



# Colorado Science and Engineering Fair

## 2024 Individual Project Abstract Form

**Please print 2 copies of the completed form. Sign both copies, keep 1 for your notebook and submit 1 copy to your Regional Fair Director with your other paperwork.**

Title of Project: Using Entanglement Entropy to Make a Solid Substance out of Staples

Finalist's Name: Lucia Nuel

School and City: Fairview High School, Boulder

Sponsor's Name: Youhan Sohn

Category: Environmental Engineering (ENEV)

Division: Senior (9th - 12th grades)

Abstract (250 words or less):

The purpose of my study was to find a viable replacement for construction materials. Nearly half of the waste deposited in landfills is due to the construction industry and the constant use of single-use materials. My solution was to use a property that staples exhibit when they are separated from their sticks and put in a shared space, entanglement. Using modified 60° staples to promote entanglement, I was able to create a solid substance out of staples. I determined the stress and strain of staple columns under compression. My exploratory trials revealed that around 47 psi of stress does not cause deformation of staple columns. This observation was used as the benchmark stress for future data sets. My second trial compared the stress and strain of three different-sized columns of staples and revealed that there is no significant difference between these variables. My third trial compared three different entanglement methods and revealed that the entanglement method significantly impacts the amount of strain that the entangled staple column experiences.

The stress-strain curves from my data allowed me to calculate the modulus of elasticity. I determined that the modulus of elasticity of staple solids is much lower than that of common construction materials, and it is too large of a difference to be a direct replacement for common construction materials. However, my experiments uncovered new characteristics of staple solids such as how the modulus of elasticity and density of staple solids is comparable to that of an elastomer and that staples are easily reused from test to test, thus fulfilling my sustainability goal.

*I hereby certify that the above statements are correct and the information provided in the Abstract is the result of one year's research. I also attest that the above properly reflects my own work.*

Finalist's Signature: *Lucia Nuel*

Date: *2/29/24*

In addition, all students must complete the ISEF Student Checklist (1A), Research Plan, Approval Form (1B), and Checklist for Adult Sponsor (1), and any other ISEF forms required for this type of project. See the International Rules and Guidelines for form requirements. Return COPIES of all of these forms to your Regional Fair Director with your Finalist Verification/Permission Form. A signed copy of this form must be included in your notebook.