Engineering Project 6: GD&T Tolerance Stack-Up Risk Analyzer (Monte Carlo)

Problem statement

- Create a Monte Carlo–based analyzer to quantify **GD&T and dimensional tolerance stack-up risk** and compute the probability of assembly failure for critical features and clearances.

The problem this project solves

- Worst-case tolerance stacking is overly conservative and does not reflect real manufacturing variation.
- Traditional spreadsheet-based methods fail to capture the combined impact of statistical tolerances, GD&T effects, and nonlinear interactions.
- This project provides a probabilistic view of assembly performance using realistic distribution-based modeling.

Applications

- Design for manufacturability (DFM) and early-stage tolerance allocation.

- Risk-based evaluation of clearance, alignment, and fit in precision assemblies.

- Identification of dominant contributors to failure for targeted tolerance tightening or cost reduction.

- Scenario analysis to assess the impact of process capability improvements or design changes.

Why it's important

- Enables data-driven tolerance decisions that balance cost, yield, and reliability.
- Reduces overdesign while maintaining assembly robustness.
- Scales effectively to complex, multi-parameter assemblies common in semiconductor tools and equipment.