An Expansion of "Buffon's Needle" to Higher Dimensions: Computational Theory of Probability Using Figures and Its Application to Geometry

Sato, Haruki (School: Nara Women's University Secondary School)

I started since I was intrigued by the by the beautiful derivation of "Buffon's needle" by integrating, and thought that it would be possible to calculate the probability of plane figures such as squares using integration instead of needles. I specifically derived the probability of dropping a regular polygon on evenly spaced parallel lines, and generalized these results to predict and prove the law that holds for high-dimensional figures. I could prove that the probability of a plane figure that is convex intersecting a parallel line is in proportional to its perimeter, which is given as a simple result. Furthermore, I proposed a model to extend the event of "dropping a needle or a plane figure against a parallel line" to a higher dimensional space, and actually generalized the "probability of a Buffon’s needle" and the "probability of a convex plane figure intersecting a parallel line" to higher dimensional figures. I expect that results obtained in this research is applicable not only for probability theory, but also geometry and engineering. For example, the result indicate that the surface area of a convex figure can be obtained by positively projecting it onto a plane from various angles and multiplying the area of the shadow by 4. In addition, we finally come up with a simple method of proving "Barbier's theorem" without using differential geometry.　In the future, I would like to deepen the application of this theorem to geometry, engineering and related topics.

Awards Won:

American Mathematical Society: Second Award of $1,000