NYC Math Festival Materials

To fully participate, please have the following materials handy for each corresponding event.

Time	Event & Presenter	Materials Needed
2:00 – 2:15 pm	**Let the Math Fun Begin** with Cindy Lawrence, Tim Nissen, and James Tanton	• No materials needed.
2:15 – 2:30 pm	**Brainteaser Kahoot** with Steve Sherman	• Smart phone, tablet, or personal computer with internet access • Please open Kahoot.com on your computer or download the app on your smart device. • During the event, you will receive a pin to access the game on your computer or app.
2:30 – 2:45 pm	**Logic Puzzle** with John Urschel	• No materials needed.
2:45 – 3:00 pm	**Mime-matics** with Tim Chartier	• No materials needed.
3:00 – 3:15 pm	**Folding Fun!** with Wendy Zeichner	• Several sheets of 8.5″ x 11″ printer paper • Pen or marker • Scissors

3:15 – 3:30 pm	**Conway's Rational Tangles** with Alex Kontorovich	• 2 strings of different colors (wires or shoelaces are also okay) • Surface to lay the strings on (e.g., floor or table is fine) • Optional materials: paper and pencil
3:30 – 3:45 pm	**Moving in Circles** with Karl Schaffer	• Several sheets of 8.5″ x 11″ printer paper • 5′ by 5′ area in which to move (non-carpeted area preferred) • After the event, please review this document for a summary of the movements you will learn today: Moving in Circles.
4:00 – 4:15 pm	**A Four-Card Mathematical Magic Trick** with Manjul Bhargava	• 4 playing cards
4:15 – 4:30 pm	**One Step Back, One Step Forward** with Ralph Pantozzi	• 1 coin • Paper • Pencil • Please open this survey at the start of the session: flip.momath.org.
4:30 – 4:45 pm	**Activities from the Julia Robinson Mathematics Festival** with Mark Saul	• Please enjoy this e-book as a gift. We will do one activity from the e-book during the festival. Please click this link to open to e-book and follow along: "A Mathematician's Travel Kit".
4:45 – 5:00 pm	**Rubik's Cube With Feet** with Daniel Rose-Levine	• Optional: Rubik's Cube

5:00 – 5:15 pm	**Math Meets Art: Rubik's Cube Mosaics** with Lauren Rose	• Please print page 2 of this handout prior to the session: Math Meets Art. – Or, have graph paper and colored pencils or markers available. • Optional: Scissors • Optional: Rubik's Cube
5:30 – 5:45 pm	**The Doomsday Rule** with Peter Winkler	• Paper • Pencil
5:45 – 6:00 pm	**Can Math Help You Juggle?** with John Chase	• 3 juggling balls or objects
6:00 – 6:15 pm	**Math Raps and the Math Behind Them!** with Mike Andrejkovics	• Ball (any kind will do, e.g., tennis ball, softball, basketball) • 3 – 5 rubber bands that will fit around the ball. • Tape that will stick to the ball if you do not have rubber bands that will fit around the ball. • Please open this link when the session begins: Mr. A's Math Rap Lyrics.
6:15 – 6:30 pm	**Math in Motion: Build Your Own Paper Spinner** with Yana Mohanty	**You are strongly encouraged to print, cut, and construct materials in advance for this session.** • Two (2) sheets of 8.5" x 11" (or size A4) card stock, ideally in two (2) different colors; manila folders cut to 8.5" x 11" will also work • Scissors • Tape • Please open this link prior to the session to print templates and access instructions: Math in Motion Instructions. • Optional: This project can also be built from 2 sets of Geometiles® Mini Set 2, available from Additions, the online shop at MoMath.

6:30 – 6:45 pm	**Fun with Mathematical Definitions** with Christopher Danielson	• Please open this link when the session begins: "Vehicle Chat". • Optional: A second internet-connected device for this Desmos activity. (No account or password needed. Please enter your name when prompted.)
7:00 – 7:15 pm	**Finding and Creating Symmetry** with David Reimann	• Paper • Pen or pencil
7:15 – 7:30 pm	**Numbers Meet Shapes in 3D Geometry** with Bruce Bayly	• 1 box of traditional rounded, toothpicks with points at both ends • 1 bag of mini marshmallows • Paper • Pencil
7:30 – 7:45 pm	**Engineering with Paper** with Godwyn Morris	• Printer paper • Tape • Scissors
7:45 – 8:00 pm	**Mathemagics!** with Art Benjamin	• Calculator
8:00 – 8:15 pm	**Math, Music, and the Moral Imagination** with Marcus G. Miller	• No materials needed.
8:15 – 8:30 pm	**How to Fold Things into Thirds, Thirty-Thirds, and Three-Hundred-and-Thirty-Three-"irds"** with James Tanton	• Something bendy, such as a tie, shoelace, or piece of string

Karl Schaffer
MoveSpeakSpin
& De Anza College
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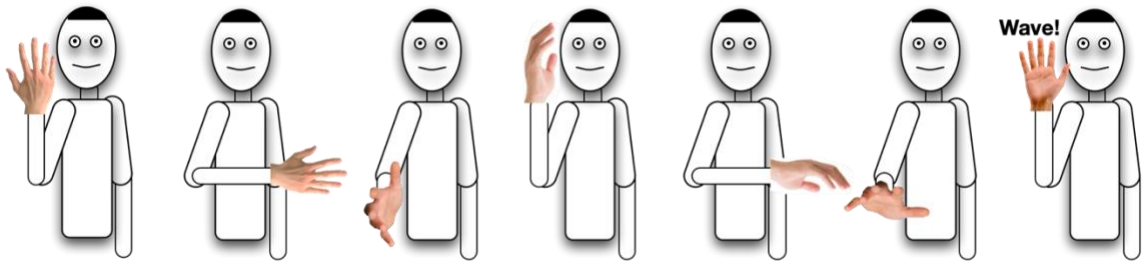
Moving In Circles

NYC Math Festival
July 18, 2020 - MoMath

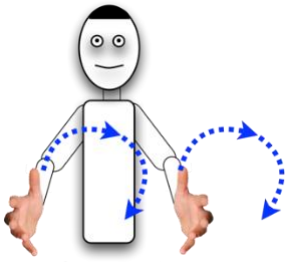
DanceAndMath@gmail.com
www.mathdance.org
More background on this session:
See my 2020 paper at archives.bridgesmathart.org

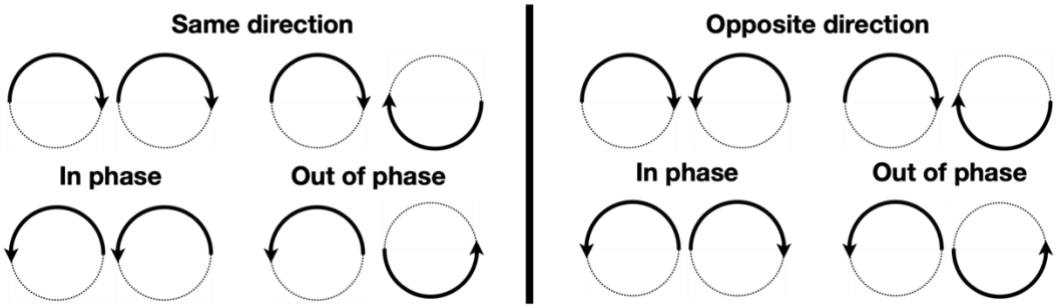
The Mathematical Hello

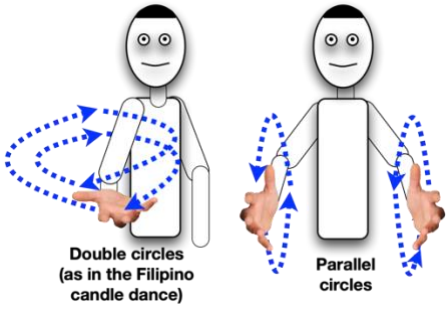


How to turn your hand around to face the front and wave hello, without just twisting your forearm.
(Inspired by John Conway and also by James Tanton's International Math Salute.)

Windmill arms







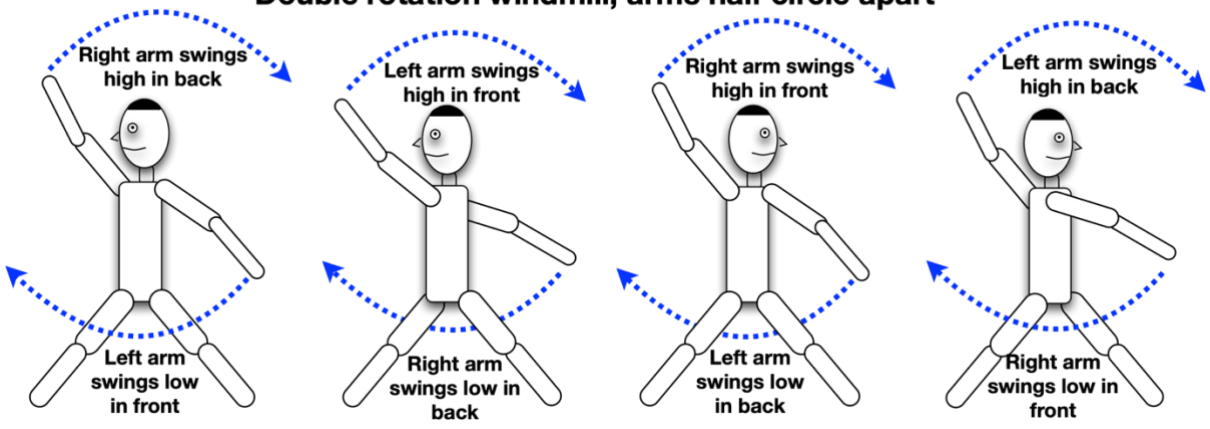
Circles to try:

- Try to explain some of the sequences of arm rotations by looking at rotations of a "1 by 1 by 1 Rubik's cube"! Try to explain using rotations of a doll!
- Find some interesting or unusual ways to make circles or swings in the air with different body parts. For example, circle the elbows while seated.
- Create a sequence of circular movements, perhaps with one or two other people. Make transitions happen fluidly, practice, try to add musical accompaniment.
- Then demonstrate to others. Give feedback to each other.

Body riddles:

- Make the circles above with one hand and the same or opposite foot. Try the same circles standing, sitting, and lying down. Can you practice those that were more difficult and make them work? Why do you think some might be more difficult?
- Try circling your two index fingers, both pointing away from you, in the same direction, going faster and faster. Did you find that suddenly they were circling in opposite directions, in mirror image formation? Try the index finger game with them pointing at each other; did you find that they start in phase, but as you go faster they move to out of phase?

Double rotation windmill, arms half circle apart

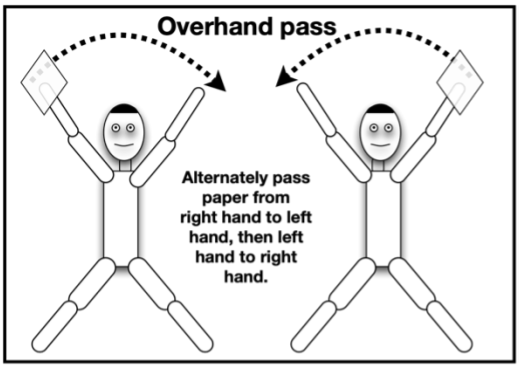


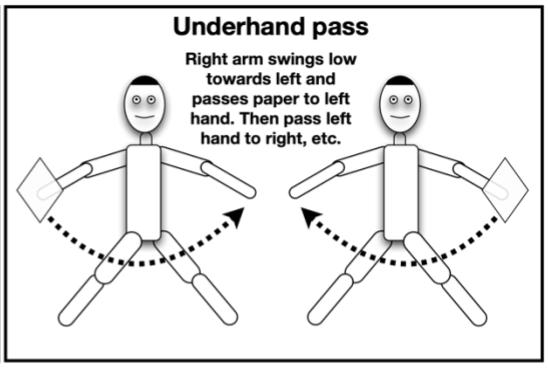
Here all arm circles are in the same direction. Can you do double rotations so the arms circle in opposite directions?

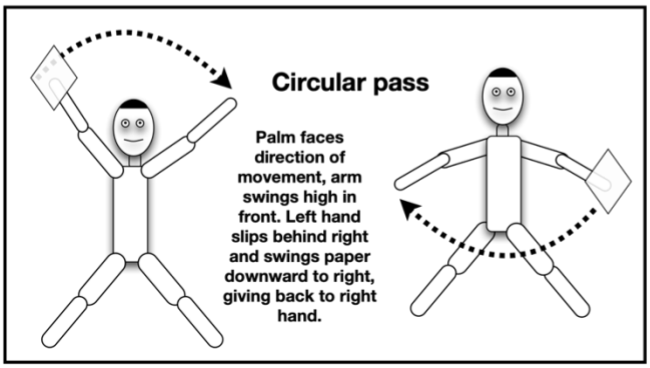
Moving - and dancing - with paper (in circles!)

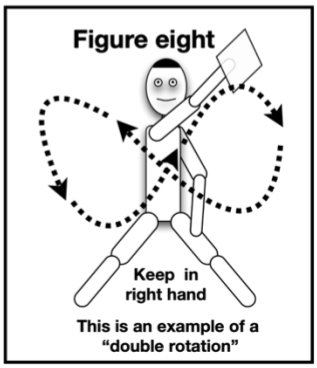
- Use ordinary 8-1/2 inch by 11 inch sheets of paper - the ultimate mathematics "prop."
- Dampening hands slightly with water or "tacky finger" helps, but with practice you won't need it!
- Keep the palm of your hand moving constantly and steadily against the paper.
- Try the simple tasks shown below first.
- Try passing a single sheet of paper from one hand to the other - or to another person.
- Try passing a sheet of paper around your back from one hand to the other.
- Try in math or dance classes! Have students create sequences and perform to music.
- The 720° rotation sequence below helps show use of quaternions, $i^2 = j^2 = k^2 = -1$, etc.
- Try to to perform various simple combinations of rotations by full or half circles around vertical, front-back or side-to-side axes (without dropping the paper!), and explain the result in terms of quaternions or rotations of a cube (or a doll!).

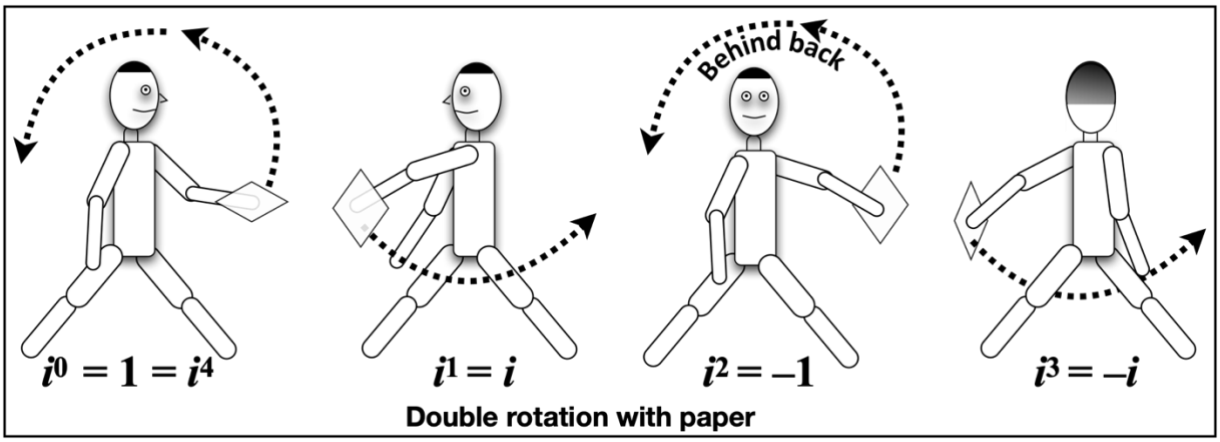
These methods of working with paper as a dance prop were developed by Karl Schaffer and Erik Stern in a number of dance performances in the 1990s, including "Bartleby," based on Melville's short story about a paper copyist.





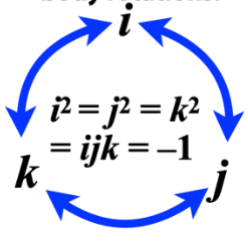


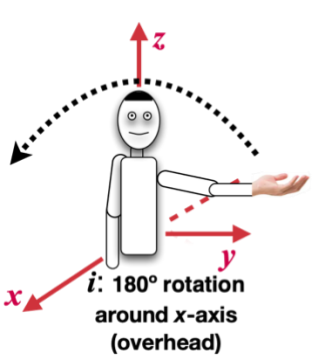


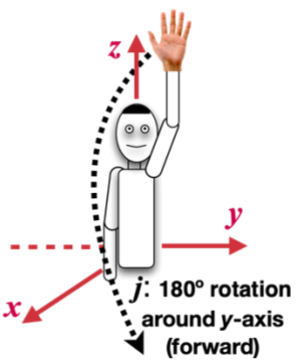


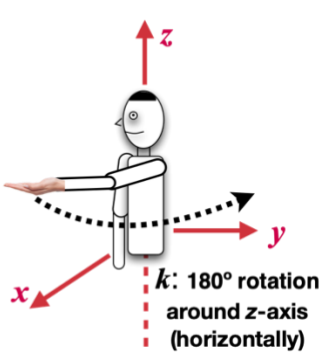
Quaternions

A way to "mathematize" body rotations!



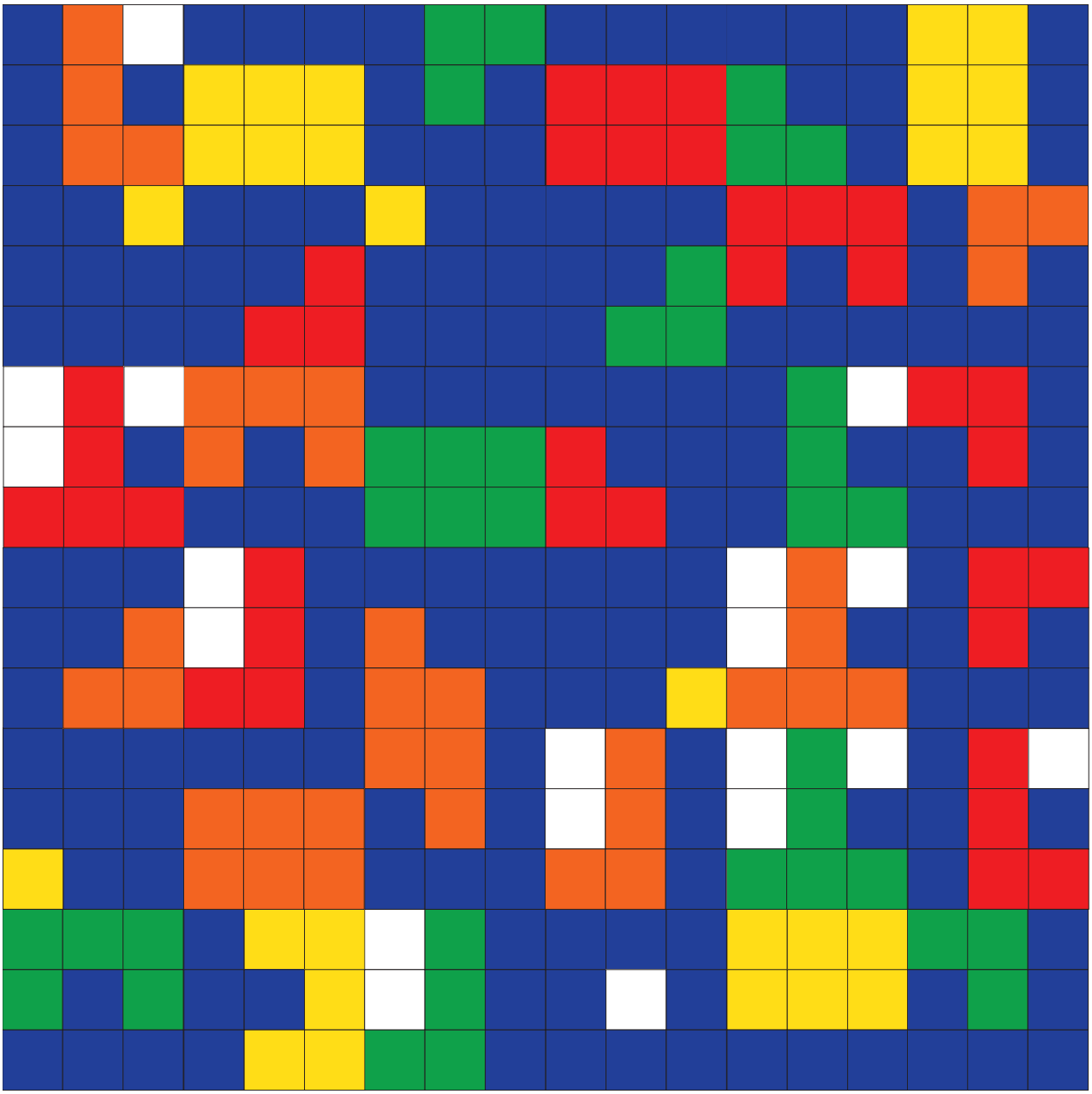






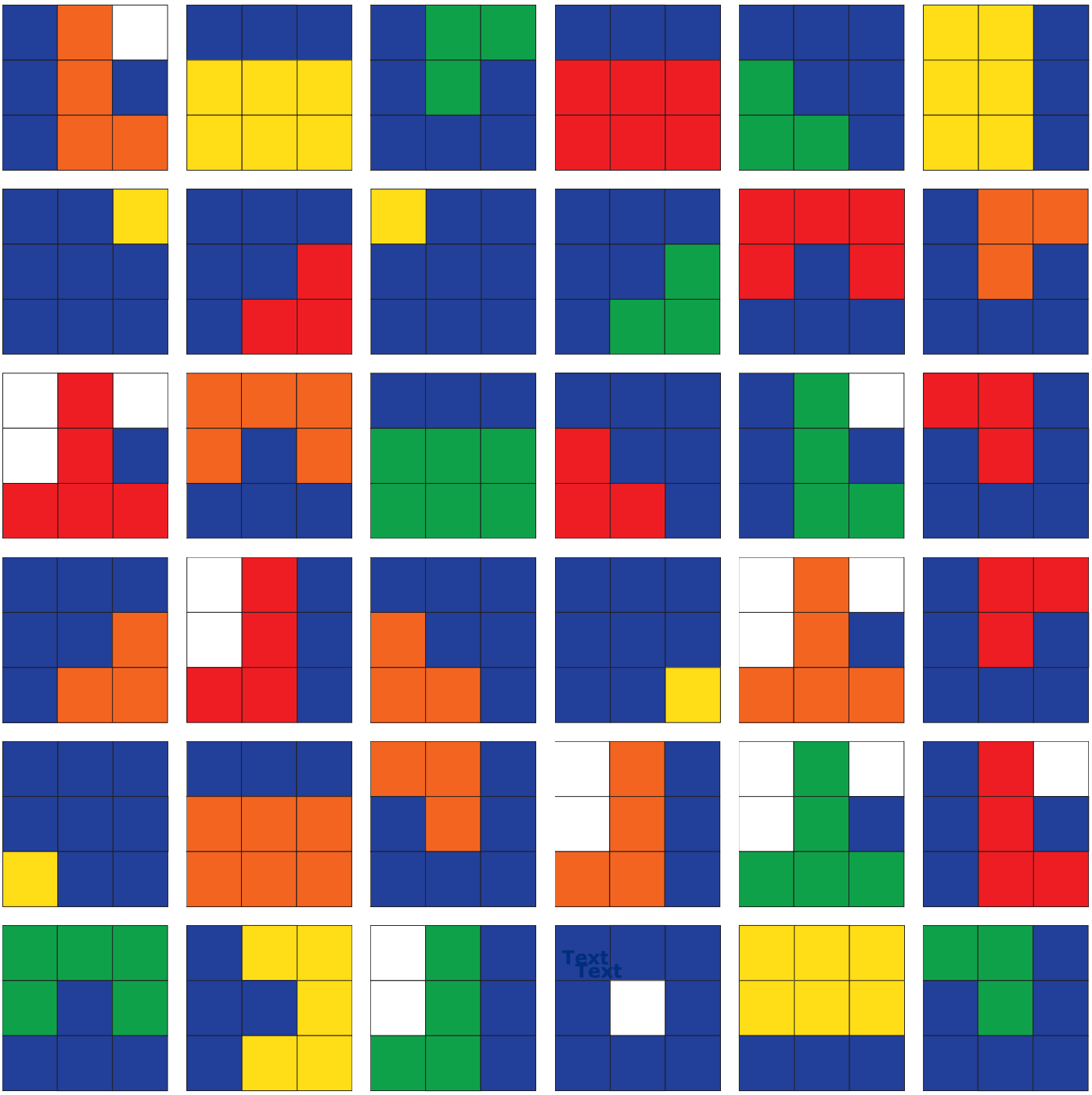
Math Meets Art: Making Rubik's Cube Mosaics

Professor Lauren Rose, Bard College



Mystery Mosaic Puzzle

Instructions: Print out puzzle and cut into separate boxes. Put together to make a picture. Hints below.



Hint #1: No rotation is needed. The boxes are all in the correct upright positions.

Hint #2: Cut out the 9 boxes with yellows, including the box with the center white piece. Those 9 boxes can be put together to make a single picture. Now do this for red, orange and green to get 4 pictures that go together.

Math Raps and the Math Behind Them! with Mike Andrejkovics

La-da-da-da-dahh, It's the mathematics teacher Mr. A — What! What!
La-da-da-da-dahh, You know I'm dropping knowledge each and every day. — Yeah - Yeah - Yeah - Yeah
You know who's back up in this math production — What What What What
Yo start the math up man, start the math up. — Here we go

Hear the bell? Get out your books, I'm 'bout to blow your mind
Maybe to start we'll just discuss how many points on this line
some of the stuff we're gonna learn can really twist your head up
so when it's making sense in class you know you've got to get pumped
it all began with just a point- a location in space
extend in three dimensions and you get a new interface
graph in x y and z to give relations a face
and if the curvature is nill you get Euclidean space
the one where angles of a triangle will sum to 180
and with just 5 postulates it can all be created
but the 5th you may have heard, well it started a rift
4's enough, so they thought, tried to show that the 5th
followed necessarily from the rest but Euclid
proved triumphant in the end, and was vindicated
cause with a different postulate you might be Hyperbolic
and even though the math still works the rules are all different

La-da-da-da-dahh - Now we're talkin Hyperbolic Geometry - What What
La-da-da-da-dahh - from the imagination of Lobachevsky

Straight out the math tower SUNY SB
That's where I started on my Pedagogy
in Harriman provin theorems
cut my teeth on Linear Algebra
working in an arbitrary n-dimensional space
orthogonal vectors all over the place
If you wanna choose a more convenient basis
maybe help you prove an even more general case
after school I went to Longwood then NHS
where I met- Winter, Perico, and all the rest
sharing love of math- man I'm doing my best
to help the kids get ready for the ultimate test
so when you're in class give it all you got
cause if you got the skills, then you know what you're not?
not gonna be left behind as the future unfolds
with math you're always ready for the next episode

Hold up, hey... - for my students who be thinking it's tough
we don't, play... - we gonna push it till it all pays off
Hold up, hey... - for my students who need to be told
take a seat... - and let's get ready for the next episode
Hey-ey-ey-yey-yay - do math everyday!

See all my math raps (and math tutorial videos): www.youtube.com/MikeDobbs76 #MrAMathRap

Math in Motion: Build Your Own Paper Spinner

with Yana Mohanty

In order to make the most of our 15 minutes together, please complete the following tasks before the session begins.

Gather materials

- Two (2) sheets of 8.5” x 11” (or size A4) card stock, ideally in two (2) different colors; manila folders cut to 8.5” x 11” will also work
- Scissors
- Tape

Create Spinner Template

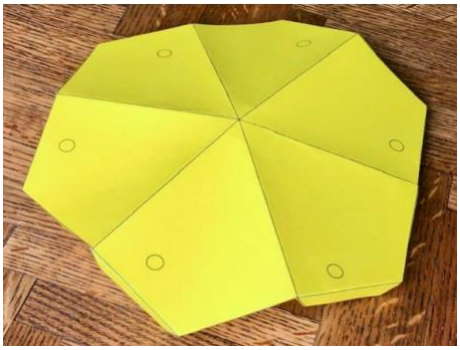
NOTE: The images on the two pages of the template are not identical. If possible, print them on two different colors to help you tell them apart.

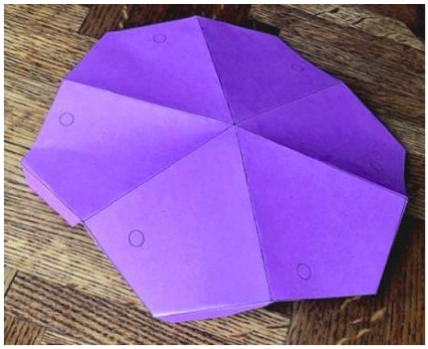
- Print this two-page Spinner Template onto two (2) separate pieces of card stock or manila folders.
- If you do not have a printer, you can follow these instructions How to Draw a Hexagon to draw 2 hexagons onto your paper using a straightedge and compass.

  MORE FUN: Even if you have access to a printer, this is a nice construction to do. Your hexagon needs to be drawn precisely in order for the spinner to work. Find the midpoint of each side of your hexagon and draw the tabs on it as shown on the Spinner Template. The tabs need not be the same as in the Spinner Template provided, but they should all be symmetric and identical to each other.
- Label the templates #1 (from page one of the template) and #2 (from page two of the template.)

Prepare your spinner for construction

- Cut out templates #1 and #2.
- Fold templates #1 and #2 along all lines, making sharp, clean creases so they look like this:





We will do some more folding and taping to complete the spinner during the session. Looking forward to meeting you!

MOMATH

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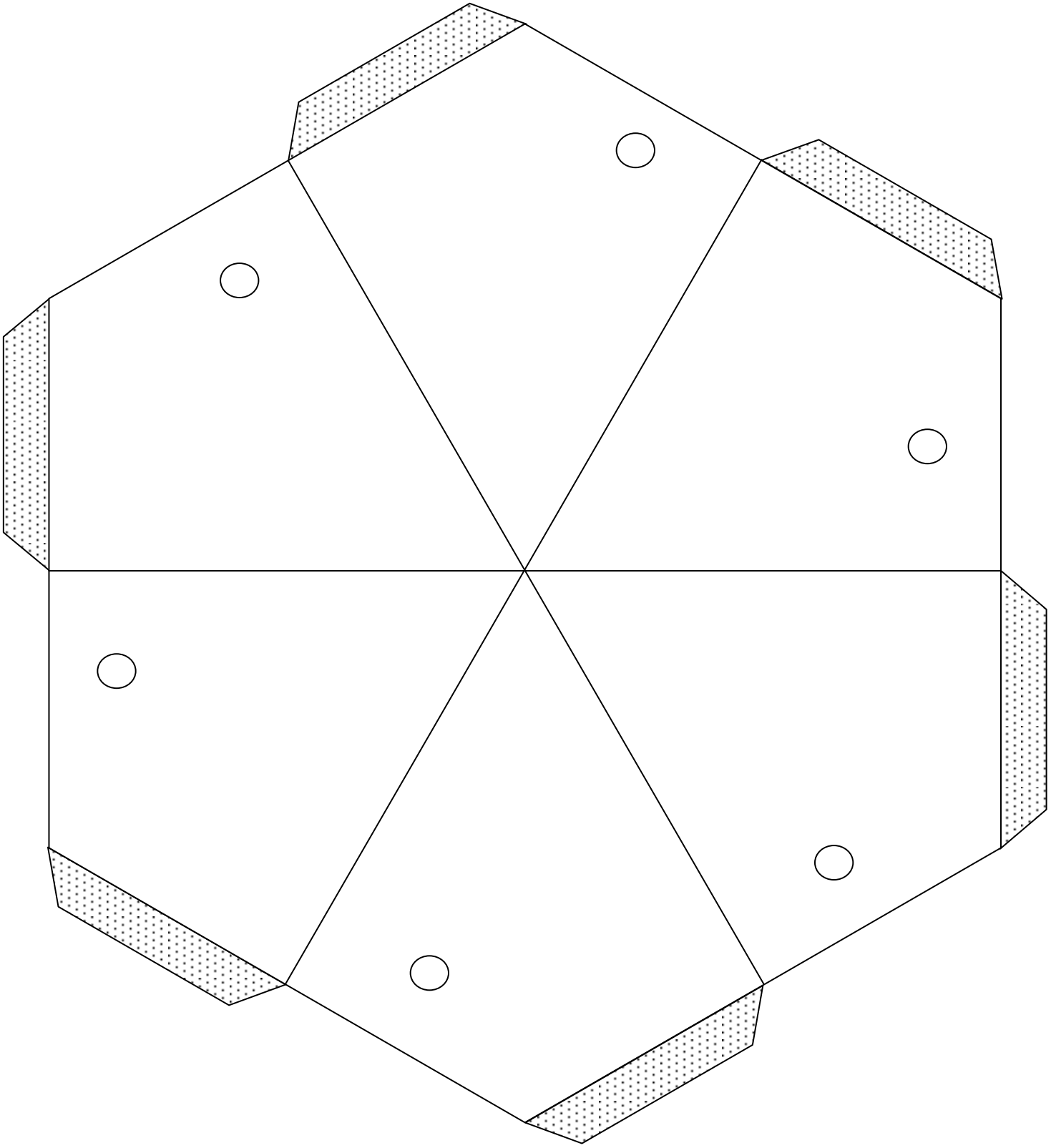
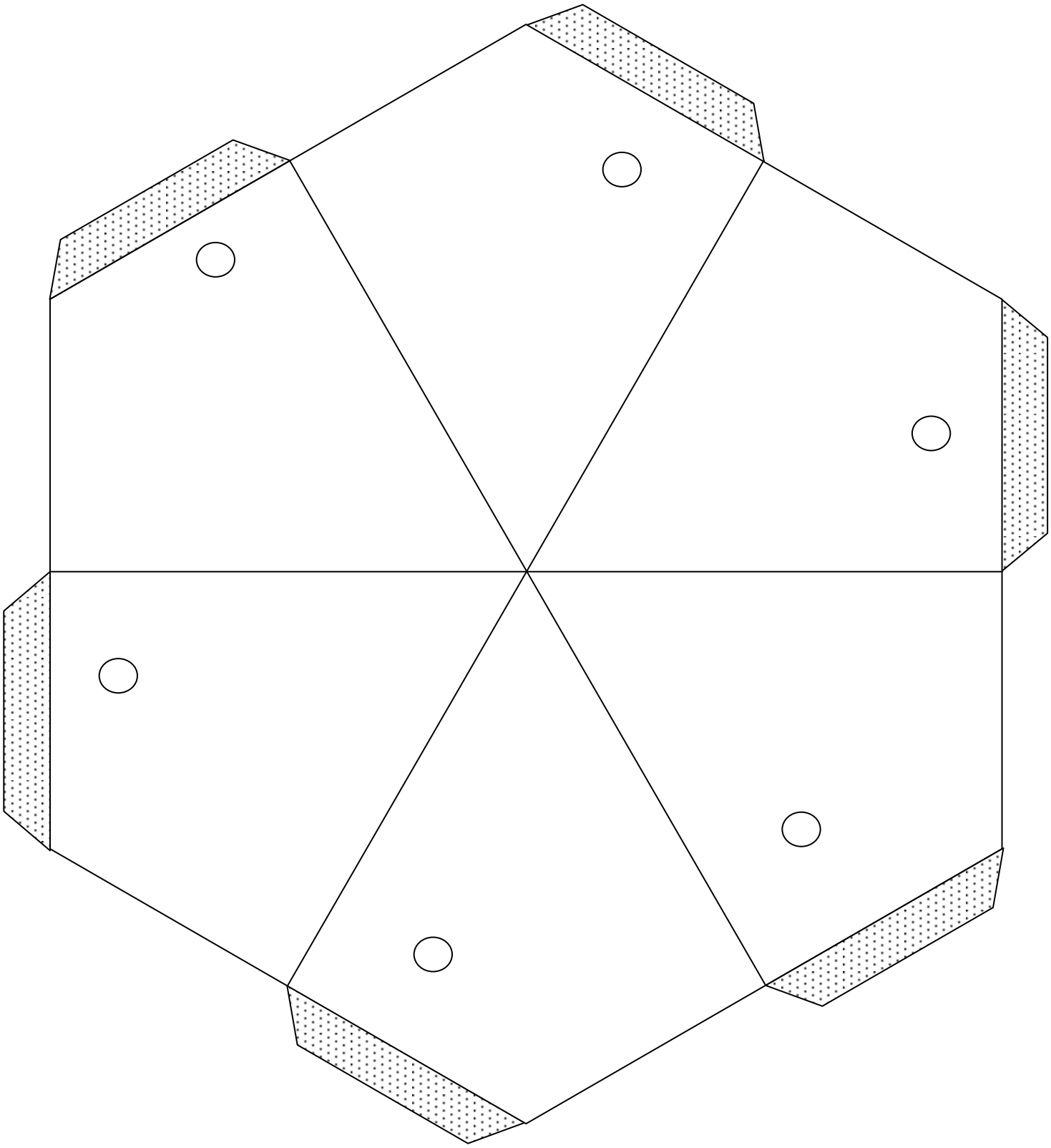




Julia Robinson Mathematics Festival®

Book 11

Julia Robinson
(1919 - 1985)

A Mathematician's Travel Kit

In this bag, you'll find 16 two-color counters, 24 matchsticks, a foldable chessboard, and these instructions for 9 different puzzles and games. All of these activities need only the materials provided here, allowing the on-the-go mathematician to turn any environment into their own mathematical playground.

Happy mathing!

By Daniel Kline
Director of Activities
Julia Robinson Mathematics Festival (JRMF)
danielkline94@yahoo.com

Activity #1: 9-Dots

Materials:

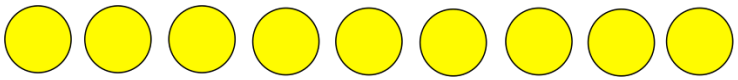
- 9 two-color counters

Objective:

Flip over the last dot. Whoever does this wins!

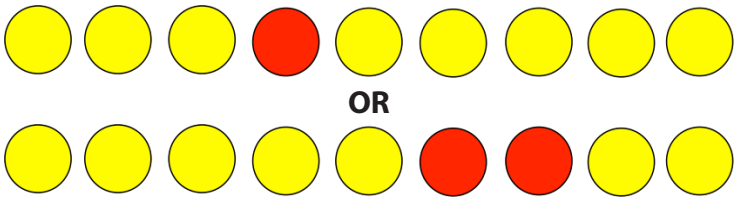
Set-Up:

1. Make a line of 9 dots so that all the dots are yellow.



Rules:

1. Players take turns either flipping over 1 dot or flipping over 2 dots that are right next to each other.
2. Only yellow dots can be flipped over.



3. Two yellow dots that are not next to each other cannot be flipped over on the same turn.

Variants:

1. Play the same game with a different number of starting dots.
2. Play the same game, but the player who flips over the last dot loses instead of wins.
3. Play the same game, but in two dimensions. Create a grid of dots (e.g. 3 x 4). Players can either flip over 1 dot or 2 dots that are horizontally or vertically right next to each other.

Puzzle

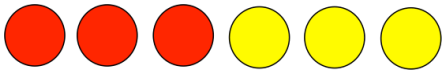
Activity #2: Goats and Sheep

Materials:

- 6 two-color counters
- 10 matchsticks

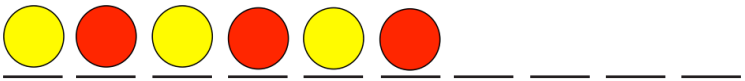
Objective:

Get all of the sheep (yellow) to be on the right and all of the goats (red) to be on the left, like below:



Set-Up:

1. Place 10 matchsticks horizontally to represent 10 animal pens.
2. Place sheep (yellow) and goats (red) into these animal pens like below:



Rules:

1. Animals must be moved into empty pens.
2. Animals are sociable! Animals must be moved two at a time.
3. Two animals that are moved together must start right next to each other and end up right next to each other.
4. Animals cannot reorder themselves while being moved.

Challenges:

1. Solve the puzzle above in 6 moves.
2. Solve the puzzle above in only 3 moves.
3. Solve the same puzzle with 12 pens, 4 goats, and 4 sheep.
4. Can you come up with a procedure that works for any number of goats and sheep?

Activity #3: Chomp

Materials:

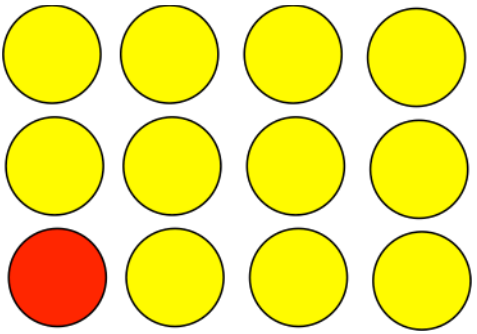
- 12 two-color counters

Objective:

Don't eat the poisoned chocolate (red). Whoever eats it *loses!*

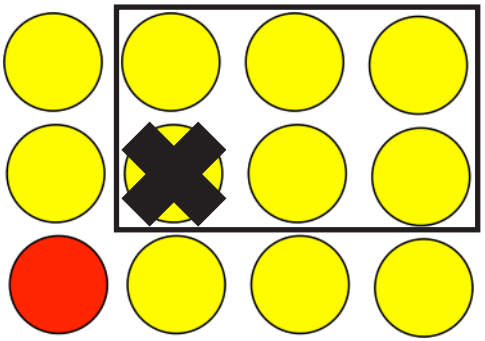
Set-Up:

1. Set up a 3 x 4 grid of yellow dots.
2. Flip the bottom left dot to the red side, like below:



Rules:

1. Players take turns chomping chocolate pieces.
2. To do this, a player eats (removes) any piece of chocolate, and then eats all of the pieces above and to the right of it.
3. For example, if a player eats the piece with an X on it, the player must eat all of the pieces in the rectangle:



Variants:

1. Play the same game with a different starting grid (e.g. 3 x 3, 2 x 5, 4 x 4).
2. Play the same game, but make more pieces of chocolate poisoned by flipping them from the yellow to the red side. After all pieces of chocolate are eaten, whoever eats the *most* poisoned pieces loses.

Activity #4: Making Squares

Materials:

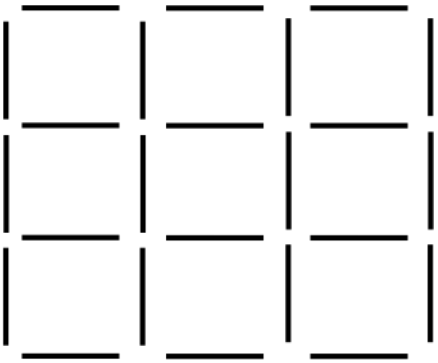
- 24 matchsticks.

Objective:

Create squares by removing matchsticks.

Set-Up:

Create a 3 x 3 grid using matchsticks, like below:



Rules:

1. Remove 4 matchsticks to make 5 squares.
2. Remove 6 matchsticks to make 5 squares.
3. Remove 6 matchsticks to make 3 squares.
4. Remove 8 matchsticks to make 4 squares.
5. Remove 8 matchsticks to make 3 squares.
6. Remove 8 matchsticks to make 2 squares.

Challenges:

1. Use all 24 matchsticks to make 4 squares.
2. Use all 24 matchsticks to make 5 squares.
3. Use all 24 matchsticks to make 6 squares.
4. Use all 24 matchsticks to make 7 squares.
5. Use all 24 matchsticks to make 8 squares.
6. Use all 24 matchsticks to make 9 squares.

Activity #5: Nim

Materials:
- 24 matchsticks

Objective:
Take the last matchstick.

Set-Up:
1. Place all of the matchsticks in a pile on a flat surface.

Rules:
1. Players take turns taking 1, 2, or 3 matchsticks.
2. The player who takes the last matchstick *wins!*

Variants:
1. Play the same game with a different number of matchsticks in the starting pile.
2. Play the same game, but allow players to take a different number of matchsticks each turn (e.g. 1, 2, 3, or 4; 2, 3, or 4; 1, 3, or 5).
3. Play the same game, but the player who takes the last matchstick *loses*.
4. Play the same game, but players take turns taking up to half of the available matchsticks. Players must take at least 1 matchstick, even if it breaks the previous rule.
5. Play the same game, but players take turns taking up to twice as many as the previous player. Players must take at least 1 matchstick. The first player must take 1 matchstick.
6. Play the same game, but start with an odd number of matchsticks. The player who has an odd number of matchsticks by the end of the game *wins*.

Activity #6:
Continuous Dots and Boxes

Materials:
- 24 matchsticks
- 10 two-color counters

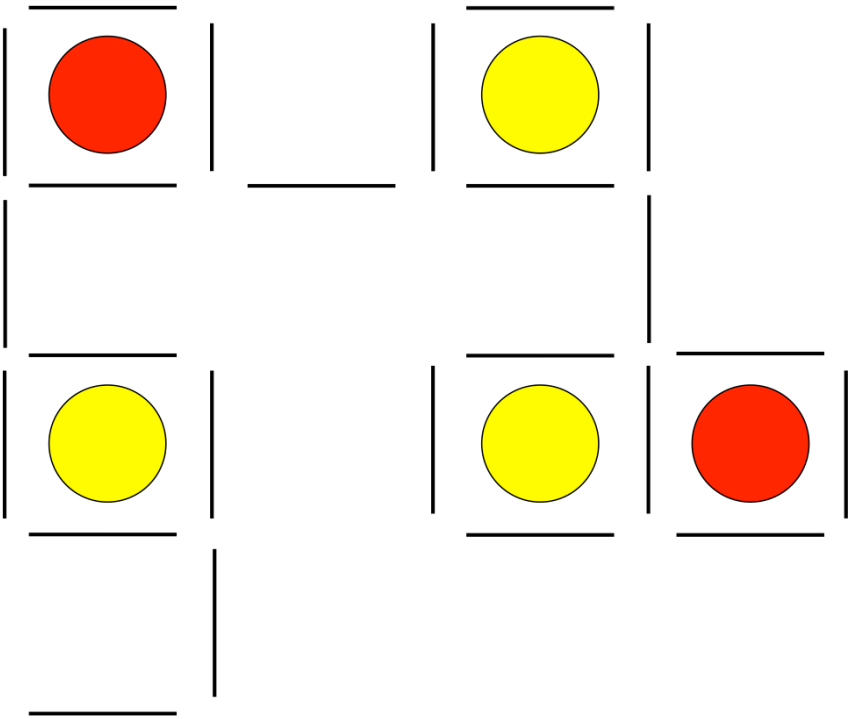
Objective:
Create the most squares.

Set-Up:
1. Find a large flat surface, like a table. Other than that, there is no setup!

Rules:
1. Each player starts with 12 matchsticks and 5 two-color counters. One person plays with red counters and the other with yellow.
2. Players take turns placing matchsticks horizontally or vertically on the playing surface.
3. When a new matchstick is placed, it must touch a matchstick that is already on the playing surface.
4. There can be no more than 3 matchsticks in a straight line.
5. When a player completes a square, the player places one of his or her two-color counters inside their square to claim it.
6. When both players run out of matchsticks, the player who completes and claims the most squares wins!

Variants:
1. Play the same game, but add the rule that when a player completes a square, the player gets another turn.
2. Play the same game, but the player who completes the most number of squares loses. Add the rule that if a player can complete a square, they must complete a square.

Example of a Completed Continuous Dots and Boxes Game



Yellow Wins!

Activity #7:
The Game of the Amazons

Materials:

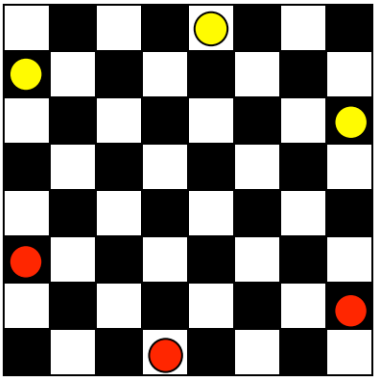
- 6 two-color counters
- 24 matchsticks
- Chessboard

Objective:

Trap all of the other player's amazons.

Set-Up:

1. One player chooses red, and one chooses yellow.
2. Each player gets 3 amazons in his or her color and places them on a chessboard, like below:



3. Place a pile of matchsticks on one side of the board.

Rules:

1. Players take turns moving one of their amazons.
2. Amazons move like queens (any number of squares up, down, left, right, or diagonal).
3. Amazons cannot land on or jump over other amazons.
4. After a player moves an amazon, that amazon shoots a flaming arrow from the square on which the amazon lands.
5. The player chooses the square on which the flaming arrow lands. A flaming arrow also moves like a queen (any number of squares up, down, left, right, or diagonal).
6. The square on which a flaming arrow lands on is destroyed for the rest of the game. Place a matchstick on destroyed squares.
7. Amazons cannot land on or jump over destroyed squares.
8. When a player can no longer move any of his or her amazons, the player loses.

Variants:

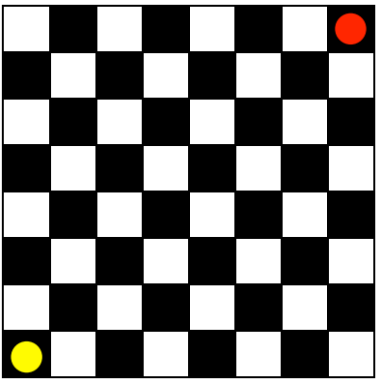
1. Play the same game, but place your amazons in different starting squares.
2. Play the same game, but start with more or fewer amazons.
3. Play the same game, but an amazon shoots two flaming arrows each turn instead of one.
4. Play the same game, but allow amazons to land on and capture enemy amazons.
5. Play the same game, but amazons now move like knights (L-shape) instead of queens.

Activity #8: Rook's Move

Materials:
- 2 two-color counters
- Chessboard

Objective:
Move the playing piece (red) onto the goal square (yellow).

Set-Up:
1. Place a red counter in the upper right-hand corner of a chessboard. Place a yellow counter in the lower left-hand corner, like below:



Rules:
1. Players take turns moving the red counter.
2. The red counter moves like a rook towards the yellow counter (any number of squares to the left or downward).
3. The first player to reach the yellow counter wins.

Variants:

1. Play the same game, but have the red counter start on another square on the chessboard.
2. Play the same game, but the first player to reach the yellow counter loses.
3. Play the same game, but the red counter moves like a king towards the yellow counter (one square to the left, downward, or diagonally southwest).
4. Play the same game, but the red counter moves like a knight towards the yellow counter (southwest L-shapes). If a player cannot move the red counter in a southwest L-shape, the player may move the red counter in any L-shape. A player cannot force the other player to return to the same square two times in a row.

Activity #9: Angels and Devils

Materials:

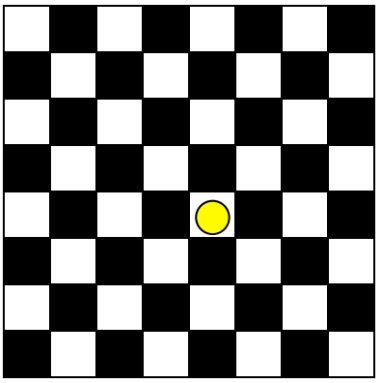
- 1 two-color counter
- 24 matchsticks
- Chessboard

Objective:

The Angel wins if she reaches any edge of the board. The Devil wins if she traps the Angel.

Set-Up:

1. One player chooses to be the Angel, and the other the Devil.
2. The Angel places a two-color counter (it doesn't matter if it's red or yellow) in one of the middle four squares on the chessboard, like below:



3. The Devil places the matchsticks in a pile next to the chessboard.

Rules:

1. The Devil goes first. The Devil destroys one of the empty squares on the board by placing a matchstick over it.
2. The Angel goes next. The Angel moves one square up, down, left or right.
3. The Angel cannot move diagonally.
4. The Angel cannot land on or jump over any destroyed square.
5. The Devil and Angel alternate turns until either the Angel escapes to one edge of the board or the Devil traps the Angel.

Variants:

1. Play the same game, but the Angel goes first.
2. Play the same game, but the Angel can only move one square diagonally.
3. Play the same game, but the Angel moves like a king (one square up, down, left, right, or diagonally).
4. Play the same game, but the Angel moves like a king, and the Devil destroys 2 squares each turn instead of 1.
5. Play the same game, but the Angel moves two squares up, down, left, right, or diagonally, and the Devil destroys a number of squares each turn that is agreed upon by the players before the game starts.

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References

Many different sources and organizations have inspired the puzzles and games found in this booklet. I wanted to give credit to my many inspirations as well as provide you all with some avenues to further explore the world of recreational math.

1. Budapest Semesters in Mathematics Education [**bsmeducation.com**] (Game #1, Game #3, Game #8)
2. The Moscow Puzzles: 359 Mathematical Recreations by Boris A. Kordemsky (Puzzle #2)
3. Tricks, Games, and Puzzles with Matches by Maxey Brooke (Puzzle #4, Game #5)
4. Julia Robinson Math Festivals [**jrmf.org**] (Game #7, Game #8)
5. Winning Ways for your Mathematical Plays by Burlekamp, Conway, and Guy (Game #9)

"The JRMF really gets it right. Usually the best parts of mathematics are kept away from the public, as if you needed to be a mathematician to get to the fun stuff! It's refreshing to see a festival that brings this stuff to light, and in such a relaxed atmosphere. If you're lucky enough to have a JRMF near you, don't miss it! It's the best math party around."

Vi Hart, Mathemusician, youtube.com/user/ViHart

Julia Robinson Mathematics Festival supports locally organized events that inspire K–12 students to explore the richness and beauty of mathematics through collaborative, creative problem-solving.

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