Virginia SkillsUSA 2024
Additive Manufacturing State Challenge

Make It Run

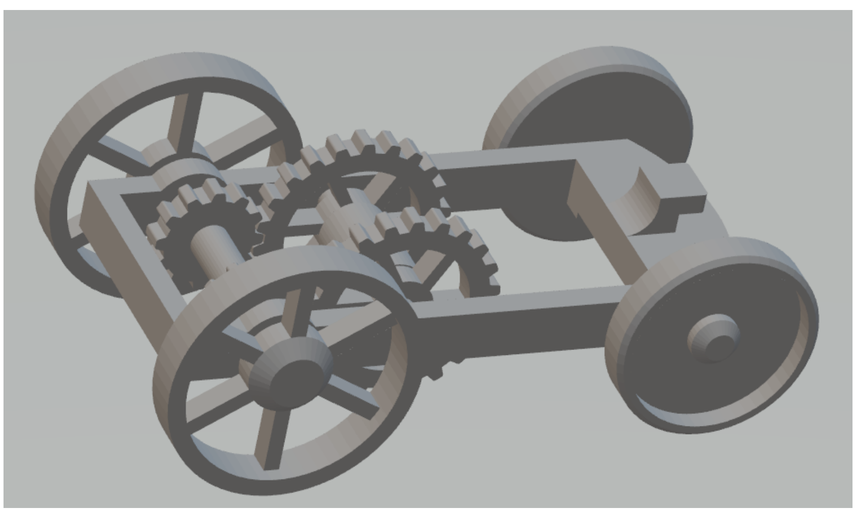
Welcome to the "Make It Run" challenge!

The task at hand is to design and fully print a 4 wheeled vehicle powered only by a single rubber band. The vehicles will then be tested on a "track" for functionality, and additional scoring.

Design Considerations:

- Interlocking parts
- Printed Assemblies
- Snap fits
- Printable Tolerances
- Motion
- Kinetic to Potential Energy

Example of Basic Design



Competition Requirements

1. The design **must** be completely 3D printed.
2. The design **must not** contain any outside hardware (axles, screws, washers), except for a rubber band for motion.
3. The design **can** be 3d printed using any technology.
4. The design **must** contain a legibly printed team number
5. The design **can** contain 3D printed bodies that are assembled after printing for the final part.
6. Parts **must** have printed wheels
7. The design **must** contain at least 3 moving parts
8. Wheels **can not** be larger than 3 inches in diameter
9. The design **must** be powered only by a single rubber band
10. The design **must not** exceed 6” x 4” x 4”
11. 3D Printed Design - Students **must** create a design that:
    - Is original and designed by contestant
    - Print all parts in less than **12** hours total
    - Uses less than **5** cubic inches of model and/or support combined for all parts.

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.

Tips for Competitors

Here are some tips to maximize the points awarded to you:

- Build debossed text on a horizontal surface for best results. This may require building the part on its edge or standing up.
- Utilize soluble support structures for print in place assemblies
- Understand the achievable design tolerance of your printer for print in place, or hand assembled designs to allow motion between parts.
- Leverage post-processing techniques to smooth printed bodies.
- Additional moving parts may add to your score but can produce more points of failure on the final assembly.
- Use online resources (YouTube, GrabCAD Tutorials)
- Whenever intellectual property (IP) deters you from a project, try using approximate geometries to communicate the design intent.
- Optional design for additive manufacturing learning resources:
    - Stratasys Think Additively™ Masterclass:

- https://youtube.com/playlist?list=PLUYaY5EIPtNBdU-s-7l9rl05lBHHlTarl

State Competition Procedure

On contest day, students will present their engineering notebook and 3D printed assembly during a 20-minute interview with the contest judges.

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.

6. Racetrack Setup

6.1. Track will have a starting line and distance markers at 1", 6",12", and with marks every foot after up to 6 feet. Ruler or measuring tape will be used for final measurement above 12".
6.2. Front tire/tires must begin behind the starting line.
6.3. A **small** nudge can be used to help get the car moving (see grading rubric)
6.4. Each design will have 2 chances to run on the track. The better of the two scores will be used for final judging.
6.5. Final distance of vehicle is measured where the front wheels touch the ground

Scoring Rubric

Criteria	Level	Points	Points awarded
The Design is Completely 3D Printed	Uses External hardware	0	
	Final design uses only 3D printed components	10	
Parts Mate, Assemble and/or Fasten Together as Designed	Parts do not fit together as intended	0	
	Some parts fit together as designs, considerable post processing is needed for fitment, or some parts do are not fully secure to one another	3	
	All parts mate and assemble as designed, and are securely fastened to one another	10	
Part Contains Legibly Printed Team Name and/or Number on Final Design	Final Design does not contain team number	0	
	Final Design contains team number but is illegible	5	
	Final Design contains legible team number	10	
The Final Design utilizes printed wheels no larger than 3”	The wheels are not printed and are larger than 3” in diameter	0	
	The wheels are not printed, and are no larger than 3 in. in diameter	2	
	The wheels are fully printed and are no larger than 3” in diameter	20	
The Final Design contains 3 individual moving printed parts	The design contains 2 or less moving parts	0	
	The final design contains 3 moving parts	8	
	The final design contains 4 or more moving parts.	10	
The Final Design must be not exceed 6” x 4” x 4” in size	The final design exceeds the dimensional limits	0	
	The final design is with the dimensional limit	20	
Total Build Time	Print time exceeded 12 hours	0	
	Print time was between 8 and 12 hours	8	
	Print time was 8 hours or less	10	

Criteria	Level	Points	Points awarded
Total amount of Material	More than 5 cubic inches of Material	0	
	2-5 Cubic inches of Material	4	
	Under 2 cubic inches of material	5	
Design Creativity and Uniqueness	Rudimentary/Basic Design	1	
	Original design displaying well thought out attributes	4	
	Creative design with functionality	5	
The Final Design is Completely Powered by a Single Rubber Band	The final design does not run by the rubber band, nor starts from a gentle nudge	0	
	The final design runs by the rubber band but requires a slight nudge to start	10	
	The final design starts and moves completely by the rubber band	20	
Final Design Drive Distance on Track	The final design travels less than 1 inch	0	
	The final design travels between 1 to 6 Inches	15	
	The final design travels between 6 and 12 Inches	20	
	The final design travels over 12 inches	+1 per inch over 12”	
Presentation	Demonstrate thought process, design process explained, identify greatest design strength and how to enhance it, identify greatest design weakness and how to improve it	0-30	
Engineering notebook	Concept description, specifications noted, dimensional and tolerance drawings or sketches, engineering design tree, CAD image of finished product, considerations of design for 3D printing, finishing aspect that affects or impacts design, mistakes made/lessons learned	0-30	
Total score		**200**	