



MESA in Collaboration with General Motors and SAE Arizona

Present

The “It’s Complicated” Contraption Challenge

- LEVEL:** Middle School/High School
- NUMBER OF TEAMS:** One (1) team per school can participate at the MESA Day state competition. Three (3) teams can participate at MESA Regionals.
- TEAM MEMBERS:** Three (3) to Five (5) students
- OBJECTIVE:** Design and build a contraption that raises a flag at least six (6) inches above the ground as a final step. The team must use creativity and knowledge to design a contraption that completes as many steps possible while keeping physical interaction to a minimum. The complexity and flow of these steps will affect the overall performance of the team.
- MATERIALS:** All materials are allowed with the exception of any hazardous material.
- BACKGROUND:** This competition resembles the well-known Rube Goldberg machine that was named after a cartoonist and inventor born in 1883. It is an over-engineered machine that completes a series of complex steps in order to complete a simple task, such as flipping a switch. As seen in various movies such as *Back to the Future III* (<https://www.youtube.com/watch?v=23Hzq8BG2YE>), these designs are generally created with the intention of making life easier by automating a process. These machines use a form of kinetic energy to start and continue their route by making an inanimate object move another; this is called conservation of energy.
- The main idea behind this competition is to challenge the team to use their creativity to design the most complex contraption. The concept of this contraption can be implemented into an infinite number of engineering applications. The contraption can be directly related to any machine that uses conservation of energy to repeat a single process consistently, such as the drivetrain in a vehicle or the thermodynamic process of Air Conditioning. The team undertaking this task will understand that the key to building a successful contraption is having complete control of where every object will move. Therefore, understanding the movement, weight, and physical dimensions of the objects while sustaining the appropriate supports will be an advantage.

DESIGN PARAMETERS:

1. The contraption must fit within a 4ft x 4ft square with no objects permitted outside of the boundaries with the exception of a power cable if applicable.
2. Any hazardous or potentially hazardous materials **must not** be included as part of the contraption.
3. Contraptions should have at least 5 steps.
4. If a step is repeated throughout the run, such as two sets of dominos in different areas, they are recorded as a single step.
5. The dimensions of the flag must **not** be less than 4” x 6”. When raised, the distance between lowest point of the flag and the floor from which it is lifted must be at least six (6) inches. Raising the flag **must** be the last step.
6. Must have a theme for the design of the contraption. This can be anything you like (e.g. school mascot or name, a game, sports team).
7. Must be clearly labeled with the school name for identification purposes.
8. Use of Engineering Design Notebook with design notes, iterations attempted, bill of materials, and reports of results is required. Any other relevant information about the design, build, and test process is a plus. See attached rubric for more information.
9. Students are encouraged to upload a video of their fully functioning contraption to YouTube prior to competition. A shared video will earn the team 5 points.

SPECIFICATION CHECK:

1. Teams must submit their engineering notebooks upon team registration. The contraption will receive a specification check to verify acceptable materials and dimensions are used. The team will proceed to a designated area to assemble and test their contraption.
2. If hazardous material is used, the team will be disqualified and will not be able to compete. Team will receive a performance score of zero but can still receive points for their video and engineering design notebook.

TESTING PARAMETERS:

1. At least two team members must be present during testing.
2. Each team has an hour to assemble and test their contraption; there is no limit as to how many times a team can test within that timeframe.
3. The start of the run is limited to one team member having physical contact with the contraption.
4. Once the contraption is in motion the team is asked to step back and is not allowed to interact with the contraption.
5. If the run comes to a complete stop before completing the run, one team member is allowed to interact with the contraption in order to resume the run. However, this will incur a penalty.

JUDGING:

1. When the assembly/testing time limit of an hour is up team will be asked to step back.
2. The team is given time before the first trial to provide an introduction of themselves and their contraption.
3. Each team is given three trials with 10 minute intervals to return the contraption to its original state.
4. Judges take the best two (2) of three (3) trials to be used for the final score.
5. Scoring is based on number of steps, the team’s theme, the complexity and flow of the contraption, whether flag was raised, and penalties are given if the contraption stops in the middle of the run or exceeds the time limit of 5 minutes.

SCORING:

1. Each step equals two (2) points.
2. If a step relies on electrically powered components, such as an electric motor, the step equals four (4) points. These will be considered Robotic elements for scoring purposes.
3. The theme and flow of the design is evaluated in a scale of one (1) to eight (8) points.
4. A total of ten (10) points will be awarded for raising the flag above 6 inches from the ground (measured from the flag’s starting point). Five (5) points will be awarded for partially raising the flag and one (1) point for having a flag.
5. If the teams, shared a video of their fully functioning contraption they will earn 5 points.
6. Any run longer than five (5) minutes will result in a penalty.
7. If the contraption stops in the middle of a run, a team member can interfere to resume the run, but this will result in a penalty for each interference. If the team completes the run without interferences an additional ten (10) points will be added to the total score.
8. Three (3) trials will be conducted and the best two (2) will be added, these will result in the final score.
9. Engineering Design Notebooks will be scored on a scale of 0-10 points and this score will be added to the performance score.

$$Total = \frac{2 * (\#ofSteps) + 2 * (\#ofRobotics) + (FlagRaised) + (Theme\&Flow) + (Flawless Run)}{Penalties + 1}$$

Resources:

Official Rube Goldberg National Competition website: <https://www.rubegoldberg.com/>

Tips to consider and background: <http://brainpowerboy.com/rube-goldberg-ideas-machine-tasks-and-materials/>

Follow General Motors: <http://www.gm.com/index.html>

Follow SAE: <http://www.sae.org/>

School: _____

Student Names: _____

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Specification Check:	Pass	Fail
Materials are safe to use?	Yes	No
Contraption fits in a 4ft x 4ft square?	Yes	No
Flag is at least 4" x 6"?	Yes	No

Performance:

	Complete	Average	Fair
Flag Raised	Raised flag 6 inches or more from the ground to the lowest point on flag. (10 points)	Raised flag less than 6 inches. (5 points)	Did not raise flag. (0 point)
Theme & Flow	Team introduced themselves and the theme before first trial. Contraption uses complex materials but is decorated and runs smoothly. (8 points)	Did a fair job or missed at least one of the following: Introduction, Complex, Decorated, Runs Smoothly. (4 points)	Missed three of the following: Introduction, Complex, Decorated, Runs Smoothly. (1 point)

	Trial 1		Trial 2		Trial 3	
Number of Steps		x 2		x 2		x 2
Number of Robotics		x 2		x 2		x 2
Raised Flag Points						
Theme and Flow Points						
Perfect Run Points						
Total = $\frac{\text{Summation of Points}}{\text{Number of Penalties} + 1}$ *						

*Penalties are awarded if time exceeds 5 minutes and for each intervention.

Notebook Score (max 10 points) = _____

Video Score (5 points) = _____

TOTAL SCORE (sum of top two trials plus notebook score and video score):

Lead Judge Signature: _____ Student Signature: _____

Rubric for Engineering Design Notebooks (EDN).

EDN Goals	3	2	1	0
1. Explore				
1.1 Problem Statement. Accurately describes, in your words, the design objective (includes success criteria, constraints constants and variables)	Specific description of problem, success criteria, constraints, variables and constants	Basic...	Weak...	No...
1.2 Depth of Free exploration. Prior knowledge, brainstorming & hands-on exploration documented.	Numerous examples of brainstorming and hands-on exploration observations.	Regular...	Few...	No...
1.3 Research in Design: Research ideas about your design that might be useful. Record information using different sources (e.g. books, websites, interviews from experts).	Clear analysis of other design pros/cons.	Basic...	Scant...	No...
2. Design				
2.1 Design Plan. Includes reasoning on your design choices (materials used, modifications, etc.). Use data from past trials, research and design considerations.	Clear reasons given (based on data or research) for each design choice.	Basic...	Scant...	No...
2.3 Design sketching and/or photos. Prior & during build, team sketches, 2-D or 3-D perspective drawings.	Numerous representations of each design iteration.	Regular...	Scant...	No...
3. Test				
3.1 Observation. Data & written observations (tables, graphs, labeled drawings, etc.).	Numerous presentation of quantitative & qualitative data, graphs & charts follow design progression.	Regular...	Scant...	No...
3.2 Reflection/Analysis. Assesses pros and cons of design/materials, testing procedure, etc. Apply test results and analysis to pose a theory, recommend and argue for a next step, or draw an insightful conclusion. Restate the purpose in your conclusion.	Detailed reflection shows how design considerations and logic flowing from research, test analysis, etc.	Basic...	Scant...	No...
4. EDN Organization				
4.1 Structured. Includes Table of Contents with key elements. Elements of EDN can be used to answer judges questions easily	Clear organization utilizes defined sections.	Basic...	Minimal..	No...
4.2 Labeled. Clearly labeled with School and Team Members names.			Yes	No
Column Totals (for selected categories)				
Subtotal (out of 25)				
Modifier			(S ÷ 25) x 10	
Score (out of 10)				

Comments/Suggestions: