Connor Donahue — Mechanical Engineering Portfolio

SolidWorks • Prototyping • Mechanisms

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CTM-131 Toy Truck

Figure 1: Half Manufactured CTM-131

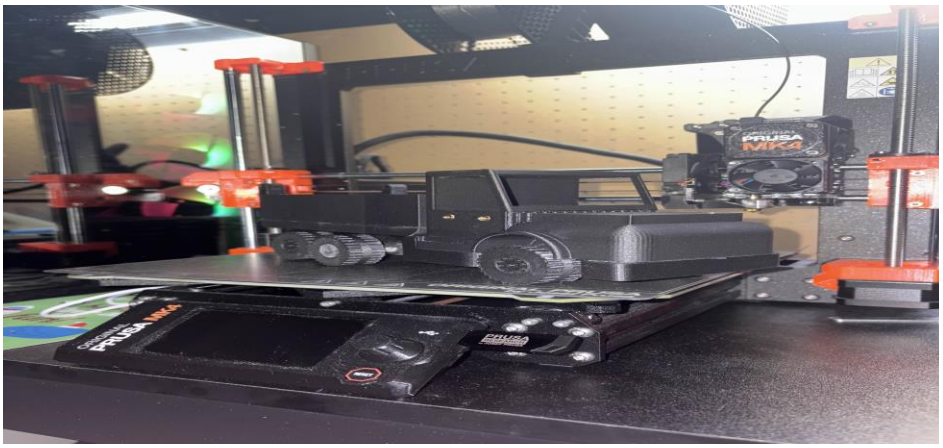
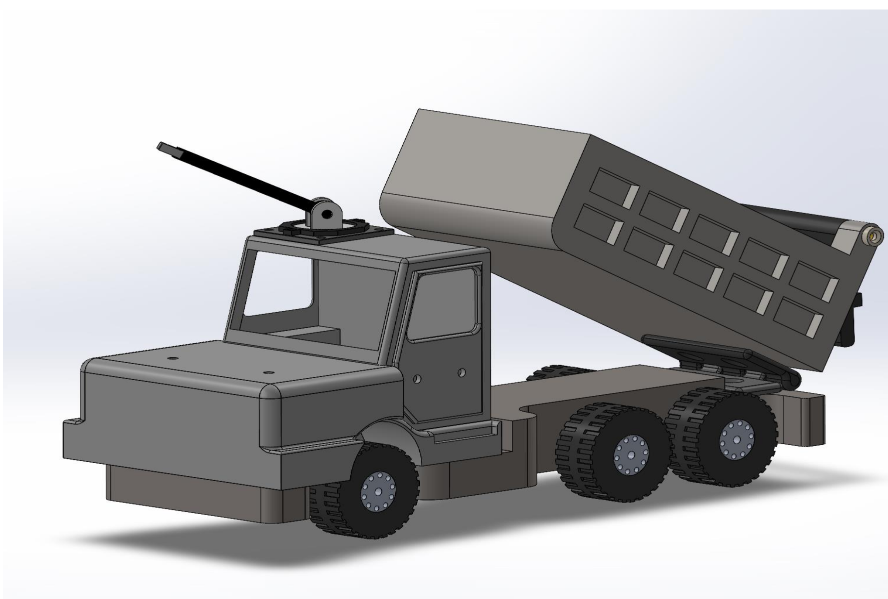


Figure 2: CTM 131 Assembly Collapsed View



Overview:

This was a class Project where I designed and manufactured a 1:35 scale toy utility truck inspired by the PLA FAW MV3 family of logistical trucks. The goal was to create a model with multiple functional assemblies that could actually be manufactured.

Tools: SolidWorks, Prusa Mk4, Generic Soldering Iron, M3-0.5 Heat Set Inserts

Requirements and Constraints:

- The truck had to be split into four subassemblies, each serving their own purpose.
- Each subassembly needed to utilize at least one heat-set insert.
- Parts needed to be designed around real assembly constraints (clearances, fasteners, and the realities of 3D printing).

Subassemblies (and what they do):

- Chassis + Axles + Wheel System: foundation of the model and mounting points for everything else. Wheels tightly fit the axle, and rotate with it, creating functional wheels.
- Cab: Mostly for shape and toy appeal to theoretical users, it also supports the crane.
- Dump Bed: hinged bed with a simple mechanism so it can move and seat properly.
- Crane Assembly: a separate mounted system intended to represent a working accessory module. Can rotate 360 degrees, and the boom arm can extend to twice its original length.

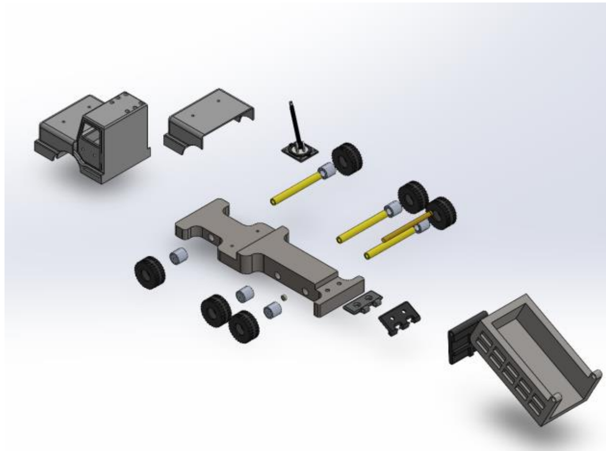
What I learned:

The project taught me how quickly a "perfect" CAD model turns into a tricky manufacturing situation. Dimensions proved to be a tricky thing, yet nothing that couldn't be overcome by opening SolidWorks back up, changing a dimension, re-converting to a .STL, re-slicing, and then re-printing. I also learned the importance of calibrating my printer, as a Z-axis failure almost cost me the entire project with a particularly important print.

Note about the first photo:

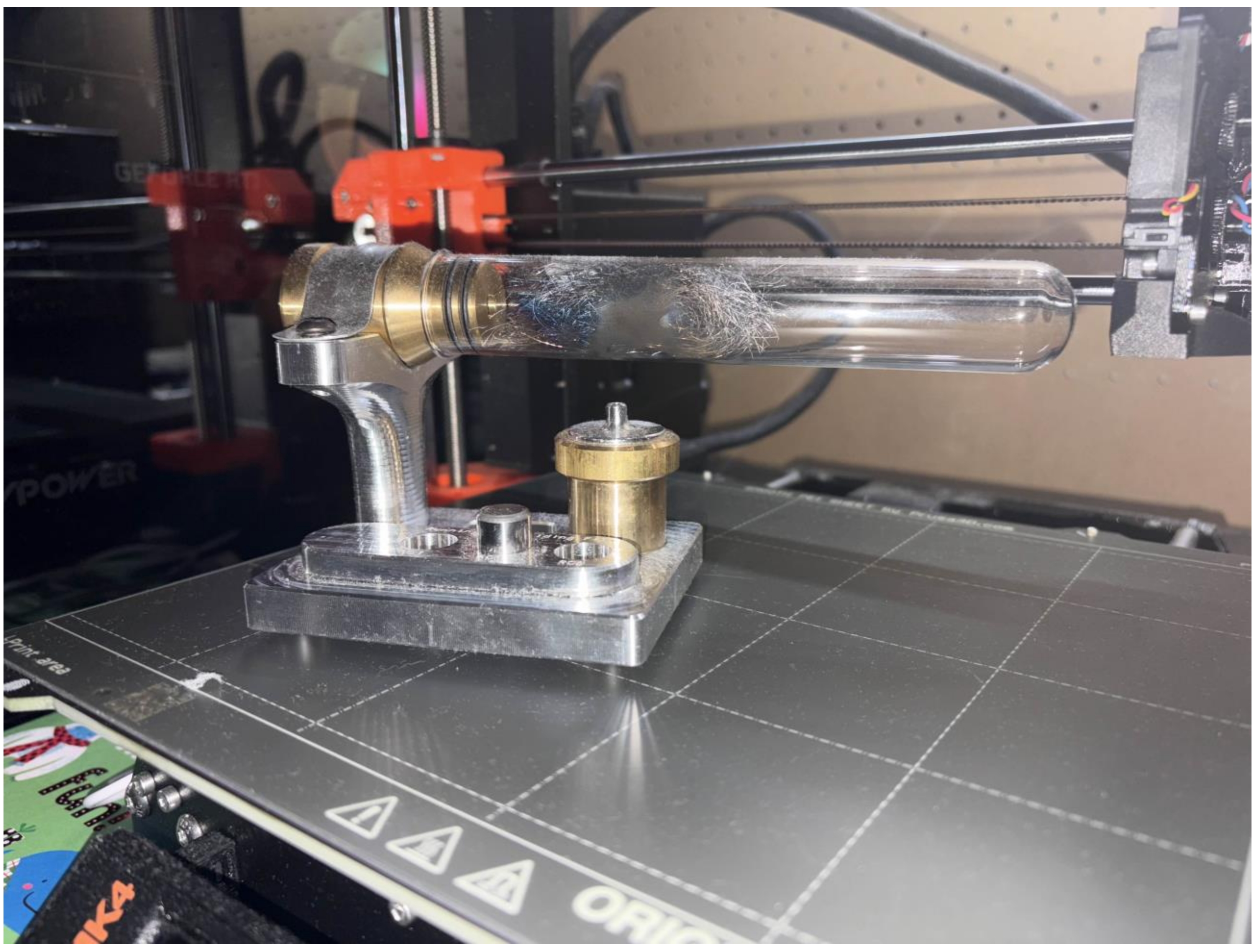
The only photo I have is from an unfinished stage, because I submitted the final model to my professor to use as a reference example for future classes, and I never actually took a picture of the finished, printed truck (very sad). The CAD and assembly structure shown reflect the full design and final intent.

Figure 3: CTM-131 Exploded View



Functional Stirling Engine

Figure 4: Assembled and Machined Stirling Engine



Overview:

This project was a full build of a small Stirling engine that truly works and moves a piston. The focus was on designing toolpaths in Mastercam 2025 based on SolidWorks modeled parts that could ultimately be used on HAAS mills and lathes.

Tools: SolidWorks, Mastercam 2025, HAAS Mill, HAAS Lathe

Requirements and constraints:

- Parts had to be designed so they were machinable with available tools and toolpath operations in Mastercam 2025.
- The piston had to fit loose enough to allow movement, but not loose enough to let out gas from the glass cylinder.
- The mills and lathes are only so accurate; multiple attempts at the same G-Code were necessary for some parts.

How the Engine Actually Works:

1. Ethanol is poured into the lower brass cylinder. This will serve as the engines fuel.
2. The aluminum plate with a central cut for a wick is placed atop the aforementioned cylinder, with the wick positioned directly under the steel wool within the glass cylinder.
3. The wick is lit, and burns, heating up the steel wool within the cylinder.
4. As the flame heats the air within the cylinder, the air expands, thus rising pressure, and pushing the piston outward.
5. The displacer, along with the piston, draws some of the hot air away from the flame, thus cooling the air down, and lowering pressure, causing the piston to retreat.
6. This cycle repeats itself for as long as fuel is provided, in and out, in and out, in and out.

What I learned:

This was one of my first projects where I really saw how different “real manufacturing” is from a perfect CAD model. The biggest lesson was that even when you think you’re controlling everything, the process still has variability. For example, I learned you can run the same program and still get measurably different results depending on machine condition, tool wear, workholding, and small setup differences.

The Adjustable Standing Stand

Figure 5: The Adjustable Standing Stand in an extended position

Overview:

This was a dorm focused design project where the constraint was to create a piece of furniture that meaningfully imporves student quality of life. My solution was an adjustable working platform that can sit on a normal dorm desk and raise a laptop, tablet, or paper workspace to a comfortable height and viewing angle for a large and diverse user base, without having to rearrange or replace dorm furniture.

Tools: SolidWorks

Requirements and Constraints:

- Must improve daily life for students in a dorm setting.
- Must work with existing typical dorm furniture (often fixed/unmodifiable).
- Compact enough to sit at a desk and be put away easily.
- Able to support common study items (laptops, iPads, notebooks) of various sizes.
- Designed in CAD only (not printed due to size limitations).

Main Assemblies (and what they do):

- Scissor Lift Mechanism: two base plates with slot cuts in them facilitate four arms that ultimately work together to lift and lower the work platform to a desired height.
- Knobs: The knobs (colored in copper) serve as the locking mechanism. Their knobs are decorative and ergonomic, beneath there is a nut, and a threaded surface that allow for the tightening of the knob onto the base plate. Eventually, the knob is tightened enough so that the friction between the knob and base plate locks the stand into place.
- Tilt Hinge Mechanism: Changes the viewing angle for comfort and ergonomics. Essentially, the work surface is screwed onto a hinge and moves with it.
- Vented Work Surface: This surface is where the theoretical laptop/iPad/notebook would be placed. It has circular cutouts to facilitate adequate airflow for devices that need it.

What I learned:

This project taught me how to design around real user constraints, not just mechanical constraints. Dorm furniture is often fixed, space is limited, and both comfort and aesthetics matter, so the best solution is one that fits into the environment students already have. It also reinforced that mechanism design is about tradeoffs. For example, with the design, raising the maximum height not only widens the sides of the base plate, but raises the center of gravity. This example faces two problems: 1. It has to fit on a desk; it needs to be reasonably wide to fit a typical range of dorm desks, and 2. The center of gravity has to be low so that it doesn't tip over in real world use, and destroys some poor student's $1000 laptop.

Even though this stayed as a CAD design (due to the size of large parts, plastics being a poor choice for some structural parts, and material cost of perhaps using metal in some areas), I learned how to build a clean, believable design that could realistically be manufactured and used.

Evaluating and Developing a Responsible AI “Copilot” RAG System

Location: Zurich University of Applied Sciences (Winterthur Campus) Centre for Artificial Intelligence (CAI), Worcester Polytechnic Institute

Overview:

In a student research project, in collaboration between WPI and ZHAW CAI, I led a multidisciplinary student research team to evaluate a Retrieval-Augmented Generation (RAG) system used in a Responsible AI (RAI) Copilot. The goal was straight forward, design a methodology that would stress-test the system like a real user would, find where it breaks down, and turn those failures into engineering feedback.

Tools: Python, Pandas, Matplotlib, Jupyter Notebook, Excel

My Role:

I led the team’s testing and analysis effort end-to-end: defining what “good” looks like, designing a repeatable test approach, collecting results, structuring the data, and summarizing the results meant for improving the system. Advised by a cross-institution team of faculty and researchers from WPI and ZHAW CAI.

Requirements and Constraints:

- Evaluate the system based on realistic user queries.
- Track results in a way that’s repeatable and comparable across runs and versions.
- Focus on weaknesses and failure modes.
- Keep findings clear, actionable, and extremely concise for busy engineers and stakeholders.

What I focused on:

- Building a structured testing set (queries + necessary documents to be retrieved in order to accurately answer said query)
- Separating the problem into parts: Retrieval quality vs. Answer quality
- Capturing results consistently in an organized Excel/Jupyter workflow (what was asked, what was retrieved by the model, model output)

What the Analysis Uncovered:

- Retrieval gaps: the right sources weren't always pulled, even when they existed in the database.
- Weak evidence linkage: the system could produce a confident answer while the citations were incomplete, vague, or not clearly supporting the claim.
- Response degradation: In longer (token wise) model outputs, responses would noticeably decrease in quality towards the end of said response.

Outcome/Impact:

I delivered a clear set of failure modes, examples, and most importantly: improvement targets and recommendations, so the next iteration of development and research could focus on concrete changes (better database structuring/clean input data/metadata, tighter evidence expectations, and evaluation that makes regressions obvious.

Note about Confidentiality:

This is a real-world product set to launch in the near future that holds proprietary technology and sensitive data. I am not at liberty to disclose everything about this project; thus, I keep my description here high-level. The full paper may be available in the future.