Mathematical Beauty

In Devlin's Letter to a Calculus Student, he is saying that he hopes students reading it will be able to see that mathematicians regard calculus with beauty and that he hopes the students will be planted with a seed that one day leads to them understand the mathematical beauty he is talking about in the article.

First of all, I think Devlin is on to something in this article regarding beauty in mathematics. Mathematicians often describe theorems or equations as "beautiful". Mathematicians had brain scans done and when they were shown different equations, their brains showed activity in areas associated with emotion, and it showed the same thing as when people look at art. There was another study in which mathematical equations were rated most beautiful and the ugliest, and Euler's identity, sin^2+cos^2=1 and Cauchy-Riemann equations came out on top. The same study also found that Ramanujan's infinite series and Riemann's functional equation were the ugliest. All of this makes non-mathematicians confused ("How can mathematics be ugly or beautiful?") but it should not because mathematics can be another form of art like music or paintings as that study found.

Mathematics is something that most people do not understand because they are not good at what they think is mathematics. Even students who take several mathematics courses in college miss the point of mathematics because they think it is about solving problems. Most non-mathematics majors just do the bare minimum and do not care about what mathematics actually is. If those students were to stop caring about their grade and getting through the class, I am sure many more people would appreciate the

beauty of mathematics. This is what I think Devlin was trying to point out. He says to stop looking at calculus as another tool and try to understand it intuitively and feel the beauty of it.

For me personally, I have learned a few things that were really interesting and applicable that others would describe as beauty, but I would not say beautiful even though it would be an appropriate use of the word beautiful. For example, I was so shocked you could use calculus to derive the kinematics equations in physics, and that the volume of Gabriel's horn is finite but has infinite surface area, and that there is a maximum efficiency of wind power due the blades of the windmill (Betz's law). These are just a few examples of mathematics that I find awesome. However, the thing I find most amazing is the application of mathematics, especially in physics. We can describe motion, energy, and forces in mathematics Planets and stars follow particular orbits described by mathematics We can model crime, the stock market, and earthquakes with mathematics Even on the microscopic level, particles and atoms can be represented as mathematical systems. Even one of the most confusing and counterintuitive things in physics, like quantum mechanics, can be described in terms of a mathematical function. Secondly, while reading this I realized there is kind of a parallel between mathematical beauty and faith. You can do mathematics (like in school) without fully understanding it and in doing so you completely miss the point. This is just like if you just go to church and just do what the bible says, you are technically doing a small part as a member of the church, but you are completely missing the point of Christianity. People who do this

get caught up in the details and do not worry about the big picture and what is really means to be a Christian.

Another thing I realized is that mathematics is another way to experience a connection to God. People often talk about how they feel close to God doing a certain thing or being in a certain place. They also say that certain things help them confirm that God is there because if He was not then something would different. This idea can be extended to mathematics as well. Feeling God's presence can happen at any time in any way for any reason while doing anything. There almost certainly is someone who feels closest to God while doing mathematics or sees the beauty of God in mathematics. I think part of this is because mathematics is in the fabric of the universe and manifests in almost everything. Even if you are a biologist, you will see that population growth can be modeled with mathematics. The number *e* appears in finance, growth, and of course logarithms. Physics would not be what is without mathematics, to the point that someone I know said, "You can have physics without mathematics, but you can only have one day of physics class."

https://www.maa.org/external_archive/devlin/devlin_06_06.html

http://www.huffingtonpost.com/2014/02/17/beautiful-math-equations-brain-great-art_n_4789667.html

http://www.scientificamerican.com/article/equations-are-art-inside-a-mathematicians-brain/

https://en.wikipedia.org/wiki/Betz%27s_law

Devin Battice

Linear Algebra

Flatland

In flatland, the Author, A Square, familiarized his two-dimensional world to us in three dimensions, by describing how their society works. He talks about how the shapes get their shape, and how different shapes are treated according to the number of sides and angles they have. He then talks about their history, and how the shapes with the most sides are the most respected, and considered the wisest. He also elaborates on a few of the revolutions that the Flatlanders had and how they caused their laws. He talks about the color in their world and how the number of sides affects the occupation each shape has. After he has set the stage, he then talks about a dream where he visits those who were on a line and tries to make them comprehend that there is another dimension. He struggles trying to communicate this to the King of Lineland and saying that they are inferior because they cannot comprehend Flatland. He then wakes up as Lineland is crying out to declare war against him. He then is talking to his grandson, a hexagon. His grandson is asking him about the meaning of cubing a number, and he has to explain that cubing a number does not have meaning in Flatland. Shortly after this, a highly respectable circle visits A Square. He soon learns that the circle is actually a sphere that is trying to explain to him the third dimension because this is the only time in the millennia that he can. The sphere tries changing size, moving things that could only be possible because of his three dimensional nature, and using analogies to convince A Square that there is a third dimension. Eventually Sphere gets frustrated

and forcibly takes A Square off of Flatland and to three dimensions so he can experience it for himself. They view a gathering that shows every millennia there are shapes in Flatland who proclaim the third dimension and they state they are going to consume those who do this millennia starting with A Square's brother. A Square becomes fascinated by the third dimension and tries to learn everything he can, and then he starts asking Sphere about four, five, and six dimensions. Sphere cannot help him and then A Square is forced back to Flatland, but knows he cannot say anything or he will be locked up like his brother. Given courage by Sphere in a dream, he tries to tell his grandson about it, but he thinks the whole thing is ridiculous and not worth the time. After his failure with his grandson he further thinks about how to explain the third dimension, and he is soon taken away and put in prison with his brother. While he is locked up he continues to think about the third dimension and writes about his experience but also wonders if it really was real because of how absurd it all was.

In class we are talking about vectors and matrices that can have n dimensions. Once $n>3$, I no longer try to visualize what the vectors are representing because I cannot do it or I try to think about the analogies to two and three dimensions. I think this book elegantly explains why you cannot visualize more dimensions that you live in. Both Lineland and Flatland are ignorant and incapable of comprehending higher dimensions. It also shows the only way to see them is to actually go the higher dimension, which is impossible as far as we know. I also find it interesting that the people of Flatland and Lineland become aggressive and dismissive at the mention of higher dimensions, just

like how some people came up with extraordinary discoveries in the past and were mocked or killed for it, like Ignaz Semmelweis, Hippasus, and Ludwig Boltzmann. Flatland's analogy of higher dimensions mimics how I see God. I know that God is on a higher dimension than I am, and I will never be able to understand God completely because of this. I can see a part of God and understand that parts in my world, but if God were to try to explain how he sees things it would all go over my head. I can mostly understand God, but if he changes the part of himself that is visible in this world, like Sphere did in Flatland, I would not be able to understand what was going on. Occasionally God lets us experience his full self for a brief period of time, but that is precious and I think we need to tell others when we can that there is "another dimension" and have faith that it all works well even if we cannot see or impact the "higher dimensions". I have gotten to the point where I know about God and how he operates on higher dimensions, but at the same time wonder if I really did experience it, like A Square does at the end of Flatland. I still have faith and hold on the experience as best as I can because it is the purest representation of God.