The Physics Behind the Violin

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August 8, 2026

Introduction

(I assume that) all high school students know why there is a distinct pitch, that is, the natural frequency of a string on the violin. However, the reason why the bow actually has the ability to sustain constant vibration and create beautiful music remains unexplained in their textbooks. This article is my personal guess toward the problem. Fortunately, as a person who plays the violin, I found several pieces of evidence to support my idea.

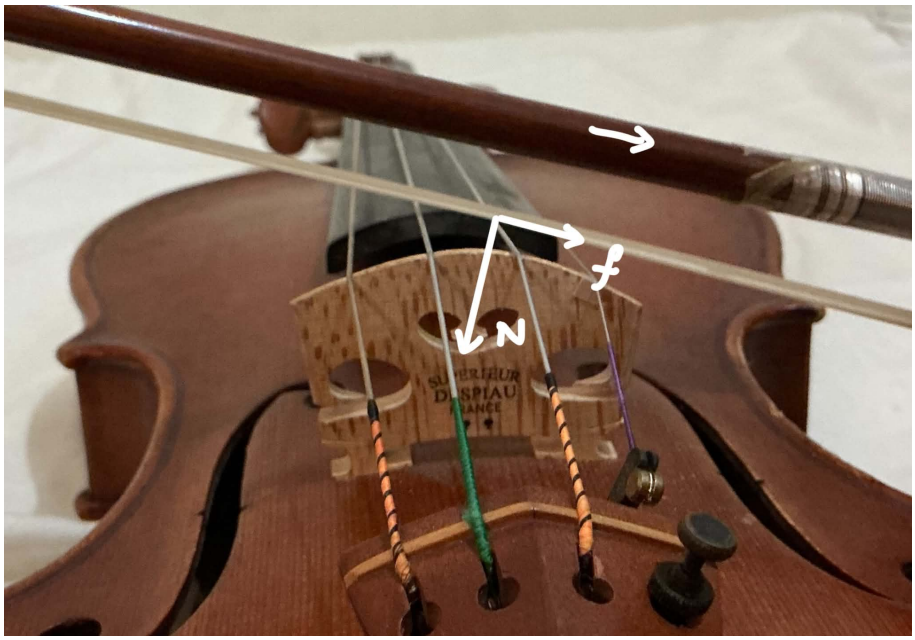

Figure 1: My violin and bow with the normal force and the friction.

1 How The Vibration Starts

When a stroke starts, the hair on the bow applies a friction force to the string and pulls it rightward. The string starts to bounce back after the leftward tension exceeds the maximum static friction.

2 How The Vibration Maintains

When the string is bouncing rightward, the friction is static; when the string is bouncing leftward, the friction is dynamic. Naturally, there is an amplitude which makes the hair constantly do positive work.

3 What If...

3.1 The Normal Force Is Too Strong, Or the Bow Speed Is Too Slow.

During most of the time process, the leftward tension does not exceed the maximum static friction, so the sound therefore collapses.

3.2 The Normal Force Is Too Weak, Or the Bow Speed Is Too Fast.

Same idea, it is the dynamic friction most of the time.

4 The Position of The Bow on The String

If you play closer to the bridge (the edge of the string), the speed of the bow cannot be too fast because the amplitude there is smaller, and vice versa. Interestingly, violinists apply stronger normal force when they play near the bridge in practice. I think this is because the horizontal component of the tension is greater near the bridge.

References

1. The masterful and friendly violinist Hilary Hahn plays Tchaikovsky's violin concerto. Youtube. www.youtube.com/watch?v=2Q_DzWUvcL8