Blackline Masters Table of Contents

M1.U3.L12 Sorting Systems card sort

Sorting Systems Card 1 $\begin{cases} y = 2x - 7 \\ y = -7x + 2 \end{cases}$	Sorting Systems Card 2 $\begin{cases} y = 2x - 3 \\ y = 2x - 13 \end{cases}$	Sorting Systems Card 3 $\begin{cases} y = -\frac{1}{3}x - 3 \\ 3y = -9 - x \end{cases}$
Sorting Systems Card 4 $\begin{cases} 3x + y = -10 \\ 3y = -x - 10 \end{cases}$	Sorting Systems Card 5 $\begin{cases} x - 4y = -12 \\ 5x - 20y = 60 \end{cases}$	Sorting Systems Card 6 $\begin{cases} x - y = -6 \\ x - 4y = 12 \end{cases}$
Sorting Systems Card 7 $\begin{cases} 4y = x + 4 \\ y = \frac{1}{4}x + 1 \end{cases}$	Sorting Systems Card 8 $\begin{cases} x + y = 5 \\ x + y = 12 \end{cases}$	

Name: Period: Date:

Station H: Are You Ready For More?

1. A 450-gallon tank full of water is draining at a rate of 20 gallons per minute.

   a.
      - How many gallons will be in the tank after 7 minutes?
      - How long will it take for the tank to have 200 gallons?
      - Write an equation that represents the relationship between the gallons of water in the tank and minutes the tank has been draining.
      - Graph your equation using graphing technology. Mark the points on the graph that represent the gallons after 7 minutes and the time when the tank has 200 gallons. Write down the coordinates.
      - How long will it take until the tank is empty?

   b. Write an equation that represents the relationship between the gallons of water in the tank and *hours* the tank has been draining.

   c. Write an equation that represents the relationship between the gallons of water in the tank and *seconds* the tank has been draining.

d. Graph each of your new equations. In what way are all of the graphs the same? In what way are they all different?

e. How would these graphs change if we used quarts of water instead of gallons? What would stay the same?

(From Unit 3, Lesson 1)

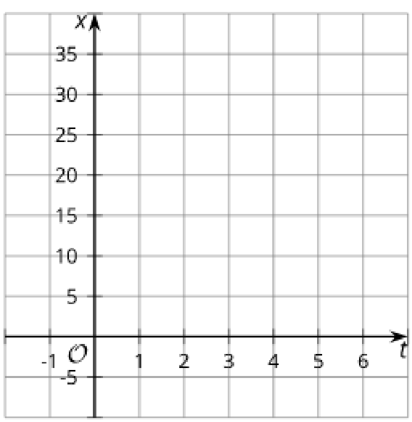
2. Another way to describe a line, or other graphs, is to think about the coordinates as changing over time. This is especially helpful if we're thinking about tracing an object's movement. This example describes the x- and y-coordinates separately, each in terms of time, t.

   a. On the first grid, create a graph of $x = 2 + 5t$ for $-2 \le t \le 7$ with x on the vertical axis and t on the horizontal axis.

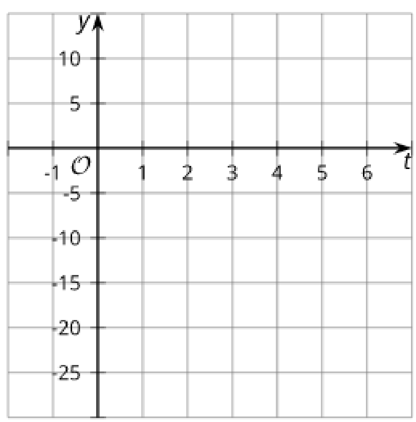
   b. On the second grid, create a graph of $y = 3 - 4t$ for $-2 \le t \le 7$ with y on the vertical axis and t on the horizontal axis.

   c. On the third grid, create a graph of the set of points $(2 + 5t, 3 - 4t)$ for $-2 \le t \le 7$ on the xy-plane.

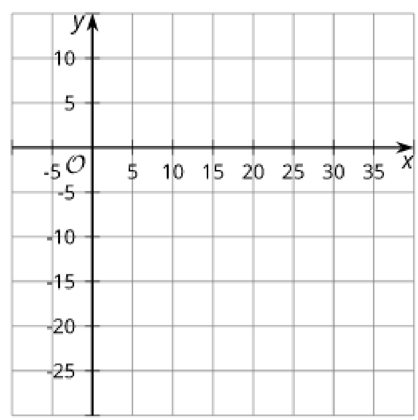
Grid 1



Grid 2



Grid 3



(From Unit 3, Lesson 4)

3.

a. Line l is represented by the equation $y = \frac{2}{3}x + 3$. Write an equation of the line perpendicular to l, passing through $(-6, 4)$. Call this line p.

b. Write an equation of the line perpendicular to p, passing through $(3, -2)$. Call this line n.

c. What do you notice about lines l and n? Does this always happen? Show or explain your work.

(From Unit 3, Lesson 6)

4.

a. Make up equations for two lines that intersect at $(4, 1)$.

b. Make up equations for three lines whose intersection points form a triangle with vertices at $(-\ 4, 0)$, $(2, 9)$, and $(6, 5)$.

(From Unit 3, Lesson 8)

5. Solve this system with four equations. $\begin{cases} 3x+2y-z+5w=20 \\ y=2z-3w \\ z=w+1 \\ 2w=8 \end{cases}$

(From Unit 3, Lesson 9)

6. This system has three equations: $\begin{cases} 3x+2y-z=7 \\ -3x+y+2z=-14 \\ 3x+y-z=10 \end{cases}$

   a. Add the first two equations to get a new equation.

   b. Add the second two equations to get a new equation.

   c. Solve the system of your two new equations.

   d. What is the solution to the original system of equations?

(From Unit 3, Lesson 10)

Card Sort: Representations of Inequalities
situation

- A jar contains only nickels and dimes.
- There is no more than $6 in the jar.
- x represents the number of nickels and y represents the number of dimes in the jar.

Card Sort: Representations of Inequalities
situation

- The length of a rectangle is represented by x and its width is represented by y.
- The perimeter of the rectangle is greater than 240 units.

Card Sort: Representations of Inequalities
inequality

$$y \geq 100$$

Card Sort: Representations of Inequalities
inequality

$$4x + 3y \geq 240$$

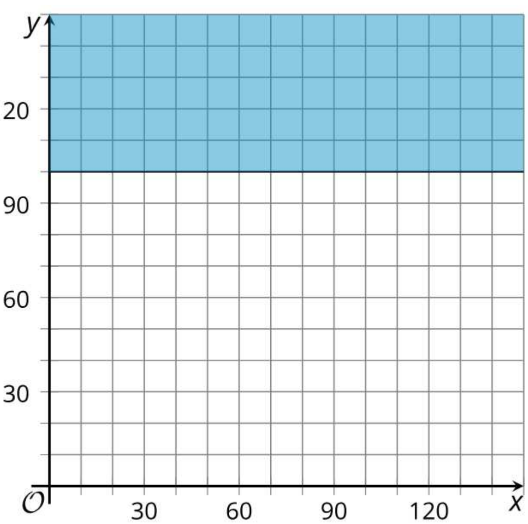
Card Sort: Representations of Inequalities
a solution

$$(80, 30)$$

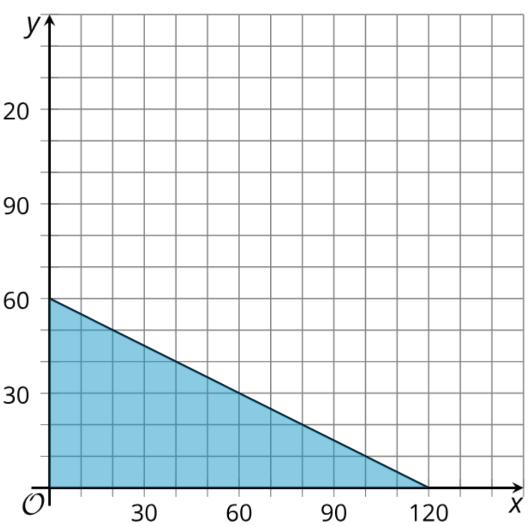
Card Sort: Representations of Inequalities
a solution

$$(20, 50)$$

Card Sort: Representations of Inequalities
graph



Card Sort: Representations of Inequalities
graph



Card Sort: Representations of Inequalities

situation

- A seller at the Saturday market sells honey and jam. He wants to make at least $240 profit this Saturday.
- He makes $4 profit for each jar of honey he sells and $3 profit for each jar of jam.
- x represents the number of jars of honey he sells and y represents the number of jars of jam.

Card Sort: Representations of Inequalities

situation

- A school is organizing a service trip. Students and teachers can sign up to go.
- x represents the number of teachers who sign up and y represents the number of students.
- The trip will only take place if at least 100 students sign up.

Card Sort: Representations of Inequalities

inequality

$$0.05x + 0.10y \leq 6.00$$

Card Sort: Representations of Inequalities

inequality

$$2x + 2y > 240$$

Card Sort: Representations of Inequalities

a solution

$$(80, 50)$$

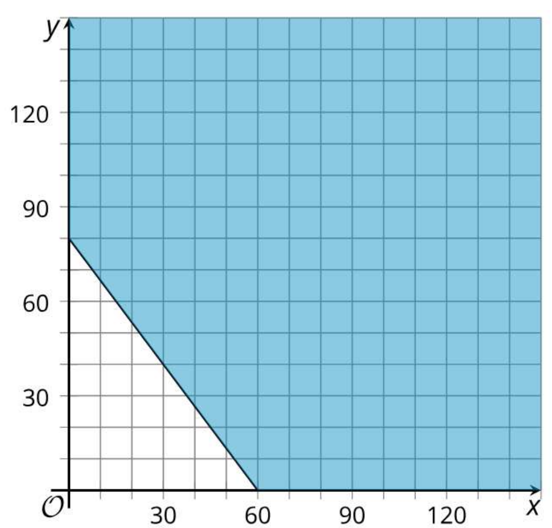
Card Sort: Representations of Inequalities

a solution

$$(20, 100)$$

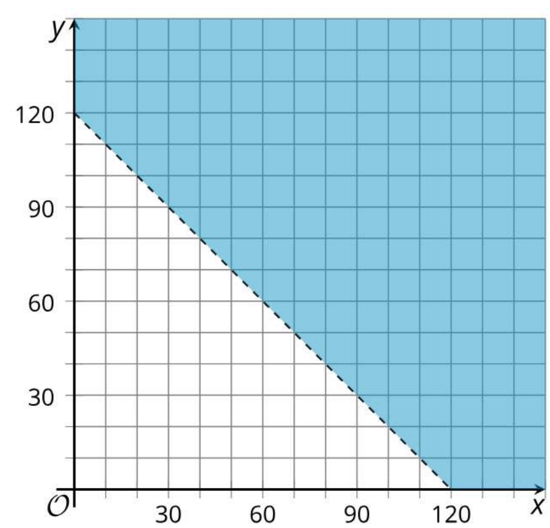
Card Sort: Representations of Inequalities

graph



Card Sort: Representations of Inequalities

graph



Adapted by Illustrative Mathematics Algebra 1, Unit 2, Lesson 23

Name: Period: Date:

End-of-Unit 3 Student Survey

1. Ending this unit I <u>feel</u> … (this question could be answered with pictures, words, etc.)

2. How much did you know about the content of this unit before starting?
   a. A great deal b. A little c. Not much

   Feel free to share more:

3. After finishing the unit did your knowledge in the content:
   a. Increase greatly b. Increase a little c. Stay the Same

   Feel free to share more:

4. What was most frustrating for you while learning during this unit?
   a. Materials Used b. Teacher strategies c. Technology d. Other: ________

   Feel free to share more:

5. What boosted your confidence in math during this unit?
   a. Materials Used b. Teacher strategies c. Technology d. Other: ________

   Feel free to share more:

6. What connections do you think the concepts from this unit make to the world around you?

7. What did your level of engagement and participation during the unit tell you about yourself and the way you see yourself and your abilities in math?

8. How would you like to improve in the next unit?

9. How can your teacher support your goals for improvement in the next unit?

10. I'd like my Math 1 teacher(s) to know that I want them to continue ________

11. Please share anything else you'd like regarding your experiences in this unit and your feelings about the upcoming unit.

Game Design and Math

The Nuts and Bolts of Using Math to Make Excellent Video Games[1]

Written by Dustin Tyler

Beneath all those cool character animations, smart enemies, and fun game mechanics in your favorite games is one thing: math.

Mathematics is the foundation of every game and necessary for everything to work as the designers intended.

This doesn't just include huge games like Middle Earth: Shadow of Mordor and its enemy-generating Nemesis system. Even Pac-man employs math to decide how the enemy ghosts move, how long they take to regenerate after being eaten, etc.

Even Pong, arguably one of the simplest games ever made, uses math to dictate the speed of the paddles and movement of the ball.

Math = The Foundation of Game Design

In the same way that math doesn't work unless you learn and apply the rules, a video game can't have rules without math. When you think about it, video games are essentially virtual worlds with lots of rules that keep everything working as intended.

No math means Mario keeps floating up after jumping, bullets in Call of Duty shoot in random directions, and even your favorite character in Angry Birds move in inconsistent ways if it moves at all.

Most of the time the math you learned in high school and college is no different than what was used to design a game. To name a few, some of the common branches of math utilized in game development include:

- Algebra
- Trigonometry
- Calculus
- Linear Algebra
- Discrete Mathematics
- Applied Mathematics
- And more …

[1] Gaming Design https://www.gamedesigning.org/questions/#citation

More specific elements of math almost always used in games include:

- Matrices
- Delta time
- Unit and scaling vectors
- Dot and cross products
- And scalar manipulation

Math In Programming

While math is useful even in the art side of game development, it's the programmers who make use of it to create the characters, mechanics, and more.

Without math, programmers wouldn't be able to make objects in the game do even the simplest of things, including movement.

Game code combined with variables, vectors, and more is what tells Sonic to run slowly when the player barely presses the D-pad, runs faster when at a full dash, stops completely when he runs into a solid object, and run move differently when underwater.

It's not hard to see why a game without programming and math would just be a bunch of pretty, useless art.
Together they allow games to simulate our worlds, such as moving water and physics, as well as to deliver something outside real-world possibilities.

Only in Portal can we know what it feels like to step through portals, while only in Halo can we dash at ridiculous speeds to impale a foe with an Energy Sword.

Lifelike water, pathfinding, procedurally generated levels, critical hits, AI that reacts to player input, and even the game engine architecture itself– all of these are not possible for a programmer to do without math.

If you're considering a career as a game programmer and even designer, expect math to be your greatest tool for creating worlds that players will enjoy thanks to addicting gameplay that not only works as intended but is fun as well.

Does Programming Require Knowing Math?

Yes, to a certain degree.
If you want to have a strong sense of control over programming basics, it's wise to have at least the basic knowledge of math concepts like logic, algebra, and more. You won't be required to answer complex math problems while coding, but there will most likely be example problems using math equations, and logic.

How Much Math Do I Need To Know To Code?

This depends because not everything in code needs the programmer to take part in the mathematical process. You won't be solving equations and going into detail. If you are hung up on numbers and problems, the computer can usually figure out those details.

Math in Video Games

Video games and math are basically interchangeable in how enmeshed they are with each other. Every action you do in-game is due to a math calculation of some sort.

Luckily for us, we harness the power of computer programming to cut away all the complicated math that would take hours to complete by hand. Without math, games wouldn't be what they are.

Running, jumping, flying, diving, surfing, and basically any physical activity is governed by some sort of school of mathematics.

Numbers

Everyone knows numbers; they're what makes our society push onward. The same goes for math in video games. If it weren't for all of those 1's and 0's, we wouldn't be able to program and create games properly.

Discreteness

This refers to the limits in which certain aspects of gaming have. Discreteness is the opposite of continuous, meaning a neverending set of numbers. In games, we need discreteness to contain and build our game.

Geometry

Geometry, the field of math that questions the properties, shape, and size of things in a given space, is vital for math in video games. It's based on right-angled triangles. The geometry makes up nearly all we see in our video games.

Coordinate Systems

You need to have a concept of where an object is in space and time. We do this by using different numbers to label the coordinates, where the object will take space.

Iteration

This is all about computers repeating themselves. This is a crucial function during the game development process. You can't have long pauses in gameplay, so you need to split up different portions and make sure they're all working correctly.

Physics

Another huge area of gaming, physics, is the broad field of math in video games. Whether your character is hitting a baseball, jumping over a hedge, or shooting at a target, physics plays one of the most prominent roles in games.

Cheating

No, these aren't video game cheat codes. Cheating refers to using shortcuts in the programming process to make our lives a little easier. This is using mathematical functions to simplify hard functions.

Intelligent Motion

Intelligent motion is the many different algorithms used by enemy characters to undertake specific actions in reaction to the player's presence. Things like acceleration, velocity, and position all affect how enemies react to a target.

Pitfalls

As you can probably guess, pitfalls refer to anything in the coding process that can mess up your code and your game. These are accidental mistakes or bugs within the code.

FAQs

What math do you need for video game design?

- It's recommended that you know the basic concepts of geometry, algebra, some trig, and logic. However, this is different for most people and shouldn't dissuade you from trying if you don't know more advanced math.

Does game development require math?

- Yes, it requires a few different subsets of math.

What kind of math is used in computer programming?

- Algebra, trigonometry, calculus, logic

Do you need to be good at math to be a programmer?

- You don't need to be 'good,' necessarily. It's a bit complicated, as math in video games is a broad concept. Essential functions like finding the sum and multiplication can be delegated to your computer.

Can you learn to code if you're bad at math?

- Yes, absolutely. Some people are fantastic programmers who have struggled with or even failed calculus classes.

Does coding involve math?

- Yes, it can use anything from linear algebra to calculus, depending on the project.

Is coding harder than math?

- It depends entirely on the capabilities of the coder. Some find it much more comfortable.

Can you be a programmer if you're bad at math?

- Yes. Coding isn't as dependent on harder math concepts as you might think. Many examples used in tutorials and books use these more difficult concepts to illustrate how to do something, which could prove to be an issue. Being better at math helps you understand more advanced concepts and what they represent.

Can you be a programmer without math?

- No, as a lot of coding is based on the mathematical field of logic. You can perhaps get by without using trigonometry and calculus, but you will most likely need to know some algebra and logic.

Article from:
Dustin Tyler. "The Nuts and Bolts of Using Math to Make Excellent Video Games". Game Designing, Lake House Media, LLC, May 25, 2021, https://www.gamedesigning.org/learn/game-development-math/.

Music and Math

How a Little Mathematics can Help Create some Beautiful Music[2]

Written by Andrew J. Milne, Postdoctoral Research Fellow in Music Cognition and Computation, Western Sydney University and Dr. Steffen A. Herff, PhD candidate, Memory and Music Perception, Western Sydney University

Since the time of Pythagoras around 500 BCE, music and mathematics have had an intimate and mutually supportive relationship.

Mathematics has been used to tune musical scales, to design musical instruments, to understand musical form and to generate novel music. But what can mathematics say about one of the most common features of contemporary music – rhythmic loops?

Repeated rhythmic loops are an essential component of most electronic dance music and hip-hop, and also play an important role in rock, jazz, Latin and non-Western music.

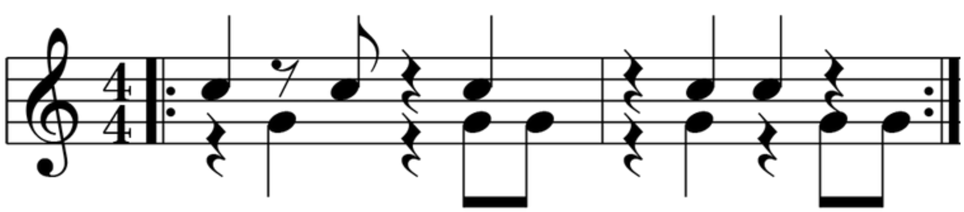
Now, two mathematical models of rhythmic loops – made in a free software application called XronoMorph – can be used to generate exciting new musical structures that would otherwise be hard to compose or perform.

Rhythmic loops: Circles and polygons

A natural geometrical characterisation of a periodic structure, such as a rhythmic loop, is as a circular arrangement of points. You can travel clockwise around a circle but inevitably you come back to where you started.

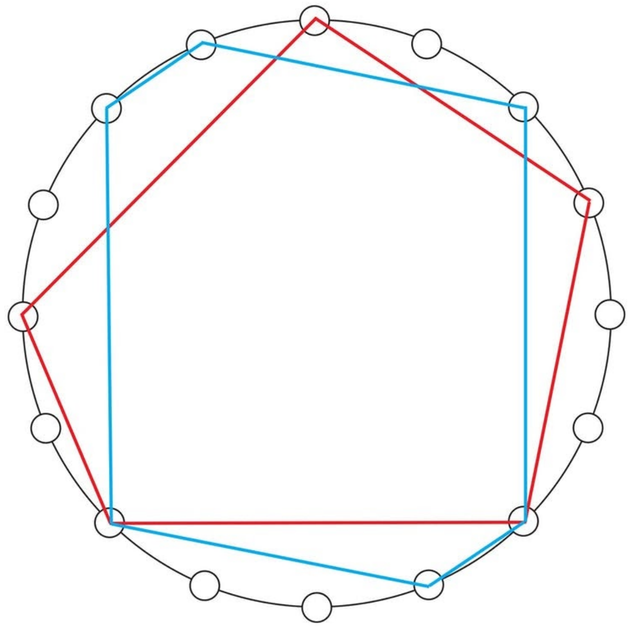
A common feature of rhythmic loops is that they are multilevel. For example, in Latin percussion, different instruments play different interlocking patterns that may or may not coincide. Such rhythms can be depicted by multiple polygons on the same circle.

A simple geometrical representation is to draw lines that make each of these independent levels into an independent polygon. In this way, a multilevel rhythm becomes a collection of inscribed polygons.



Clave (top) + Conga (bottom) rhythm in score notation. Andrew Milne, Author provided

[2] From https://theconversation.com/how-a-little-mathematics-can-help-create-some-beautiful-music-61812



Clave (red) + Conga (blue) rhythm as polygons. Andrew Milne, Author provided

But which polygons?
There are more than 17 trillion different rhythms, and that is only counting rhythms with three levels where every beat occurs at one of 16 distinct time locations (16 being a very common temporal subdivision in music).

But, realistically, only a small proportion of these are of musical interest. The trick is to find them.

Two mathematical principles – well-formedness and perfect balance – allow us to easily navigate two distinct rhythmic sub-spaces that are of musical interest, but hard to explore with traditional computational tools or notation.

Well-formed polygons
Well-formedness elegantly generalises three properties commonly found in real-world multilevel rhythms:

- each rhythmic level comprises only a small number of distinct beat lengths, often only one or two;
- each level's beats are fairly evenly spaced in time – there aren't sudden clusters of events followed by long gaps; and
- the rhythmic levels are hierarchical – there is a slow and metrically dominant level; above this is a faster and weaker level that splits the previous level's beats; above this is an even faster and weaker level that splits the previous level's beats; and so on.

Every level of a well-formed rhythm has two beat lengths: a long beat and a short beat. The length of a given beat is the time between its onset and the onset of the following beat.

A multilevel well-formed rhythm can then be fully defined by three numerical parameters: the numbers of long and short beats in the lowest level rhythm, and the ratio of the sizes of its long and short beats.

From these three numbers, an entire rhythmic hierarchy can be calculated, such that each level has no more than two beat lengths, each level arranges these beat lengths to make them as evenly spaced as possible and each successive level in the hierarchy is created by splitting the long beats of the level below.

Using XronoMorph, the above three parameters can be freely manipulated. The rhythmic hierarchy emerging from them often has great aesthetic appeal. Every level is related to every other level and is also intrinsically well-formed. Together, they create a somewhat self-similar and interwoven structure reminiscent of fractals.

Perfectly balanced polygons

Perfect balance is a mathematical principle that can generalise polyrhythms, a type of rhythm commonly used in sub-Saharan African music.

Unlike well-formed rhythms and most Western rhythms, polyrhythms are not hierarchical. They are more like an alliance of different rhythmic levels, each of equal status.

In a polyrhythm, two or more levels, each comprising evenly spaced beats, are superimposed.

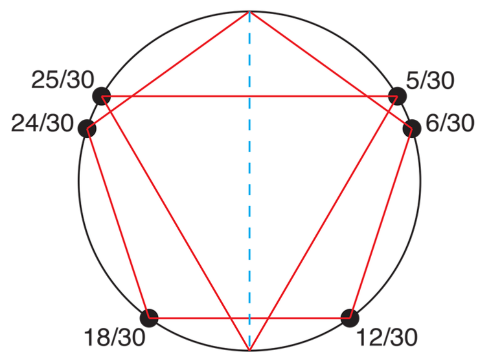
Geometrically, they are combinations of regular polygons like equilateral triangles, squares, regular pentagons, and so forth. In real-world polyrhythms, beats from all levels typically coincide at a single location in the period.

A notable feature of these polyrhythms is that the average position, or centre of gravity, of the circularly arranged beats is precisely at the centre of the circle. This property is defined as perfect balance.

All regular polygons are perfectly balanced, so any combination of regular polygons is also perfectly balanced, and this is true regardless of the individual rotations of the polygons.

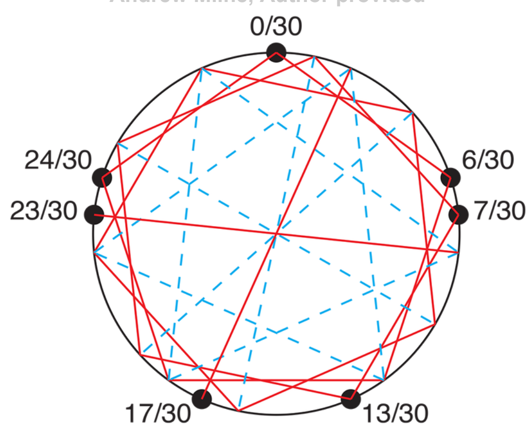
This allows an immediate generalisation of standard polyrhythms. The regular polygons can be independently rotated (time-shifted) so they never coincide. This is a musical feature that is, as far as we know, rarely exploited but which produces exciting rhythmic grooves.

But perfect balance opens up yet another fascinating generalisation of standard polyrhythms. There are certain perfectly balanced shapes – irregular elemental polygons – that are not produced by a simple combination of regular polygons.



An irregular elemental polygon: 1 triangle + 1 pentagon - 1 digon. Only the labelled vertices are sounded.

Andrew Milne, Author provided



An irregular elemental polygon: 2 digons + 3 pentagons - 3 digons - 2 triangles. Only the labelled vertices are sounded.

Andrew Milne, Author provided

Intriguingly, such polygons are constructed by summing differently rotated positively-weighted and negatively-weighted regular polygons. When a positively-weighted vertex and a negatively-weighted vertex coincide they cancel out.

Legal patterns are produced when no negative weights are left behind. So, although we never hear these negative beats directly, they have a ghostly impact by cancelling out some of the positive beats.

In XronoMorph, a wide choice of regular and irregular elemental polygons can be combined and independently rotated, creating a fascinating subspace of generalised polyrhythms.

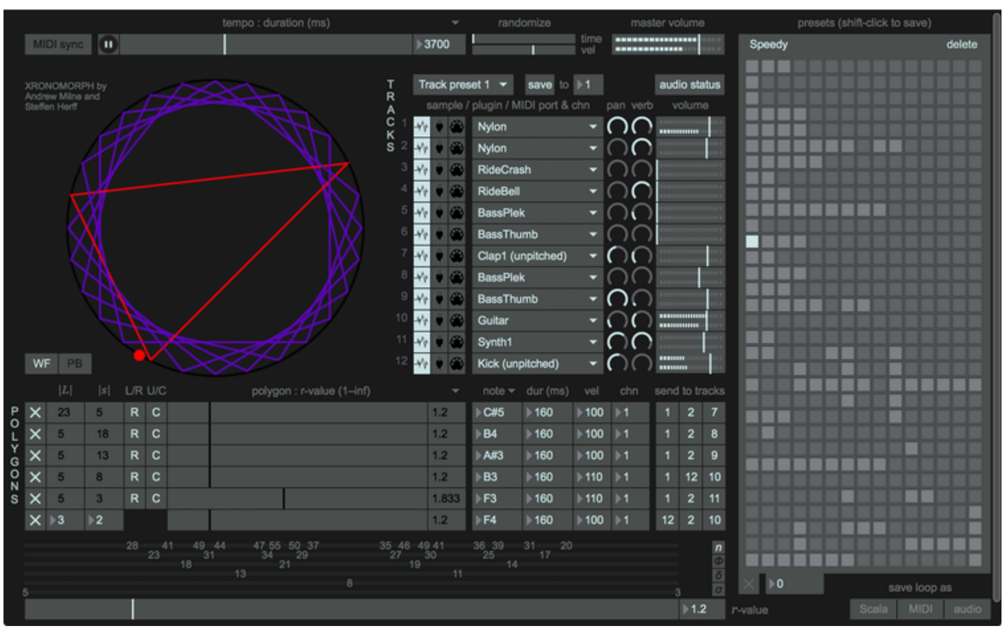
XronoMorph

We developed the rhythmic loop generator XronoMorph to demonstrate these principles, hoping it might inspire musicians and music enthusiasts to create novel and interesting rhythms that would be hard to play manually or to otherwise compose.

Simple and attractive software interfaces can also transform a need for expert knowledge into a willingness to intuitively interrogate the interface. In this way, we also hope it will encourage musical engagement, with potential application in music education by allowing visual exploration of complex rhythmic patterns.

Early reaction from musicians and composers has been highly enthusiastic with comments such as “This is an inspired design – truly musical”, “the most interesting and inventive new app around” and “this really helps me better understand and create beats”.

This lends support to the long-held notion that there is a profound connection between mathematics and music, and that a little mathematics can help create some beautiful music.



XronoMorph screenshot. Andrew Milne, Author provided

Article from:

Andrew J. Milne and Dr. Steffen A. Herff. “How a little music can help create some beautiful music.” The Conversation, https://theconversation.com/how-a-little-mathematics-can-help-create-some-beautiful-music-61812.

Cooking and Math

How to Convert Cups to Pounds[3]

Written by Keith Dooley

Converting measurements is often necessary when you are involved in cooking. Measuring ingredients can require that liquids be converted from one unit of measure to another. A liquid such as water, for example, may need to be converted to ounces or pounds before being mixed. This can at first seem a daunting task, however, when the problem is approached from a point where basic equivalents are considered, then the problem may be more easily worked and the conversion made.

Begin converting cups to pounds by understanding a few basic conversion points. 16 ounces equals one pound or two cups. Another way to look at the equivalent is that one cup weighs eight ounces and therefore two cups equal 16 ounces and this is the same weight of one pound--16 ounces.

Convert a cup measurement to pounds by applying the formula in step one to the problem. For example, if you are converting five cups to pounds you will first multiply five (the number of cups) by eight (the number of ounces in one cup). The answer here is 40.

Divide the number 40 by 16 or the number of ounces in one pound. So, in the example, 40 divided by 16 equals two and one half. The answer is five cups weighs 2.5 pounds. Another way to look at the problem is that for every one pound you must have two cups.

Article from:
Keith Dooley. "How to Convert Cups to Pounds". Sciencing, July 21, 2017,
https://sciencing.com/how-to-convert-cups-to-pounds-12324030.html

Why Is Mathematics Important in Culinary Arts?[4]

Written by Kelly Chester

Surprisingly, mathematics plays an important role in the culinary arts. There are helpful tools, such as measuring cups, measuring spoons and scales, to aid in food preparation. However, some background in measurement, fractions and geometry is necessary when cooking and baking. Chefs need to be able to measure and weigh ingredients, time recipes and adjust and measure cooking temperatures. Furthermore, when creating recipes for special diets, it's important to have a background in the science and mathematics of nutrition.

Measuring in the Kitchen

Measurement is an important math skill that significantly impacts the ability to cook properly. Tools like a glass measuring cup with a spout for liquids and measuring cups for dry ingredients are needed in every kitchen. Measuring spoons for spices and a scale to measure the weights of different foods are also necessary. Even with the use of all measurement kitchen tools, it is required that cooks and bakers understand the metric system and standard system of measurement so that they can apply those skills to following a recipe.

Temperature and Time

Telling time and adjusting temperature are important math skills that factor into the culinary arts. Recipes require different amounts of time, so cooks need to set a timer and monitor food accordingly. Furthermore, temperature adjustment is also very important. When cooking meat in an oven, use a meat thermometer to determine whether your dish is completely

[3] From *https://sciencing.com/how-to-convert-cups-to-pounds-12324030.html.*
[4] From *https://classroom.synonym.com/homemade-facial-using-overripe-banana-11509.html*

cooked. For example, chicken should be cooked to 180 degrees to ensure that bacteria are killed. When cooking at different altitudes, temperatures may need to be increased or decreased in your oven to bake successfully. In addition, altitude effects the boiling point for range-top cooking.

Fractions, Division, and Geometry

An understanding of fractions is crucial to cooking. Aside from measuring in recipes, the use of fractions also impact serving size. For example, if a recipe claims to serve eight people, but you are only serving four, the cook must be able to divide the entire recipe in half. Typically the cook will be required to divide whole numbers as well as fractions. Geometry is used in the presentation of food and baking. If a cook is creating a fancy layer cake, the use of rectangles, squares and circles may be necessary. When arranging food onto a plate, cooks should use different shapes to make foods aesthetically pleasing.

Nutritional Data

Many cooks must take into consideration health and a balanced diet when cooking. As a result, knowledge of calories, fat, sugar and sodium are important for the everyday cook. Using the nutritional information on fresh and packaged foods will enable a cook to provide guests or family members with balanced meals that use a variety of food groups. In addition, calorie, sodium and fat needs vary greatly from person to person. Knowing the dietary requirements of those you are cooking for allows you to create an appropriate menu using nutritional calculations.

Article from:
Kelly Chester. “Why Is Mathematics Important in Culinary Arts?” Sciencing, September 26, 2017, https://classroom.synonym.com/homemade-facial-using-overripe-banana-11509.html

Graffiti through the Looking Glass: Graffiti as an Intersection Between Mathematics and Artestry[5]

Written by Lina

Mathematical minds have long been associated with a lack of creativity and artistry, only holding the ability to think and act linearly. Conversely, artistic minds are thought to hold a special amount of imagination, unbounded by science and logic, and thus do not require a working knowledge of such. In reality, many mathematicians necessitate creativity to succeed just as much as artists do, and many artists need mathematics to succeed just as much as mathematicians do.

In the field of pure mathematics, success is measured not by one's ability to simply compute problems where the answers are known to exist, but by one's ability to prove something true or false, or solve a problem that is thought to be impossible. In order to accomplish such tasks, a vast amount of creativity and ingenuity is required. A mathematician must be able to seemingly conjure ideas out of thin air, the same as any artist would be expected to do. What might come as even more of a surprise is that many artists utilize mathematics throughout many steps of their artistic process, even those who practice art in its most rebellious and cageless form: graffiti. Math is extremely important for the success of many graffiti artists, as perfecting the scale, proportions, shapes, and even the amount of materials necessary for each piece would not be possible without the use of mathematics, even if not used in the most traditional form.

A graffiti artist who is very outspoken about their unique utilization of mathematics for their work is Scape Martinez. Scape is from San Jose, California, which is actually very close to where I grew up. In a series of videos he did for PBS, Scape describes in detail how integral math is to his artistic process. When it comes to scaling, Scape explains that before tackling a piece on a wall, graffiti artists will sketch versions of the work in a notebook. This way, the artists come to the site with a clear conception of what the final product should be beforehand, which helps avoids possible complications that could occur due to time restraint. Scape claims to use math when scaling his projects, which is necessary if an artist intends to maintain proper proportions when transferring their sketches onto a full sized wall. Scape says that in some cases he will even draw a grid underneath his project in order to maintain appropriate distances and proportions throughout his piece, an example of such shown in figure 1. Most interesting though is how Scape has created his own informal measurement system that is specific to graffiti. Because of the high risk and time constraint that comes with creating graffiti, most artists don't have the time to break out a measuring tape to carefully quantify lengths and sizes in inches or meters. In order to combat this obstacle, Scape uses his feet as his point of reference when measuring distance. For example, in order to find the center of a large wall, Scape will walk one foot in front of the other along the entire length of the wall area, then divide the number of steps by two in order to find the halfway point of this distance.

Figure 1. Unfinished Math is Life by Scape Martinez. Preliminary stages showing grid used for scaling. Spray paint on concrete wall. Building/wall unknown. San Jose, California. 2014. Screenshot of video by PBS. Could not find updated contact information to ask for permission.

[5] From https://onthewall.classics.lsa.umich.edu/fall2016/?p=216

An additional issue that at times can arise due to the risky nature of graffiti is figuring out the exact volume of materials needed for a certain piece beforehand. It is important for graffiti artists to get the amount of paint needed for a project as accurate as possible, because bringing too little paint might result in an unfinished piece, but bringing too much paint causes the artist to bring unnecessary weight, which could be dangerous in such a high pressure situation. When configuring a process for calculating the volume of spray paint necessary for any given project, Scape settled upon the fact that each 11 ounce can of spray paint will cover about 25 square feet of wall as a unit of measure. Thus, before purchasing his supplies, Scape will calculate how many cans of each color he will need based upon the scaling done from his sketchbook. Figure 2 shows the final version of the piece in which Scape utilized each of the aforementioned mathematical techniques.

Figure 2. *Math is Life* by Scape Martinez. Final product after utilizing math for grids, scaling, and calculating necessary supplies to ensure a successful piece. Spray paint on concrete wall. Building/wall unknown. San Jose, California. 2014. Screenshot of video by PBS. Could not find updated contact information to ask for permission.

Another artist who uses mathematics extensively throughout his artistic process is the unique street artist Aakash Nihalani. Based in New York City, Aakash primarily utilizes colored tape and cardboard to create geometric and optical illusionary effects on everyday objects across the city. Aakash is most famous for imposing 3 dimensional geometry on 2 dimensional urban spaces. In many instances, Aakash manipulates the natural architecture of the city in order to create his desired effect. An example of such is a series of pieces entitled *Sum Times*, shown by figures 3 and 4, in which Aakash cleverly transformed average building sides into mathematical equations. Akaash used tape on cardboard cutouts to create the mathematical symbols, and their simplicity makes the buildings themselves the focus of the piece, while his own creations simply highlight them. While this series is Aakash's most obvious and simple use of mathematics in his street art, Aakash also utilizes mathematics in a variety of much more subtle ways.

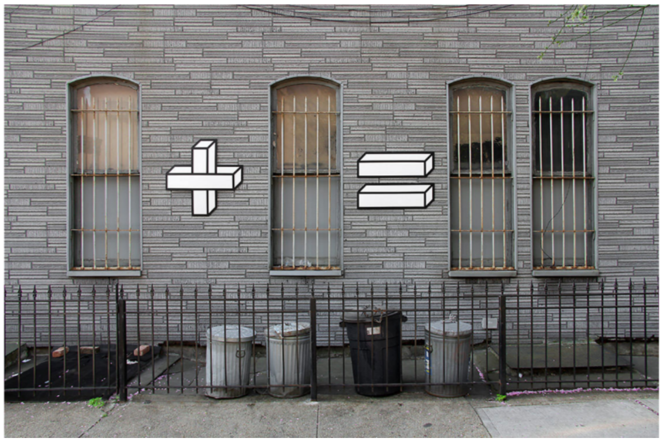


Figure 3. *Sum Times* by Aakash Nihalani. Tape on cardboard cut outs. Using addition and equal signs to form a mathematical equation using the natural architecture of the city. Unknown building. NYC, NY. 2012. Photographed by Aakash Nihalani. aakashnihalani.com Used contact portal on aakashnihalani.com to ask for permission.

Figure 4. *Sum Times* by Aakash Nihalani. Tape on cardboard cut outs. Using subtraction and equal signs to form a mathematical equation using the natural architecture of the city. Unknown building. NYC, NY. 2012. Photographed by Aakash Nihalani. aakashnihalani.com Used contact portal on aakashnihalani.com to ask for permission.

Because many of his designs incorporate elaborate geometric shapes and optical illusions, all utilizing strictly linear tape as his medium, Aakash requires immense precision that must be mathematically planned and modeled before each project can be executed with success. As shown on his website, Aakash's process includes sketching ideas first, scaling them, transferring them to cardboard where he places the tape over his sketched lines, then cuts out of the cardboard so that all that remains is his desired shape. Though math is incorporated through each step, it is within the process of scaling that math plays the largest role. For example, when creating a design such as that in figure 5, Aakash must measure the lengths and widths of each square in order to maintain correct proportionality, or else the illusion would be ruined. Furthermore, proper placement of each piece is extremely important in order to maintain each illusionary effect, and thus accurate measurement of the space in which Aakash is working with is necessary.

Figure 5. *Untitled* by Aakash Nihalani. Optical illusion of 3 dimensional shapes on 2 dimensional surface. Colored tape, cardboard, and corrugated plastic. Brooklyn, NY. 2014. Photographed by Aakash Nihalani. aakashnihalani.com Used contact portal on aakashnihalani.com to ask for permission.

No matter the style of graffiti or street art, as exemplified by Scape Martinez and Aakash Nihalani, mathematics can be integral to the success of any piece. It is where math and artistry converge, whether that be in the graffiti world or elsewhere, that the most triumph can be found. As someone with a mathematically centered mind, I of course attempted to find all the numbers within graffiti I possibly could. With my head primarily in the math world, I've always been able to recognize the artistic nuances necessary for the best of mathematicians. Knowing this, I wanted to explore the mathematical side of artistry within graffiti, which is something I have very little to no experience with. Through the two artists Scape and Aakash, I was able to find the intricate ways in which math is weaved into the artistic processes of street art, and thus show show that mathematics and artistry do have the capability to work hand in hand to create something beautiful.

Article from: Lina. "Graffiti Through the Looking Glass: Graffiti as an Intersection Between Mathematics and Artestry." On The Wall, December 18, 2016, https://onthewall.classics.lsa.umich.edu/fall2016/?p=216.

Dancing and Math

Dancing: Revealing the Beauty of Mathematics[6]

Written by admin

'Mathematics is an easy and exciting subject to learn'. When you hear or read this statement, what is on your mind, will you agree or disagree?. Mathematics is embedded in our daily lives, our culture, in which art is a part of. In painting, the role of mathematics has already been widely applied. For example in one the most famous paintings, The Mona Lisa, ratio plays an important role. In another kind of art, namely dance, mathematics also has an important role.

To some, Mathematics is generally seen as a bunch of numbers and formulas, which is considered to be near polar opposites of dancing. General society might see that these two worlds have nothing in common. Yet, when we look closely, similarities and connections reveal themselves.

There are thousands of cultures spread around the globe and each have their own dances with various kinds of moves. As we look closely into these dances, we can see that they are made of rhythm, shapes, and patterns. These can be linked to the mathematical concepts. Therefore, mathematics can be taught using dance. Teaching mathematics with dancing can help students to understand abstract concepts of mathematics more joyfully. Implementing mathematics in 'real life' such as in dancing will certainly help to erase the stigma of the subject being dry and inaccessible.

Expert in mathematics from Australia, Dr. Mathews says "Math involves creating symbols and putting them together to represent the real world". Based on this theory, students become the mathematics themselves. It has been proven in an Australian based school that students understand the mathematical concept better when they are encouraged to be creative and create their own symbol, relating them with stories in their own world.

Mathematical concepts such as Geometry can be introduced to students by teaching them dancing. This concept can be seen in the positioning of a dancer's body in relation to themselves and their surroundings. Within the dancer's body, he or she can create shapes, angles, and lines which contributes to the effect of the dance. Concerning shapes and angles, dancers need to focus on the angles they make with their bodies to form the correct shapes. Meanwhile, talking about the lines concept through the dance, dancers often have to think about staying parallel to other dancers to preserve formations. They need to keep the same distance between each other no matter how they move.

Picture of math teachers dance performance

Furthermore, Geometry is also used to unify between one and another dancer. Without Geometry, dancers would not be able to be synchronized and create shapes. Besides Geometry, everything in dancing has to do with patterns. Dancers memorize patterns in the steps in their dances. The rhythm in music usually consists of patterns in the form of beats. This pattern is generally synchronized with the dancers' movement.

[6] From https://www.qitepinmath.org/en/math-articles/dancing-revealing-the-beauty-of-mathematics/

One of a well-known dance which employs the use of Geometry is Saman. This dance originated from Aceh, Indonesia. The Saman dance requires high movement synchronization among each dancer, the timing of each dancer plays an important role. From this dance we can also explore other mathematics concepts such as line, symmetry, and patterns. The larger the number of dancers, the more possible relations of lines, shapes and patterns arise from their interacting bodies.

Another example of mathematics used in dancing is in figure skating. Assistant Professor of mathematics at Towson University states “Figure skating is a great model for mathematical instruction.” Brian Shackel and Marion Alexander of the University of Manitoba mentioned that the angles of the skaters is an important aspect in ice skating such as when they jump, spin, skid, glide, and even during landing. The more accurate the angles used in each stage, the higher the score they will get.

Picture of SEAQiM event “Understanding SEAMEO Countries Culture”

With this in mind, SEAQiM incorporated the idea of mathematics as an art in the session Understanding SEAMEO Countries Culture. Having backgrounds in mathematics, teachers are able to present a great dancing performance in a very limited amount of time. The dance consists of symbols and patterns as well as timing of the rhythm, which are basically mathematical concepts performed in reality.

For people out there who think dance has nothing to do with mathematics, think twice. Mathematics is not merely just an equation to be memorized. How to turn this subject into a fun activity, goes back to the teacher’s creativity. One way to teach this subject is through dancing.

Article from:
Admin. “Dancing: Revealing the Beauty of Mathematics.” SEAMEO Regional Centre for QITEP in Mathematics,May 26, 2017, https://www.qitepinmath.org/en/math-articles/dancing-revealing-the-beauty-of-mathematics/.

Sports and Math

How Sports Announcers Use Math[7]

Written by Chron Contributor

Most sports are quantitative. Individuals or teams score points and the highest score at the end of the game wins. You measure not just the final score but also the outcomes of individual plays that lead to the final score, and these measurements create historical statistics that can help predict the future outcome of a game or play. The outcome might even be quantified as money in a sport that allows betting. From basic addition to probability and statistics, math is used everywhere in sports. A sports commentator uses math to report the facts and to make predictions.

Using Math to Calculate Scores

A sports commentator uses math to calculate the new score of a game when a team completes a play successfully. For example, if a basketball team has 68 points and completes a regular basket, the announcer may announce a new score of 70 by adding two points to the current score. Announcers also use math to predict future scores based on the outcome of a play. For example, in a baseball game, if Team A has six runs and Team B has two runs, three players on base and a player at bat, an announcer might predict a tie game if Team B's batter were to hit a home run.

Understanding Statistics in Sports

Ratios are used extensively in sports to measure the success rate of a particular task or skill. A sports commentator uses math to calculate, understand and interpret these ratios. For example, a basketball announcer might discuss a player's free-throw percentage, which is the ratio of successful shots to total shots taken. Baseball announcers commonly discuss a player's batting average, which is not an average but a ratio of the number of hits to the total number of times at bat.

Using Math to Predict Strategies

When predicting a team's strategy, the next play in a game or even the winner of an event, a sports commentator often interprets and analyzes statistics to arrive at a conclusion. For example, a commentator might predict whether a football team decides to go for a touchdown or kick a field goal by reviewing its field goal percentage, the distance to a first down and the team's historical performance of similar plays against its opponent.

Interpreting Numbers for the Audience

A sports commentator for an event such as a horse race uses their math knowledge to understand, interpret and explain betting odds to listeners and to calculate the payout for a $2 bet at the end of a race. They also use math to convert measurements between units in a measuring system – such as converting furlongs, yards and feet – or to convert measurements between measuring systems such as the imperial and metric systems.

Article from:
Chron Contributor. "How Sports Announcers Use Math." Chron, October 2, 2020, https://work.chron.com/sports-announcers-use-math-4127.html.

[7] From *https://work.chron.com/sports-announcers-use-math-4127.html.*

Public Policy and Math

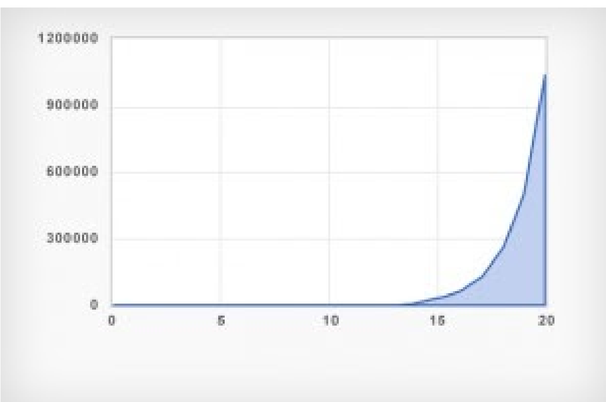
The Basic Math of Politics[8]

Written by Jeremy Teitelbaum

In his latest blog, “The Politics of Calculus,” my colleague Dean Jeremy Paul of UConn’s Law School laments our collective tendency to oversimplify our society’s problems and to view them as simple questions of, for example, “maximizing profit.” He calls for a public discourse that allows us to consider more than one variable at a time, and calls on all of us to pay more attention to “our friends in the math department” who know how to do this using Calculus.

It’s flattering to be called on to help heal society’s woes – mathematicians aren’t often put in that role – so I spent some time thinking about how a mathematical perspective might help improve our collective approach to societal problems. In response to Dean Paul’s shout-out, I offer three specific areas of mathematics that people don’t seem to properly appreciate, leading them to poor decision-making in many different areas of society. As it turns out, all three areas are even simpler than Calculus.

Chart showing exponential growth.



The first huge gap in our mathematical discourse concerns the process of exponential growth. Exponential growth is the process where a quantity increases by a fixed proportion every period, doubling, say, at a fixed interval. As the chart shows, exponential growth can seem very slow for a very long time before suddenly exploding.

The dramatic run-up in the price of Apple stock is a striking example of some people’s failure to grasp the explosive nature of exponential growth. As James Stewart explained in the New York Times, a continuing rate of 20 percent growth in Apple’s stock price over the next 10 years would lead to a market value in excess of the GDP of, say France. Beyond that, it wouldn’t take long for Apple to sell an iphone to every man, woman, child, and pet living on planet Earth. Such growth obviously will not continue – but many people are going to pay a high price for failing to appreciate that fact.

More broadly, we haven’t collectively appreciated that the same analysis applied to any fixed resource – like, say, fossil fuels – means that no amount of drilling will ever overcome an underlying exponential growth in demand. That growth in demand will eventually be impossible to satisfy.

The second area of mathematical knowledge that I’d like to see more widely appreciated is the notion of relative risk. We are very weird in our appreciation of risks. We turn our society upside down to minimize the risk of a terrorist attack, but we pick up our cell phones to send texts while driving down the highway. We buy guns to protect ourselves from intruders, vastly increasing the risk that one of our family members will use that gun to kill themself or accidentally kill or injure another family member. Some of us avoid vaccinating our children out of fear of side effects, putting them at much higher risk of dangerous diseases.

This inability to deal with relative risk has become a significant area of public debate recently, with the release of studies regarding the appropriate frequency of diagnostic tests such as mammograms and prostate cancer screenings. Many groups reacted with outrage and horror at suggestions that such tests be given less frequently or even not at all.

It seems obvious that more testing for dangerous diseases is better, and it’s difficult to suggest to someone that they wait longer before being tested. However, the tests themselves have risks, they are expensive, and they produce false

[8] From *https://today.uconn.edu/2012/03/the-basic-math-of-politics/#*

positives leading to anxiety, even more testing, even more costs, and even more risks. In an ideal world, the public would have enough understanding of the science of relative risk to approach these problems deliberately, rather than jumping to the most simplistic conclusion that more testing, and earlier testing, is necessarily better.

The third type of mathematical knowledge that I wish was more widely understood isn't really mathematics proper. Rather, it's an appreciation for the fact that real world problems are amenable to analysis generally, and mathematical analysis in particular. Eugene Wigner, an important 20th-century physicist, wrote a famous essay called "The Unreasonable Effectiveness of Mathematics in the Natural Sciences," in which he pointed out just how striking it is that mathematics – a product of abstract thought – should be so powerful as a tool for understanding the natural world. More recent developments in the social sciences, and even in areas like recommending music and movies, have shown that mathematics can be similarly powerful in other contexts as a tool for understanding the implications of different choices.

Dean Paul hopes that mathematical literacy will help us with the key questions that confront our democracy. Certainly mathematics provides tools – the methods of probability and statistics, the study of exponential growth, and many other concepts – that can help illuminate the world we live in. But to realize that potential, we need to be more than literate, we need to apply what we know. And that means we need to stop and think, hard, about what to do about our major problems before leaping to a plan of action. Unfortunately, that willingness to do some hard thinking seems even rarer than a knowledge of Calculus.

Article from:
Jeremy Teitelbaum. "The Basic Math of Politics." UConn Today, March 19, 2012,
https://today.uconn.edu/2012/03/the-basic-math-of-politics/#