Talk Topics for 2023-2024 School Year

Below are some possible topics. I hope these include something for each taste. (I can also make other suggestions.)

Mathematics Education

1. Here is an article on proving that $\sqrt{2}$, $\sqrt{3}$ and $\sqrt{5}$ are irrational numbers geometrically.
https://maa.tandfonline.com/doi/epdf/10.1080/0025570X.2023.2168436

2. A visual proof that $\sqrt{2}$ is an irrational number using a balanced beam.
https://maa.tandfonline.com/doi/epdf/10.1080/07468342.2023.2201569

3. Elementary Methods for Solving Calculus Problems - Many calculus problems can be solved using algebra and geometry, without using the mathematical tools developed in calculus. The Armenian astrophysicist Mamikon A. Mnatsakanian went to Caltech after the fall of Soviet Union and returned to his first love of developing geometric and visual methods for solving calculus problems. There he worked with the famous American mathematician Tom M. Apostol at "Project MATHEMATICS!". Any of their papers include a wealth of insight and are great for presentations at any level. The first paper was titled "A Visual Approach to Calculus Problems" which you can find below. References: http://calteches.library.caltech.edu/4007/1/Calculus.pdf, http://www.its.caltech.edu/~mamikon/calculus.html and http://www.projectmathematics.com/.

4. Short biographical talks on female mathematicians, for example, Margherita Piazzolla Beloch, Elizabeth Smith, etc. See https://en.wikipedia.org/wiki/List_of_women_in_mathematics.

5. Present the paper *An Alternative to Integration by Partial Fractions Technique*. This is the title of a short paper by Yusuf Gurtas published in The College Mathematics Journal, vol. 50 (2019), no. 2, 140-142, and available at https://www.tandfonline.com/doi/full/10.1080/07468342.2019.1561125.

6. Present the paper *A Simple Proof of Descartes' Rule of Sign*. This is the title of a short paper by Xiaoshen Wang published in Amer. Math. Monthly, vol. 111 (2004), no. 4, 525-526, and available at https://www.tandfonline.com/doi/abs/10.1080/00029890.2004.11920108.

7. With the discovery of an Einstein shape to form an aperiodic tessellation, a talk about the tessellation history, results and the newest discoveries is very timely. See https://www.scientificamerican.com/article/newfound-mathematical-einstein-shape-creates-a-never-repeating-pattern/.

8. On the theme of tessellation. Here is an article that discusses *Integral Titling Pentagons* from all possible convex tilling families, https://maa.tandfonline.com/doi/epdf/10.1080/0025570X.2023.2176101

9. Here is an interesting "Proof Without Words" involving Fibonacci numbers. https://maa.tandfonline.com/doi/epdf/10.1080/0025570X.2023.2176682. Here is another neat result using golden ratio. https://maa.tandfonline.com/doi/epdf/10.1080/0025570X.2022.2125732

Applied Mathematics

10. This article discusses mathematics involved in using miter saws to build things. https://maa.tandfonline.com/doi/epdf/10.1080/0025570X.2022.2093547
11. This article uses a balance beam to proofs of Mean Inequalities. https://maa.tandfonline.com/doi/epdf/10.1080/0025570X.2023.2167431 The next article gives a generalization of Pythagorean Means (three of the means discussed in the last article) using geometry. https://maa.tandfonline.com/doi/epdf/10.1080/0025570X.2022.2125729
12. Padovan numbers arise in architecture. This article discusses them in rectangular tilings. https://maa.tandfonline.com/doi/epdf/10.1080/0025570X.2023.2165864
13. Presentation of the calculus based proof of $\frac{1}{1} + \frac{1}{4} + \frac{1}{9} + \cdots = \frac{\pi^2}{6}$. You learned in Calculus II that this infinite series is convergent (p-series with $p = 2 > 1$). In Boundary Value Problems, you use Fourier series to find its value. But this can be done elegantly using calculus and is included in the book *Proofs from THE BOOK* by Martin Aigner and Günte Ziegler*, available in the library. However, there are other proofs. The paper http://math.cmu.edu/~bwsulliv/basel-problem.pdf lists several solutions with references.
14. With COVID-19 epidemic, the interest in mathematical models of diseases is on the rise. They span statistical, discrete, and continuous models. For example, discrete or continuous SIR or SEIR models. Any overview talk of such models or specific development of models for COVID-19 will make an interesting talk.
15. Here is an article on spread of an infection, like COVID-19, in a network. https://maa.tandfonline.com/doi/epdf/10.1080/0025570X.2022.2125732
16. Fibonacci Day is Nov 23 (1123). There are many aspects of Fibonacci numbers that can easily be discussed.

Mathematics

17. Here is an interesting article on a series test not typically covered in calculus books. https://maa.tandfonline.com/doi/epdf/10.1080/0025570X.2023.2168433
18. Pi Day (Mar 14, 3/14). A talk about number π; history, calculation, properties, and applications. Last year we had a talk on its irrationality, a talk on pi being transcendental will complete proof of these important properties.
19. Proof of Convergence of Fourier series. Read, understand, and rewrite the proof in your own words. Reference: David Powers, BVP's and PDE's, 6th edition, ISBN 978-0-12-374719-8.
20. Present the paper *Finding Real Roots of Polynomials Using Sturm Sequences*. This article compares Descartes' Rule of Signs, the Budan-Fourier Theorem, and versions of Sturm's Method in contrast with the approximate root count gleaned from graphing utilities. This articles is published at PRIMUS, (30)1:36-49, 2020, and also available at https://www.tandfonline.com/doi/full/10.1080/10511970.2018.1501626.
21. Present the paper *Inflating the Cube Without Stretching*. This is the title of a short paper by Igor Pak published in Amer. Math. Monthly, vol. 115 (2008), no. 5, 443-445, and available at http://www.math.ucla.edu/~pak/papers/milka2.pdf. In this article the author describes a way to deform a cube that distances between points are

maintained while the volume is increased. The beauty of this article is that one can actually construct the deformed cube!

22. Address the conjectures in the paper https://maa.tandfonline.com/doi/pdf/10.1080/0025570X.2020.1704613 regarding certain primes. One such prime is 29 for which $2(29) + 9 = 67$ is also a prime and again $6(67) + 7 = 409$ is another prime.

23. The Arithmetic Mean – Geometric Mean (AM-GM) Inequality has many proofs and applications. A new proof is at https://maa.tandfonline.com/doi/pdf/10.1080/07468342.2020.1697605. An overview of this topic and presentation of interesting proofs will make a nice talk.

Statistics/Data Science

24. Give a talk on probability of randomly selected positive integers being relatively prime. A quick search will result in many references.

25. Present the paper Absent-Minded Passengers published in American Mathematical Monthly, 126:10,867-875, and available at https://www.tandfonline.com/doi/full/10.1080/00029890.2019.1656024. Here is the abstract of the paper. Passengers board a fully booked airplane in order. The first passenger picks one of the seats at random. Each subsequent passenger takes his or her assigned seat if available, otherwise takes one of the remaining seats at random. It is well known that the last passenger obtains her own seat with probability 1/2. We study the distribution of the number of incorrectly seated passengers, and we also discuss the case of several absent-minded passengers.

26. Present the paper Three Persons, Two Cuts: A New Cake-Cutting Algorithm in Mathematics Magazine, Vol 95, Issue 2, 110-122, and available at https://maa.tandfonline.com/doi/full/10.1080/0025570X.2022.2023300

27. A recent computational work by Professor Neal and Mario Rivero that the assumption of population normality in ANOVA test may be violated. It is interesting to consider tests for differences in means for populations with non-normal distribution different and also nonparametric ANOVA.