SkillsUSA 2025/2026 Additive Manufacturing State Challenge

Send it

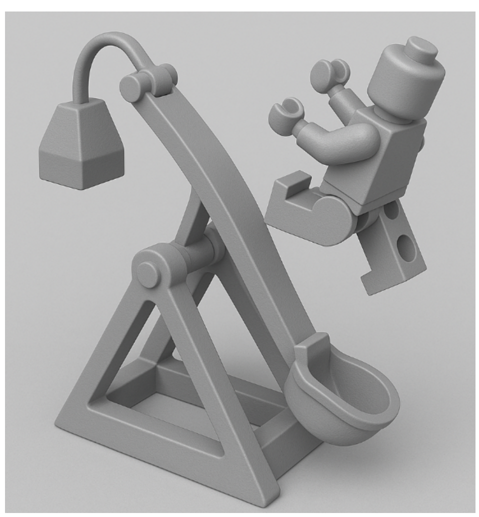
Welcome to the "Mini-Figure Catapult/Trebuchet Challenge" challenge!

The Additive Manufacturing (AM) contest evaluates students' ability to design, prototype, validate, and communicate a functional mechanical device using **only 3D-printed components**.
Competitors must design a **catapult or trebuchet** capable of **launching a standard LEGO® minifigure** using **no added materials**, relying exclusively on the **properties of 3D-printed plastics**

Competitors create a **fully additively manufactured launcher**—catapult or trebuchet—where all energy storage and mechanical action originate from **3D-printed geometry alone**, including:

- Printed torsion beams
- Printed elastic flexures
- Printed springs or spring arms
- Printed counterweights (printed material only)
- Printed tension/flexural systems

No external rubber bands, cords, metals, or weights may be used.



Competition Requirements

Design Requirements

Each team must design a launcher that:

1. **Launches a standard LEGO® minifigure** (supplied by contest judges).
2. Stores and releases energy **using only 3D-printed material behavior**:
   - Elastic bending
   - Torsional flexure
   - Printed leaf or coil springs
   - Beam deflection
   - Printed counterweight (printed plastic only)
   - No metal, rubber, glue, magnets, or external energy inputs.
3. Operates using **a catapult or trebuchet mechanism**:
   - Catapult: energy stored in flexural or torsional arms.
   - Trebuchet: energy stored in printed counterweight or pendulum motion.
4. Has a locking trigger mechanism
5. Is safe and stable during operation.
6. Requires no fasteners—**all connections must be printed or snap-fit**.
7. May be a **single print** or **multi-component assembly** (can use multiple 3D printed material):
   - **Bonus points** for functionally integrated, single-print solutions.

Size & Print Constraints

- Fully assembled launcher must fit inside: **150 × 150 × 150 mm**
- All components must be **100% 3D-printed**
- **Any** 3D printer technology may be used:
  - FDM, SLA, DLP, PolyJet, SLS, SAF, MJF, etc.
- **Any printable material** is allowed:
  - PLA, ABS, TPU, Nylon, resin, PA11/12, etc.
- If multiple materials are used, all still must be 100% AM-produced.

Performance Requirements

During testing, each launcher must:

1. Securely hold and release the minifigure.
2. Launch the figure forward, not upward only.
3. Complete **three launches**, which are measured for:
   - Distance
   - Repeatability (all three launches must land within a 6-inch diameter of first launch.
   - Safety and stability (No part interference, damage during operation, or unsafe trajectories)

Design Considerations

4.1 Energy Storage Methods (Allowed)
Teams may use:

- Printed flexible beams (like bow limbs)
- Printed torsion rods
- Printed leaf springs
- Printed coil springs
- Printed counterweights (solid or hollow filled only with printed material)
- Printed whip-action arms

4.2 Energy Storage Methods (NOT Allowed)

- Rubber bands
- Metal or lead weights
- Ball bearings
- Strings or ropes
- Electronics
- External kinetic input beyond human-triggered release

4.3 Stability & Safety

- Broad base recommended
- Ensure center of mass remains within footprint
- Avoid high-tension prints that may crack explosively
- Ensure minifigure is not struck by structural components during firing

4.4 AM Material Behavior Tips

- FDM: stronger along filament path; avoid layer-splitting by orienting beams horizontally
- Resin: brittle; great for fine details but avoid ultra-high deflection
- SAF/SLS: excellent for small flexures; nylon is durable
- Multi-material: optimize stiffness vs elasticity

4.5 Recommended Geometries

- Arched, tapered arms for elastic bending
- Hollow counterweights (printed-only mass)
- Integrated bearings or bushing pockets
- Snap-fit axles and pivot joints
- Lattice structures for energy absorption

State Competition Procedure

Before or on contest day:

1. Students submit Engineering Notebook (Engineering notebook guidelines below)
2. Students submit print files in both CAD (.step, .iges, .sldprt, etc.) and mesh (STL, 3MF, OBJ, etc) format to [State Designated File Share Site]
3. Students submit physical parts
4. Students submit final assembly if applicable
5. Students submit their Presentation

State Competition Judging Criteria

1. The Engineering Notebook should contain robust content, including at a minimum the following:
    - 1.1. Be clearly labeled with contestant name(s), date and page # on each page
    - 1.2. Begin with a problem statement
    - 1.3. Include discovery and documentation of approach to solve problem
    - 1.4. Include sketched design concepts with critical features labeled
    - 1.5. Critical dimensions clearly labeled in design sketch
    - 1.6. Considerations for designing for additive manufacturing distinctly addressed (i.e. part strength, part orientation) especially including any expected risks during printing
    - 1.7. Screenshots of the print time and material usage for all printed parts
    - 1.8. Design decisions and alternatives are documented and evaluated thoughtfully

2. The design must adhere to the Competition Requirements stated in the prior page.

3. Quality of final assembly
    - 3.1. Does it perform the function in the manner it was designed to do?
    - 3.2. Does it meet all requirements in contest guidelines?
    - 3.3. Do inserted components or multiple printed parts mate together properly?
    - 3.4. Did the students design the part with additive manufacturing in mind?
    - 3.5. Is there sufficient tolerance between parts for movement?

4. The design must illustrate best practices for “design for additive manufacturing (DFAM)”. Below are some *potential* DFAM metrics to optimize for.
    4.1. Build Time
    4.2. Post-Processing/Support Removal Time
    4.3. Functionality Optimization (gear ratio, pliability, strength, etc.)
    4.4. Monetary Savings
    4.5. Material Consumption
    4.6. Energy Usage
    4.7. Component Consolidation (lack of store-bought hardware)
    4.8. Lightweighting for Ergonomics

5. **Presentation Criteria**
    5.1. The team clearly describes their understanding of the problem to be solved.
    5.2. Design Process: good design logic is used for key design choices. Intentional and well-communicated
    5.3. The presentation is professional and well-rehearsed
    5.4. The presentation emphasizes quantitative improvements (measured and estimated) of the time, quality, or cost of the improvement as well as any DFAM tactics employed.
    5.5. Practical evaluation: team demonstrates visually (videos, photos, drawings, animation, etc) the task they improved, both before and after.

Grading Rubric

GR.1 Launch Performance — 35 pts

- Distance (best of 3 launches): 25 pts
  - Compare to peer competitors
- Consistency: 5 pts (all 3 figures land within a 6-inch diameter)
- Safe trajectory & controlled release (no interference or damage to parts while operating): 5 pts

GR.2 DFAM Execution & Print Quality — 20 pts

- Efficient use of AM geometry
- Thoughtful layer orientation
- Integrated mechanisms (springs, hinges, etc.)
- Complexity that adds functional value
- Built in locking trigger
- Clean print
- Quick assembly
- Good tolerances

GR.3 Engineering Notebook — 15 pts

- Completeness
- Technical clarity
- Analysis & iteration
- CAD quality

GR.4 Presentation — 15 pts

GR.5 Knowledge Exam - 15 pts

Pass with 70% or better or Fai