Fit and Tolerance Investigation

Difficulty	Time	Type
Advanced	2-3 class periods	Engineering Challenge

Background

Two CAD parts may share the same nominal dimension but still fit differently after printing because of machine and material variation.

Engineering Problem

Design and test a tolerance coupon that identifies useful clearance, transition, and press-fit dimensions for the classroom printer.

Learning Objectives

- Connect nominal dimensions to physical fit
- Design a controlled experiment
- Collect repeated measurements
- Recommend tolerances from evidence

Materials

- Fusion 360
- 3D printer and approved filament
- Calipers
- Tolerance data sheet
- Engineering notebook

Procedure

1. Choose a nominal peg or hole size approved by the instructor.
2. Create a parametric coupon with at least six fit offsets spanning loose to tight.
3. Label each test position in the model.
4. Predict which offsets will produce clearance, transition, and press fits.
5. Slice and print using recorded settings and orientation.
6. Measure printed pegs and holes before fit testing.
7. Test each fit using the same procedure and rate insertion force and retention.
8. Recommend one offset for each target fit and explain uncertainty.

Engineering Requirements

- Use one nominal size and at least six controlled offsets
- Keep all non-offset geometry identical
- Record printer, material, orientation, layer height, and scale
- Measure at least three printed features
- Define a repeatable fit-rating method

Constraints & Safety

• Do not force parts in a way that creates sharp fragments

• Use only approved print settings

• Results apply only to the tested machine, material, and orientation unless additional evidence is collected

Deliverables

• Parametric coupon file

• Prediction table

• Printed coupon

• Measurement and fit data

• Recommended clearance/transition/press-fit offsets

• Short limitations statement

Reflection Questions

1. How did actual dimensions compare with CAD?

2. Which fit category had the widest acceptable range?

3. How did print orientation affect the result?

4. Why should tolerances be based on process capability?

Engineering Tip
Change only the fit offset. Keep every other feature and test condition constant.

Common Mistake
One successful fit is not enough evidence. Manufacturing variation requires repeated or carefully controlled testing.

Stretch Goal

Repeat the best three fits in a second orientation or material and compare.

Career Connection

Design and manufacturing engineers specify tolerances based on function and process capability, not guesswork.