, add the packages *rmarkdown*, *bookdown*, and *tidyverse* by:

- Clicking on the Packages tab in the bottom right pane.
- Clicking on the Install icon in the bottom right pane.
- Typing the names (rmarkdown, bookdown, tidyverse) in the Packages box of the Install Packages window.
- Make sure the box to the left of Install dependencies is checked.
- Click the Install button.

Next,

- Click on the gear box in the top right of RStudio Cloud.
- Click on the Access icon and change who can view the project to “Everyone in MyClasses.”

To set all of your future projects in MyClasses to use the files and packages in your base project, return to the MyClasses space then click the gear box in the top right of RStudio Cloud and set the base project. Figure 2 shows the gear box in the top right and an example of setting the base project to base of a space named MyClasses. To use the functions and data sets in an R package, the package must be installed and loaded. Packages need only be installed once but must be loaded each R session. Packages are generally loaded at the R prompt with the command: `library(Package_Name)`.

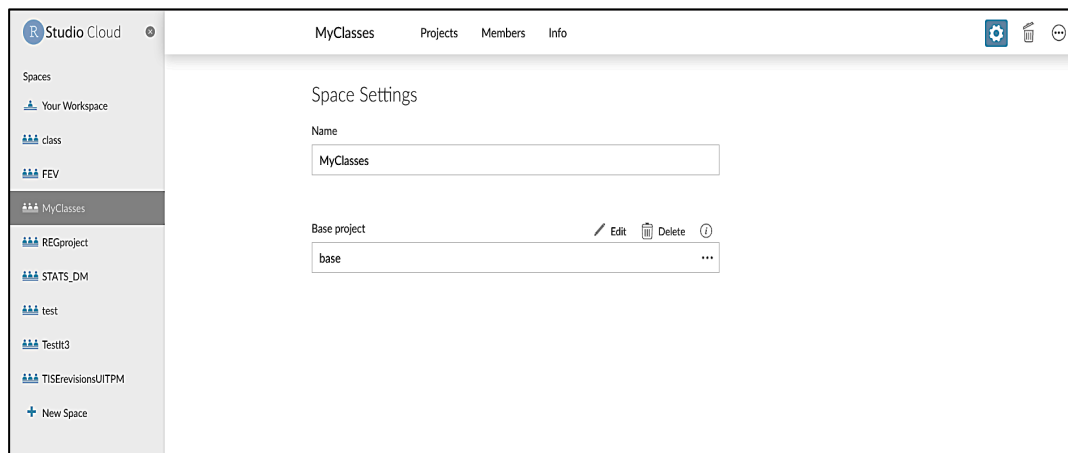


Figure 2. Screen shot of space settings window of RStudio Cloud.

To create your first assignment in a project named *FirstAssignment*, first click on the *MyClasses* space under *Spaces*. Next, click *New Project* and remember to name the project by clicking on the *Untitled Project* and typing *FirstAssignment*.

To create an R script file, select *File > New File > RScript* from the top right of the interface. Once you have a bit of code, you can save your script with *File > Save As*. In the lab explained later in this article, the first bit of code is given in Figure 3.

```
url <- "http://jse.amstat.org/datasets/fev.dat.txt" # url for data
fev.data <- read.table(file = url) # read data from url
colnames(fev.data) <- c("age", "fev", "height", "fm", "smoke") # name columns
# Convert numeric vector fm with values of 0s and 1s to a factor with labels of
# Female and Male
fev.data$fm <- factor(fev.data$fm, labels = c("Female", "Male"))
# Convert numeric vector smoke with values of 0s and 1s to a factor with labels of
# No and Yes
fev.data$smoke <- factor(fev.data$smoke, labels = c("No", "Yes"))
head(fev.data) # display first 6 rows of fev.data
```

	age	fev	height	fm	smoke
1	9	1.708	57.0	Female	No
2	8	1.724	67.5	Female	No
3	7	1.720	54.5	Female	No
4	9	1.558	53.0	Male	No
5	9	1.895	57.0	Male	No
6	8	2.336	61.0	Female	No

Figure 3. Code to enter for the lab.

The best way to ensure that your students each get their own copy of the project is to flag the project as an assignment. To create an assignment:

1. Open the project.
2. Click on the Project Settings button (the gear icon in the upper right).
3. Select the Access icon.
4. Verify that the project can be viewed by everyone in the space (the default is You).
5. Check *Make this project an assignment*.

When the student opens an assignment project (either via the projects listing, or via a link to the project), RStudio Cloud will automatically make a copy for them. To convey this special behavior, assignments are displayed a bit differently. You can see the students' copies of the assignment by clicking on the "View n derived projects" link that will appear with your original project. Note that changes you make to the original assignment will not be applied to any student copies already created. The changes will only apply to future copies of the assignment. Also note that the assignment feature is not available in your personal workspace (RStudio Cloud, n.d.).

### Forced Expiatory Volume Lab Intro

Now that you have familiarized yourself with the interface, you will certainly want to create assignments for your class. A *Journal of Statistical Education* article by Kahn (2005), has information about a measure of lung capacity (fev) as well as variables that might be related to it (height, age, sex, smoker). The dataset and a description are available in the JSE Data Archive ([http://jse.amstat.org/jse\\_data\\_archive.htm](http://jse.amstat.org/jse_data_archive.htm); search for "fev"). The data will provide an excellent illustration of confounding variables and may convince students that smoking is not a good choice for them.

In the lab itself, reasonable questions to have the students answer include:

- How are fev and smoke related overall?
- How are fev and age related for smokers and non-smokers?
- How are fev and sex (fm) related for smokers and non-smokers?

- How are fev and height related for smokers and non-smokers?
- Based on these answers only, does it appear that smoking is detrimental to fev?
- Since it is generally accepted that smoking is not good for lung function, what may be causing this? That is, what paradox seems to be in effect? Create a graph that accurately reflects the effect of smoking on fev, including all appropriate variables.

## Forced Expiratory Volume Lab R Commands and R Markdown Rationale

As the *tidyverse* has developed, a few ideas have become standard. The first idea is that data should be “tidy.” This generally means that each row represents an observation and each column is a variable (Wickham, 2014). The second idea is that graphs should be created that follow a particular grammar. Graphs in the *tidyverse* are generally created with the *ggplot2* package using the `ggplot()` function (Fig. 5).

A typical `ggplot()` graph starts with “tidy” data passed as either a data frame or a tibble to the “data =” argument. Aesthetic mappings such as *x* and *y* are specified in `aes()` and `geom_`, which specifies the type of geometry one desires. The arguments for the aesthetics determine the coordinate system, while the various geoms determine the visual marks that represent the data.

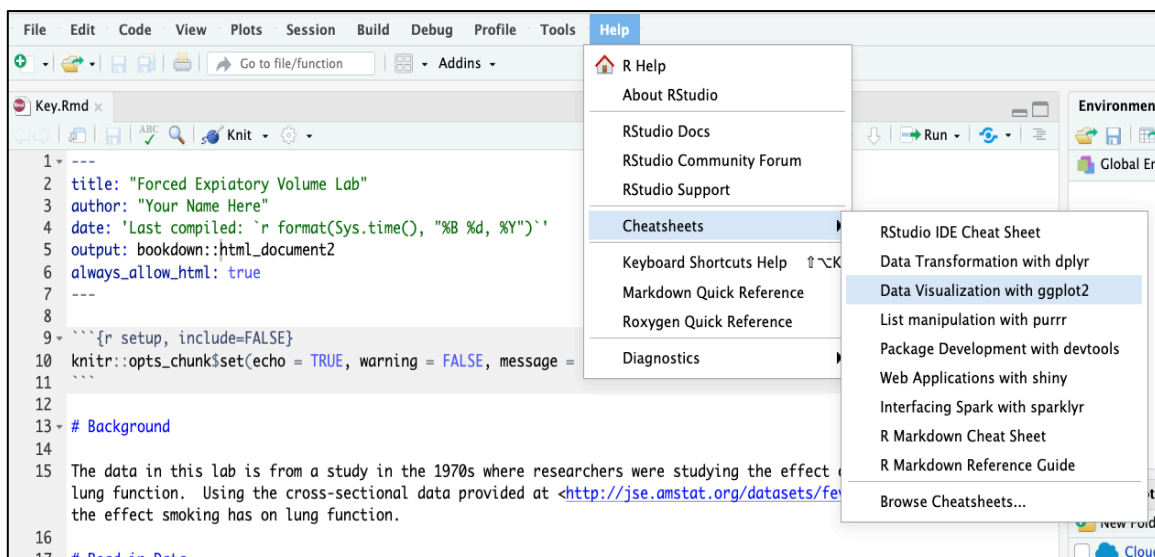


Figure 4: Screen shot of help path to ggplot2 cheat sheet.

The “Data Visualization with ggplot2” cheat sheet provides helpful reminders for using *ggplot2* and is available in the RStudio Integrated Development Editor by clicking *Help* > *Cheat Sheets* > *Data Visualization with ggplot2* (Fig. 4). A template for creating the graphs in the lab provided with this article is given in Figure 5.

```
ggplot(data = fev.data, aes(x = YourIndependentVariable, y = YourResponseVariable)) + geom_
```

Figure 5. Graph template for the lab.

Two separate documents ready to use for this lab are included at <https://rstudio.cloud/project/649008> (you will need to log in to access this project site; as noted above we suggest using a google account to do so). One is the actual lab to assign to students (Lab.Rmd); the other is a partial key (Key.Rmd). Both documents are provided in R Markdown format as advocated by Horton et al. (2014) and Baumer et al. (2014).

There are many outstanding online reference texts for using R Markdown (e.g., Xie, 2020; Xie et al., 2020). For a short tutorial, see *Using R Markdown with the RStudio Integrated Development Editor* (Arnholt, 2017a). For some additional ideas for using R Markdown, see *Using R with the RStudio Integrated Development Editor—Ideas, Pointers, and Teasers* (Arnholt, 2017b).

## Conclusion

With the availability of cloud computing, any teacher and any student can access the best and most up-to-date statistical analysis tools to solve problems. With internet access and a device that can connect to the internet, anyone with appropriate motivation can solve problems that would have been intractable and time consuming for even professional statisticians 50 years ago. It is our hope that this paper has provided enough guidance that RStudio Cloud will become the new favorite tool of statistics analysis at every level of education.

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# Applying for NCCTM Mini-grants

NCCTM provides funding for North Carolina teachers as they develop activities to enhance mathematics education. This program will provide funds for special projects and research that enhances the teaching, learning, and enjoyment of mathematics. There is no preconceived criterion for projects except that students should receive an on-going benefit from the grant. In recent years, grants averaged just less than \$800.

The application is available on the NCCTM website [ncctm.org]. Proposals must be postmarked or emailed by September 15, and proposals selected for funding will receive funds in early November. Be sure that your NCCTM membership is current and active for the upcoming year! Each year we have applications that cannot be considered because of the membership requirement. Email Joy McCormick [[jmccormick@rock.k12.nc.us](mailto:jmccormick@rock.k12.nc.us)] with questions.



In each issue of **The Centroid**, Problems2Ponder presents problems similar to those students might encounter during elementary and middle school Olympiad contests. Student solution submissions are welcome as are problem submissions from teachers. Please consider submitting a problem or a solution. Enjoy!

*Problem submissions:* If you have an idea for a problem to publish, please email Holly Hirst ([hirsthp@appstate.edu](mailto:hirsthp@appstate.edu)) a clear photo or PDF document of a typed or neatly written problem statement, along with a solution. Include your name and school affiliation so that we can credit you with the submission.

*Solution submissions:* If teachers have an exceptionally well written and clearly explained correct solution from a student or group of students, we will publish it in the next edition of The Centroid. Please email Holly Hirst ([hirsthp@appstate.edu](mailto:hirsthp@appstate.edu)) a clear image or PDF document of the correct solution, with the name of the school, the grade level of the student(s), the name of the student(s) if permission is given to publish the students' names, and the name of the teacher.

*Deadline for publication of problems or solutions in the Fall 2020 Centroid: December 30, 2020.*

Solutions will be posted in the next edition of The Centroid.

## Fall 2020 P2P Problems

Problem A: A train is exactly 12 miles from Greensboro at 7:00 PM. It is traveling at a constant speed of 45 mph. At what time will the train reach the terminal in Greensboro?

Problem B: The Math Olympiads began in the prime year 1979. Find the product of the fractions below in simplest form

$$\left(1 - \frac{1}{1980}\right)\left(1 - \frac{1}{1981}\right)\left(1 - \frac{1}{1982}\right) \dots \left(1 - \frac{1}{2004}\right)\left(1 - \frac{1}{2005}\right)$$

## Spring 2020 P2P Problem Solutions

Both of these problems involve number and operation and have multiple solution approaches!

Problem A: A, B, and C represent digits in the following subtraction problem. Find the sum of A, B, and C.

$$\begin{array}{r} 8 \ A \ 4 \\ - 3 \ 7 \ B \\ \hline C \ 7 \ 8 \end{array}$$

Solution: There are many ways to think about this problem. One way to approach the problem is to rewrite the subtraction as addition of  $C \ 7 \ 8$  and  $3 \ 7 \ B$ , which must equal  $8 \ A \ 4$ .

$$\begin{array}{r} C \ 7 \ 8 \\ + 3 \ 7 \ B \\ \hline 8 \ A \ 4 \end{array}$$

Now look at the individual place values:

- In the ones position,  $8 + B$  cannot equal 4 for any positive value of  $B$  so it must be 14, resulting in  $B = 6$  and regrouping of the 10.
- In the tens position,  $1 + 7 + 7$  is 15, resulting in  $A = 5$  and regrouping again.
- In the hundreds position,  $1 + C + 3 = 8$ , results in  $C = 4$ .

**Problem B:** the first four terms of the sequence 2, -3, -2, 3, 2, -3, -2, 3,... repeat endlessly. Find the sum of the first 2013 terms in this sequence.

**Solution:** As with problem A, there are many ways to solve this problem and we will see that the number 4 plays a crucial role.

Since we want to know the sum of many terms, we can start by listing the “partial sums” of 1 term, then 2 terms, then 3 terms and so on to gain understanding of how the sums behave. In the table below are the sums of the first 7 partial sums, and a pattern has appeared.

Number of terms	Partial Sum	Total
1	2	2
2	$2+(-3)$	-1
3	$2+(-3)+(-2) = -1+(-2)$	-3
4	$2+(-3)+(-2)+3 = -3+3$	0
5	$2+(-3)+(-2)+3 + 2 = 0+2$	2
6	$2+(-3)+(-2)+3+2+(-3) = 2+(-3)$	-1
7	$2+(-3)+(-2)+3+2+(-3)+(-2) = -1+(-2)$	-3
8	$2+(-3)+(-2)+3+2+(-3)+(-2)+3 = -3+3$	0

- Adding either 1 or 5 terms result in 2
- Adding either 2 or 6 terms results in -1
- Adding either 3 or 7 terms results in -3
- Adding either 4 or 8 terms results in 0
- These totals will repeat: 0 for a multiple of 4; 2 for one more than a multiple of 4; etc.

Since the total repeats, so we just need to determine which of these four possibilities is the sum for 2013! Since 2013 divided by 4 is 503 with a remainder of 1, the sum will behave like the sum of 1 term or 5 terms, so the answer is 2!

## Trust Fund Scholarships: Now \$1000

Scholarships are available from NCCTM to financially support North Carolina teachers who are enrolled in graduate degree programs to enhance mathematics instruction. Applicants must be:

- Currently employed as a pre-K-12 teacher in North Carolina;
- Currently an NCCTM member (for at least one year) at the time of submitting the application;
- Currently enrolled in an accredited graduate program in North Carolina;
- Seeking support for a mathematics or mathematics education course in which they are currently enrolled or have completed within the previous four months of the application deadline.

Applications will be reviewed biannually, and the deadlines for applications are March 1 and October 1. The application can be downloaded from the NCCTM website under the “grants & scholarships” link. The nomination form can be obtained from the grants and scholarships page on the NCCTM Website ([ncctm.org](http://ncctm.org)). More information can be obtained from: Janice Richardson Plumblee, [richards@elon.edu](mailto:richards@elon.edu).



# Donating to the NCCTM Trust Fund

Did you receive a Trust Fund Scholarship that helped you to complete your graduate coursework and you want to show appreciation? Do you wish to memorialize or honor someone important to you and your career as a math teacher?

Consider making a donation to the NCCTM Trust Fund, please send your donation, payable to Pershing LLC for the NCCTM Trust Fund, to:

Joette Midgett  
North Carolina Council of Teachers of Mathematics  
P. O. Box 33313  
Raleigh, NC 27636

## Puzzle

Holly Hirst, Appalachian State University, Boone, NC

Have you seen the version of Sudoku called "Killer Sudoku"? It combines a KenKen-like puzzle and a Futoshiki-like puzzle with traditional Sudoku. Below are two from the website <https://www.dailykillersudoku.com/>, one easy and one hard. The developer of that page, James, went from writing code to solve these problems to writing code to create them! You can play daily puzzles or register to track your successes and look at the archived puzzles.

### The Rules (<https://www.dailykillersudoku.com/>):

As with Sudoku, the objective of Killer Sudoku is to fill the grid with the numbers 1 to 9, such that each row, column and nonet (3x3 group of cells) contains each number only once. In addition to this, a Killer Sudoku grid is divided into cages, shown with dashed lines. The sum of the numbers in a cage must equal the small number in its top-left corner. The same number cannot appear in a cage more than once.

Greater-Than Killer Sudoku has exactly the same rules as Killer Sudoku, except that not every cage has a sum in its top-left corner. Instead, some cages are linked together with symbols:

- < The left cage's sum is less than the right cage's sum.
- = The left cage's sum is equal to the right cage's sum.
- > The left cage's sum is greater than the right cage's sum.

Puzzle 20640 - Thursday, 27 August, 2020 - Difficulty 2

13		8	12			16	15	7
17			9	18				
	13				8			8
		16		19		9		
9		21	6			9	8	16
			9	12				
9	6			16		12		10
	6		23		14			
16				5		10		

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Puzzle 20644 - Thursday, 27 August, 2020 - Difficulty 9

	6		10	9	<	<		13
	9						15	
				5	13	=		14
							10	
12								6

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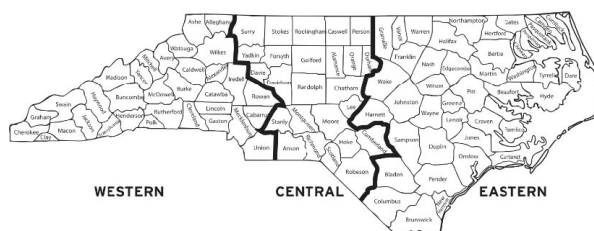
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NORTH CAROLINA COUNCIL OF TEACHERS OF MATHEMATICS

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