Spaghetti Challenge: Engineering Principles & Demos

A complete facilitation slide outline and 2-minute hands-on demonstrations for teaching structural physics, mechanics, and iterative design.

Learning Objectives

Structural Mechanics Principles

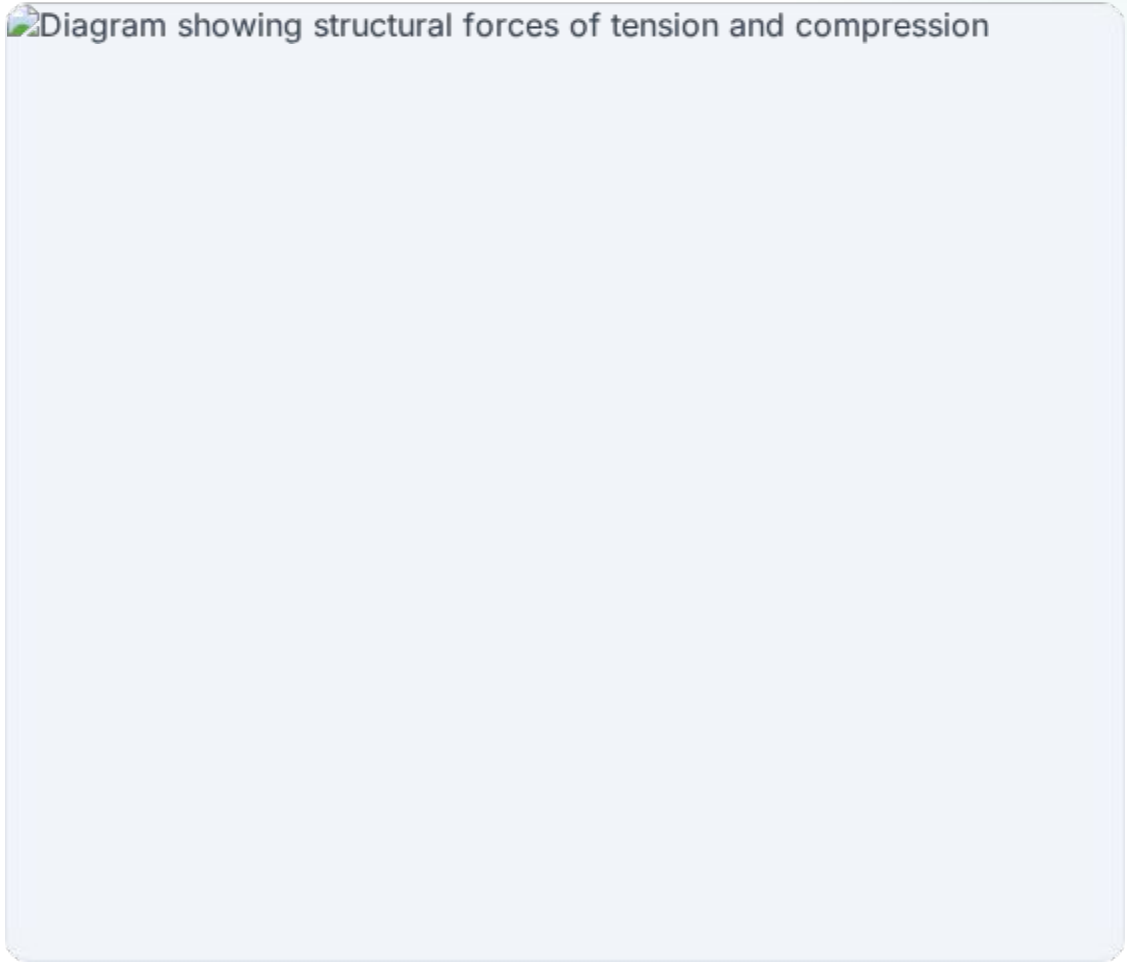
Participants learn how physical forces interact within a space-truss system, discovering why brittle materials like dried pasta fail under bending and compression while excelling under uniform axial load.

Engineering Design Mindset

Teams experience the Engineering Design Process (EDP) firsthand, learning that early physical prototyping and continuous load testing outperform prolonged theoretical planning.

Tension vs Compression

- **Compression (Pushing Force):** Uncooked spaghetti is extremely rigid under axial pushing, but quickly snaps if allowed to bow or bend sideways.
- **Tension (Pulling Force):** Spaghetti handles moderate tensile pulling forces; string and tape serve as primary tension members in guy-wires.
- **Joint Softness:** Marshmallows act as pinned/flexible joints rather than rigid welds, requiring external diagonal triangulation to prevent rotational sway.



Geometric Rigidity & Trusses

Triangles vs Squares

Four-sided square frames deform easily under sideways shear force. Triangles possess fixed side lengths that naturally lock all angles in place.

3D Tetrahedrons

The 3-sided pyramid (tetrahedron) is the strongest 3D building block. Stacking tetrahedrons creates a light, highly stable space frame lattice.

Truss Networks

Interconnected triangular trusses spread heavy point loads (like the target marshmallow) across multiple structural members down to the base.

Column Buckling Metric

4x

Strength Increase

Slenderness Ratio & Euler Buckling

According to Euler's Column Formula, doubling the thickness of a column (bundling 2–3 spaghetti strands together) or cutting the unbraced column length in half quadruples its resistance to buckling failure.

Short cross-braced members prevent long vertical legs from bowing outward under compression.

Demo 1: Geometry Push (2 Mins)

- **Objective:** Prove in 120 seconds why triangular frames dramatically outperform square frames.
- **Setup:** Pre-assemble one flat square and one flat triangle using spaghetti noodles and marshmallow corners.
- **Action:** Set both flat on a table. Apply a downward and diagonal push on the top node of the square, then do the same to the triangle.
- **Observation:** The square pivots at the marshmallow joints and instantly flattens into a rhombus; the triangle remains completely rigid.

Demo 2: Column Buckling (2 Mins)

Test A: Single Strand

Stand a single 10-inch spaghetti noodle vertically on a table. Press down gently from the top with your fingertip.

Result: The noodle bows violently and snaps under minimal vertical load due to a high slenderness ratio.

Test B: Bundled Column

Tape 3 spaghetti strands tightly together into a single column (or support a single strand with a mid-height cross brace).

Result: The column withstands significantly higher downward force without bending, illustrating structural reinforcement.

Design Process Steps

1. Ask & Brainstorm

Review constraints, analyze material properties, and sketch triangular designs.

2. Prototype Early

Build the base and tier 1 modules within the first 5 minutes of the build.

3. Test Under Load

Mount marshmallow on top mid-build to detect sway and low center of gravity issues.

4. Reinforce & Finish

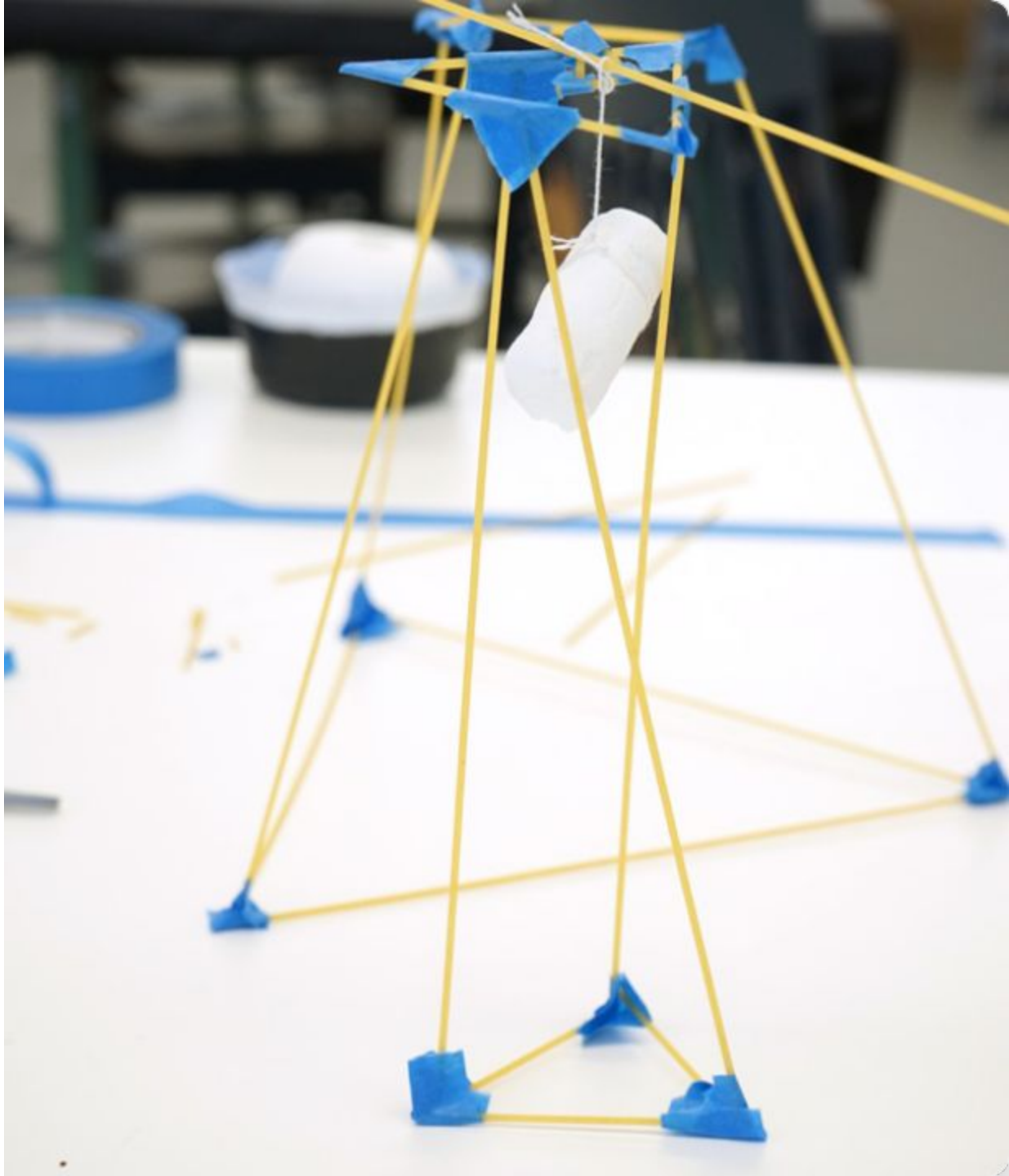
Add diagonal cross-braces and guy-wire tension tape before time expires.

Workshop Agenda

Time Window	Activity Phase	Facilitator Action	Student Key Task
0:00 – 0:05	Concept Intro & Demos	Run 2-min Push & Buckling Demos	Observe tension/compression behavior
0:05 – 0:23	18-Minute Spaghetti Build	Announce remaining time & enforce rules	Iterate, build, test marshmallow placement
0:23 – 0:27	Height Measurement	Verify unassisted standing structures	Hands-off official measurement
0:27 – 0:30	Engineering Debrief	Highlight winning structural choices	Reflect on structural failures and successes

Winning Strategies

- **Broad Triangular Foundation:** A wide base lowers the center of gravity and prevents tipping.
- **Bundled Vertical Legs:** Grouping 2–3 spaghetti strands quadruples column buckling resistance.
- **Early Load Testing:** Placing the marshmallow early reveals hidden structural weaknesses fast.

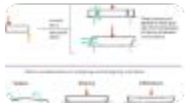


Questions & Discussion

Ready to facilitate your engineering design challenge?

UConn School of Engineering | ENGR 1166 Foundations of Engineering

Image Sources



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