Creativity and Storytelling in Mathematics Education

Philipp Legner, @MathigonOrg
6 May 2020
What is Mathematics all about?

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

SINE RULE
\[ \frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C} \]

COSINE RULE
\[ a^2 = b^2 + c^2 - 2bc \cos A \]
\[ \cos A = \frac{b^2 + c^2 - a^2}{2bc} \]

\[ \frac{12}{\sqrt{15} - \sqrt{7}} = \frac{12}{\sqrt{15} + \sqrt{7}} \cdot \frac{\sqrt{15} + \sqrt{7}}{\sqrt{15} + \sqrt{7}} \]
\[ = \frac{12\sqrt{15} + 12\sqrt{7}}{15 - 7} \]
\[ = \frac{12\sqrt{15} + 12\sqrt{7}}{8} \]
\[ = \frac{3\sqrt{15} + 3\sqrt{7}}{2} \]

A U B : “A union B” i.e. A or B or both
A \cap B : “A intersection B” i.e. both A and B

A + B + C = 180°

SOH
\[ \sin \theta = \frac{a}{h} \]

CAH
\[ \cos \theta = \frac{a}{h} \]

TOA
\[ \tan \theta = \frac{a}{h} \]

\[ \frac{d}{dx} (\sin(x)) = \cos(x) \frac{dx}{dx} \]
\[ \frac{d}{dx} (\cos(x)) = -\sin(x) \frac{dx}{dx} \]
\[ \frac{d}{dx} (\tan(x)) = \sec^2(x) \frac{dx}{dx} \]
\[ \frac{d}{dx} (\csc(x)) = -\csc^2(x) \frac{dx}{dx} \]
\[ \frac{d}{dx} (\sec(x)) = \sec(x) \tan(x) \frac{dx}{dx} \]
\[ \frac{d}{dx} (\cosh(x)) = \sinh(x) \frac{dx}{dx} \]
\[ \frac{d}{dx} (\sinh^{-1}(x)) = \frac{1}{\sqrt{x^2 + 1}} \frac{dx}{dx} \]
What is Mathematics all about?

**Meaningful Mathematics**
- Art and Beauty
- History of Mathematics
- Puzzles, Patterns and Games
- Understanding Nature and Science
- Fiction

**Useful Mathematics**
- Problem-solving
- Critical Thinking
- Creativity
- Abstraction
- Precision

**Applications**
- Arithmetic + Algebra
- Modelling + Simulation
- Data Science
- Cryptography
Storytelling
Trigonometry
Trigonometry

\[
\frac{\sin 151^\circ}{d} = \frac{\sin 6^\circ}{5}
\]
INDEX CHART
TO THE
GREAT TRIGONOMETRICAL SURVEY
OF
INDIA
NOJLI TOWER.

A STATION OF THE GREAT TRIGONOMETRICAL SURVEYED IN THE PLAINS OF UPPER INDIA NEAR RANCHI AND FROM WHICH THE HIMALAYAN PEAKS OF RAINIMATI, KEDARMATI, NOJLI AND RANBARVINGI HAVE BEEN OBSERVED.

FROM A PHOTO BY C.E. BROWNS.
Sports Brackets
EPV = 1.3%
Carbon Dating
Carbon Dating
Cicadas

13 17

mathigon.org/go/cicadas
Public Key Cryptography

Alice

13, 17

Bob

Public Key

221

https://mathigon.org/
Roller Coasters

Position

Velocity

Acceleration

Jerk
Monopoly
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**Monopoly**
Roulette
Roulette
THE SIMPSONS AND THEIR MATHEMATICAL SECRETS

SIMON SINGH
AUTHOR OF FERMAT'S LAST THEOREM
TODAY'S MATH JOKE
\[ \sqrt{-1} 2^3 \sum \pi \]
AND IT WAS DELICIOUS

TONIGHT'S ATTENDANCE:
A) 8,191
B) 8,128
C) 8,208
D) No way to tell

\[ M(H^4) = \pi \left( \frac{1}{137} \right)^{\frac{8}{3}} \sqrt{\frac{hc}{G}} \]
\[ 3987^2 + 4365^2 = 4472^2 \]
\[ \Omega(t) > 1 \]
Mathematics is filled with Stories!

- Applications
- Science and Nature
- Games and Puzzles
- History and Mathematicians
- Fiction
Stories are great for teaching!

- Get students excited and motivated
- Make the content more memorable
- Show careers and people who use math
- Encourage to keep studying math and STEM
Tessellations
Alhambra
17 Wallpaper Groups

mathigon.org/go/wallpaper
Volume
Surface Area
Nets/Cross Sections
Euler’s Formula
5 Platonic Solids

Photo by Dirk Eisner
Photos by Dirk Eisner, Joel Lord, Andre Wiederkehr, Michal Kosmulski, noricum, ServeSmasher and fdecomite
**DRAGONS**

This model requires one quadratic sheet of paper.

- Crease horizontally and vertically along centre.
- Flip over and fold along both diagonals.
- Put two opposite corners on top of each other, to create a smaller square.
- Fold the bottom edges towards the centre.
- Repeat previous step on opposite side.
- Fold top triangle down. Unfold the previous three steps.
- Fold the bottom corner upwards.
- Repeat previous step on opposite side.
- Fold top two edges towards the centre.
- Repeat previous step on opposite side.
- ‘Close’ the front two sides and repeat on the back.
- Rotate by 180° and fold the first wing.
- Fold top edges towards centre as shown.
- Repeat previous two steps to create the second wing.
- Fold up the neck of the dragon.
- Rotate unit and repeat steps 3 to 8 at opposite end.
- Fold entire unit along its centre.

1. Fold along centre, then unfold.
2. Fold both edges towards centre, don't open.
3. Fold both edges towards centre again, unfold.
4. Fold bottom corner onto line in centre of top half.
5. Repeat for top corner.
6. Unfold.
7. Fold bottom corner inwards.
8. Fold top corner as shown.
9. Rotate unit and repeat steps 3 to 8 at opposite end.
10. Fold entire unit along its centre.

Each of these 30 units will form the edge of one tetrahedron. At every vertex, three units link together.

- Fold neck twice in opposite directions for the head.
- Fold the tail upwards.
- Add additional creases to both wings.
- This is the final Origami Dragon.

© Mathigon.org

**RHOMBICOSIDODECAHEDRON**

14 Faces (Triangles and Squares)
24 Edges
12 Vertices

This model consists of the interlocking frames of five tetrahedra. It is one of the most difficult models on Mathigon.org, but also the most impressive.

Every tetrahedron is made out of six strips of paper with dimensions in the ratio 1:3. These can be created by cutting a square into three parts. We recommend that you use different colours for every tetrahedron, which means you need two squares in each of five colours.

Once you have created all 5 x 6 x 30 strips, they each need to be folded as follows:

- Fold along centre, then unfold.
- Fold both edges towards centre, don't open.
- Fold both edges towards centre again, unfold.
- Fold bottom corner onto line in centre of top half.
- Repeat for top corner.
- Unfold.
- Fold bottom corner inwards.
- Fold top corner as shown.
- Rotate unit and repeat steps 3 to 8 at opposite end.
- Fold entire unit along its centre.

- Connect all 6 units in any one colour to make the first tetrahedron.
- For the second and third tetrahedra, first create one corner (‘tripod’) and interlink it with the existing shape. Then lock it in place using the remaining three edges of that colour.
- Add the fourth and fifth tetrahedra in a similar way.

© Mathigon.org

**5 INTERLOCKING TETRAHEDRA**

1. Fold along centre, then unfold.
2. Fold both edges towards centre, don't open.
3. Fold both edges towards centre again, unfold.
4. Fold bottom corner onto line in centre of top half.
5. Repeat for top corner.
6. Unfold.
7. Fold bottom corner inwards.
8. Fold top corner as shown.
9. Rotate unit and repeat steps 3 to 8 at opposite end.
10. Fold entire unit along its centre.
11. Connect all 6 units in any one colour to make the first tetrahedron.
12. For the second and third tetrahedra, first create one corner (‘tripod’) and interlink it with the existing shape. Then lock it in place using the remaining three edges of that colour.
13. Add the fourth and fifth tetrahedra in a similar way.

© Mathigon.org
Intersecting Tetrahedra
$x_{n+1} = x_n^2 + c$
MandelComp = Compile[
    {{c, _Complex}},
    Module[{{num = 1},
        FixedPoint[(num++; #^2 + c) &, 0, 8191, SameTest -> (Re[#]^2 + Im[#]^2 >= 4 &)];
        num],
        CompilationTarget -> "C",
        RuntimeAttributes -> {Listable},
        Parallelization -> True}
    ];

Mandelbrot[x_, y_, m_] := ArrayPlot[
    MandelComp[Table[a + I b,
        {b, y - 2.7 * 2^-m, y + 2.7 * 2^-m, 0.005 * 2^-m},
        {a, x - 4.8 * 2^-m, x + 4.8 * 2^-m, 0.005 * 2^-m}(*0.002*)
    ]] / 8192,
    ColorRules -> {1 -> Black},
    ColorFunction -> MandelColor,
    ColorFunctionScaling -> False,
    Frame -> False,
    PixelConstrained -> 1]
imaginary.org/program/surfer

\[ x^2 + y^2 + z^2 + 2 \cdot x \cdot y \cdot z - 1 = 0 \]
imaginary.org/program/surfer

\[(x^2+9/4\cdot y^2+z^2-1)^3-x^2\cdot z^3-9/80\]

\[x^3+x^2\cdot z^2-y^2\]
#MathArtChallenge

@KjerstiFried
@RosieTChen
@jayproffitt
@anniek_p
@Cshearer41
@bquentin3
\[ \frac{12}{\sqrt{2}} \approx 1.4983... \approx 1.5 \]
Creativity is Problem Solving!

- Reduce complex problems to their essentials and discover patterns.
- Express situations using new or different representations.
- Recognise implicit assumptions and think outside the box.
- Combine tools and results from different parts of mathematics.
You break a stick in two different places, uniformly at random. What is the probability that the three resulting pieces form a triangle?
You break a stick in two different places, uniformly at random. What is the probability that the three resulting pieces form a triangle?
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You break a stick in two different places, uniformly at random. What is the probability that the three resulting pieces form a triangle?
Here are some *Trapezium Numbers*. There is just one number between 1000 and 2000 that *doesn’t* form a Trapezium. Which one?
Here are some Trapezium Numbers. There is just one number between 1000 and 2000 that *doesn’t* form a Trapezium. Which one?
Here are some *Trapezium Numbers*. There is just one number between 1000 and 2000 that *doesn’t* form a Trapezium. Which one?
Resources
Good Will Hunting

**Noun**: Parallelogram  
**Pronunciation**: /ˌpærəˈlɛləɡram/

1. a portmanteaux word combining parallel and telegram. A message sent each week by the Parallel Project to bright young mathematicians.

There are only 3 more Parallelograms this year, as we will be starting our summer break at half-term. If you score highly enough in the last 4 Parallelograms (#12, this one, #14 & #15) by June 1, **then you will receive a Parallel certificate**. An average of more than 40% in these four Parallelograms wins a bronze certificate, then 60% or more wins silver...
Welcome to the home of rich mathematics

**Teachers**

Free resources and curriculum mapping documents

Early Years

Primary

Secondary, Post 16 and STEP

**Primary Pupils**

The tasks in this feature encourage you to play and explore, then think deeply about the mathematical ideas underneath.

See all problems Open for Solution

See all Resources for ages 5-11

**Secondary Students**

In this feature, explore the problems and then try to explain what's going on!

See all problems Open for Solution

See all Resources for ages 11-18

**Events and PD**

**Your Solutions**

Tweets by @nrichmaths

First day of @nrichmaths PD with a new group of primary teachers from Tower Hamlets. Six days focusing on whole class reasoning. And I get to work with @FranMaths too. Woo hoo
Welcome to the FIFA World Cup!

From making penalties fairer or taking the perfect free kick, to designing an ideal ball and predicting results using an octopus, it's all there in our collection of football articles. Take your pick!

Genetics: Nature's digital code
Is nature using digital tools to deal with genetic information?

Maths in a minute: Chomp
Explore a game that involves biscuits and comes with a surprising mathematical twist — what could be better?

The real numbers and Cauchy sequences
We take the real numbers for granted, but what are they really? Here's an interesting way to look at them...

Clocking the schedule
The way many football leagues schedule their fixtures can lead to unfair effects — and unsolved maths problems! Dries
“Pure mathematics is, in its way, the poetry of logical ideas.”

Albert Einstein
The Golden Ratio (why it is so irrational) - Numberphile

2,398,250 views • 1 year ago

Check out Brilliant (and get 20% off) by clicking
https://brilliant.org/numberphile

Featuring Ben Sparks --- More links & stuff in full description below ↓↓↓

Golden seeds limited edition T-Shirt:
https://teespring.com/NP-Seeds

READ MORE
The diagram above highlights the “shallow” diagonals in different colours. If we add up the numbers in every diagonal, we get the $\text{???}$.
Thanks for listening!

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@MathigonOrg