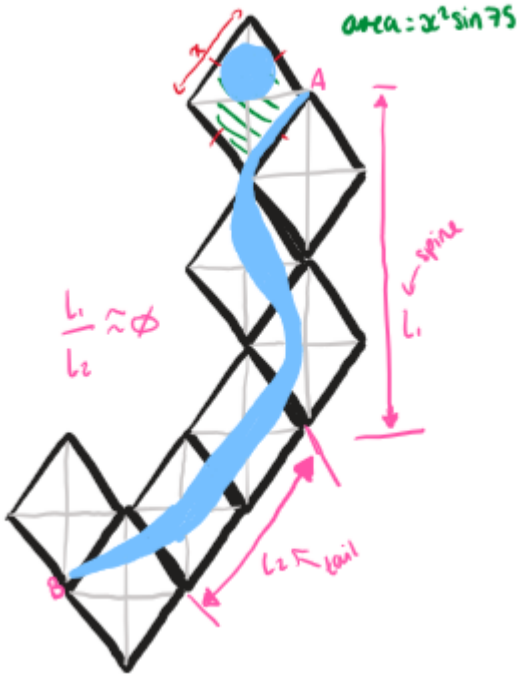
The Nuqta of Zay

Arabic calligraphy isn't just based on how good of an artist it was drawn by, but rather it's derived by mathematical proportions. My favourite letter is ز (Zay). As a child, I thought of this just as a curve and a dot . However, growing up I've realised the amount of geometry blended in with the art to create the letter ز.



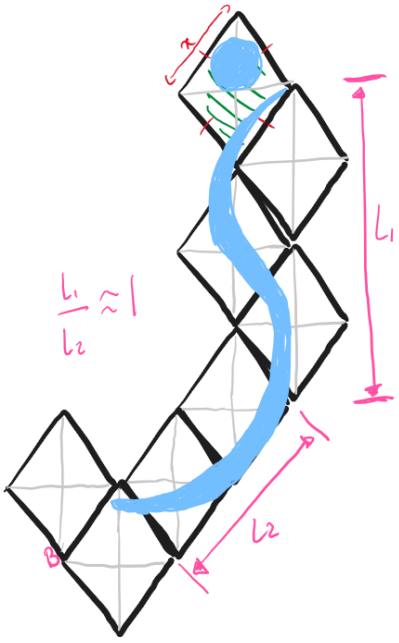
The geometric schematic of the letter ز (Zay) drawn by me is shown above. The whole calligraphy of arabic is based upon the rhombus's and uses it like a grid which is the essential of how all the arabic calligraphy is written (in arabic this is called the mizan (scale)). Despite the final product looking like ز and being all smooth, to practice and perfect this form, you would have to practice this on a rhombus grid as your constraint.

As mentioned earlier there is geometry in this, but there's a substantial amount of trigonometry in this. The foundation of the letter Zay lies in the rhombus "dot" which is called the nuqta. To perform this using a reed pen, it solely relies on the specific angle. In my schematic, the area of a single nuqta is: **Area=x²sin(75°)**. The angle you use changes the shape of how it will turn out. Using the function sin(θ) determines the stretch of the rhombus. If the calligrapher were to hold the pen using a 90 degree angle, the area would be x²sin(90°) and sin(90°) = 1 so it would be a perfect square which isn't how calligraphy works. By having the calligrapher use an angle of 75° or 80°, there is the introduction of shear. This shear is what allows the writing to have a sense of motion and a "forward lean". The x used in the equation is the width of the pen nib which would not impact the ratio of the calligraphy but the sin(75) represents the directional constraint. When writing ز , it's determined based upon the initial nuqta. This means that if the nuqta is in a certain way then the rest of the letter must also follow that way due to the same trigonometric slope to maintain the scale.

Upon the topic about the x being the pen nib's width, it's allowed to be any size. This is because the letter Zay is built upon ratios like the Golden Ratio(φ) so the letter is basically a mathematical fractal. This means whether the Zay is 4cm or 4 metres, the math is the same similarly how vector graphics work today but calligraphers did this centuries ago using pens rather than a device. This means that the scale/Mizan isn't all just art but it's rather geometry.

The nuqta being a heart basis of the letter ز , the overall silhouette of the Zay is related none other to the Golden Ratio(φ). In my schematic, I have labeled the primary stroke as the spine (L1) and the exit

stroke as the tail (L2). When we analyse the relationship of the 2 segments we find that **L1/L2 ≈ 1.618.** This Golden Ratio(φ). is a mathematical constant throughout nature and architecture which also ends up happening to be throughout Arabic Calligraphy. In Arabic Calligraphy, applying ⌀ to the letter Zay will create a type of asymmetric equilibrium. If the ratio was 1:1 then the letter would be as followed:



(I tried my best to draw it to scale)

When L1 = L2, the letter Zay loses its forward lean and its grace because the letter ز in traditional scripts is supposed to be a dynamic stroke. The 1:1 ratio disrupts this momentum by having the end point having too much visual priority over the descent. Also, the 1:1 ratio feels forced and rather calculated geometrically without the aspect of art which is the backbone of Arabic Calligraphy .

Enough about the letter being built of the rhombus grid, the actual calligraphy will take place using a pen which has the process of fluid motion. On the blue line in my schematic, it follows like an S shape. The letter ز must have a smooth curve with a constantly changing gradient and no sharp corners. If there was a gradient that didn't change or a sudden jump, the flow of the ink would allow the curve to look disconnected. This will make the letter Zay look jagged and not perfect which isn't what Arabic calligraphers aspire to achieve. For them to obtain the perfect ز shape, their hand follows a math that has the least g-force which is known as the path of least resistance.
To 7 year old me, the letter ز was just a ر with a random dot on top that could be placed anywhere as long as it's on the top but to Arabic calligraphy this is a calculated point. The dot must be placed directly one x / nuqta (height of one diamond) above the highest point of the curve. This is because if the dot was any closer, the letter would feel cramped and if it was further away it would look detached and isolated. For Arabic calligraphers to place this 1 nuqta away using spatial geometry is an astonishing thing for me and maybe you, as it demonstrates an intuitive grasp of proportion which has allowed them to have the perfect scale without having a ruler but only their rhombus.

Overall, my favourite letter ز isn't just a linguistic symbol, but rather a blend of art, geometry and many more mathematical aspects which I may have not touched upon (like the physics of the ink viscosity). Viewing the letter through a mathematical lens, we can see how a little change in the angle of the pen nib can create changes on how the shape appears due to the rhombus used. Through the geometry we can see how the Golden Ratio(φ) used to define nature and galaxy was rather applied to Arabic Calligraphy which is impressive. We can also understand that the calligrapher manages to create a smooth curve to the eye by using the path of least resistance.
What is the most fascinating to me is that calligraphers weren't using technology or AI to achieve this

perfect ز but rather the understanding of spatial geometry that allowed them to create the Zay into a perfect letter. By studying the letter Zay, it emphasises that mathematics isn't just solving abstract problems with no real application in a classroom but rather a language universally to define beauty and perfection.

References:

- **The Golden Ratio : The story of Phi, the World's Most Astonishing Number by Mario Livio**
- **Ibn Muqla's System of Proportional Calligraphy**
- **Mathematical Proportions in Arabic Scrip**