SkillsUSA Virginia
2026 Additive Manufacturing Challenge
Send It

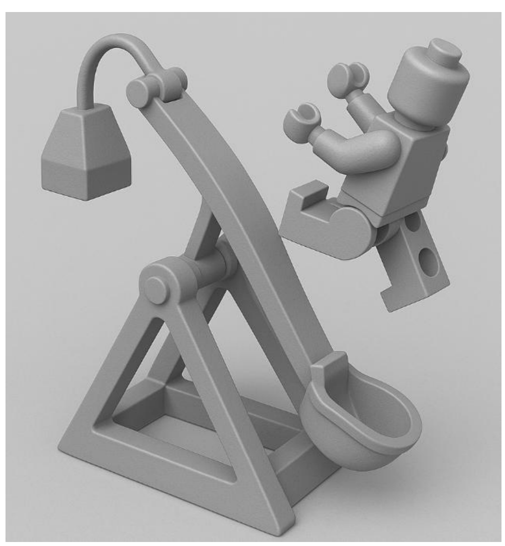
Welcome to the “Mini-Figure Catapult/Trebuchet Challenge” challenge!

This 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** (consisting of standard minifigure legs, torso, hands, and head; 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.
    - During launch, the device may be held to the ground for stability with one hand while the other hand triggers the release mechanism. The hand holding the device for stability may not perform any other motions or actions to aid the launch, and the hand holding the device for stability may not serve as the locking trigger mechanism.
    - The device may not be affixed to the floor in any way.
6. Requires no store-bought, non-3D printed 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).

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.
- Total build time* should be no more than 5 hours.

- Total model material* should be no more than 35 cubic inches.
- Total support material* should be no more than 8 cubic inches.

Note (*): As documented using GrabCAD Print software using Stratasys F170 template.

Performance Requirements

During testing, each launcher must:

1. Securely hold and release the minifigure.
    - The minifigure may not be modified or adjusted in any way by teams in preparation for launch, to include addition or removal of any minifigure parts.
    - The launcher may not damage the minifigure in any way.
2. Launch the figure forward, not upward only.
3. Complete **three launches**, which are measured for:
    - Distance
        - Maximum of the 3 launches will be used for score.
        - Measured distance includes flight distance and any sliding upon landing.
        - All measurements will be taken from a start line on the floor. Teams may place their device and conduct launches at any location behind the start line, but all parts of the device must be behind the start line when launch is triggered. Any launches conducted with any part of the device across the start line will be assessed as 0 distance.
    - Repeatability (all three launches must land – to include flight distance plus any sliding on landing – within a 6-inch diameter).
    - Safety and stability (No part interference, damage during operation, or unsafe trajectories)

Final products and engineering notebooks may not contain contestant names, school, county or city, or SkillsUSA district. All products should be identifiable only by the ID number assigned for these contests. Any note or reference to the contestants' names, school, city or county, or SkillsUSA district will result in disqualification.

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 generate Engineering Notebook (guidelines below).
2. Students generate physical parts and final assembly.

On contest day:

1. Students will present their engineering notebook and 3D printed assembly during a 20-minute interview with the contest judges.
2. Teams will perform 3 launches using contest-chair-provided minifigures.

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

     Use GrabCAD Print software (free download) with the Stratasys F170 template to obtain build time/material estimates. GrabCAD is also used in and specified by the national competition regulations.
   - 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.

Scoring Rubric

Prototype and Design (40% of total score)		
Description	**Basis of calculation**	**Possible**
Build time	Full points if total build time is less than 4 hours; half points if 4-5 hours; zero points if more than 5 hours	50
Model material	Full points if total model material is less than 25 in^3; half points if 25-35 in^3; zero points if more than 35 in^3	50
Support material	Full points if total support material is less than 6 in^3; half points if 6-8 in^3; zero points if more than 8 in^3	50
Finish quality	Judge's assessment based on quality of print, lack of cracks, burrs, etc.	75
Product durability	Judge's assessment based on design robustness, lack of obvious weak points or part failures, etc.	75
Overall design creativity	Judge's assessment based on creative and unique approach to product design leading to quality product	100
Subtotal		**400**

Performance (20% of total score)		
Description	**Basis of calculation**	**Possible**
Distance launched (max of 3 launches)	Proportionally allocated across teams (team with max distance after successful launch receives full points; team with min distance after successful launch receives 10 points; any teams that fail to launch receive zero points)	100
Landing consistency	Full points if all 3 minifigs land within 6" diameter circle; otherwise, zero points	50
Time to launch	Full points if all 3 launches completed under 2 minutes; half points if within 2-4 minutes; otherwise, zero points	50
Subtotal		**200**

Scoring Rubric (cont'd)

Engineering Notebook and Interview (35% of total score)		
Description	**Basis of calculation**	**Possible**
Design documented with sketches and CAD drawings	Judge's assessment based on engineering notebook and interview responses	100
Engineering design tree	Judge's assessment based on engineering notebook and interview responses	75
Consideration of design for 3D printing	Judge's assessment based on engineering notebook and interview responses	50
Screenshot of 3D printing software setup page	Judge's assessment based on engineering notebook and interview responses	50
Mistakes made and lessons learned	Judge's assessment based on engineering notebook and interview responses	25
Identify strengths and how to enhance	Judge's assessment based on engineering notebook and interview responses	25
Identify weaknesses and how to improve	Judge's assessment based on engineering notebook and interview responses	25
Subtotal		**350**

Resume (5% of total score)		
Description	**Basis of calculation**	**Possible**
Resume	See SkillsUSA Virginia resume rubric	50
Subtotal		**50**

Penalties		
Description	**Basis of calculation**	**Possible**
Clothing penalty	See SkillsUSA Virginia clothing requirements	-50
Non-3D printed material penalty	Full penalty applied if any non-3D printed material is used in product	-500
Assembled product size penalty	Full penalty applied if product does not fit inside 150mm x 150mm x 150mm volume	-250

GRAND TOTAL	**1000**