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 machine that opens a hardcover book as a final step. The team must use creativity and knowledge to design a controlled contraption that completes as many steps as 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 and videos, *https://www.youtube.com/watch?v=qybUFnY7Y8w*, 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 (A/C). 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.

The "It's Complicated" Contraption Challenge
Event Specifications
MESA Day 2017

DESIGN PARAMETERS:

1. Any hazardous or potentially hazardous materials **must not** be included as part of the contraption.
2. The contraption **must** fit within a 4ft x 4ft square with the exception of a power cable, if applicable.
3. Contraptions **must** have at least 5 steps. Using a single object to trigger multiple contraptions counts as one step (e.g. a ball setting off a mousetrap and dominos).
4. The width and height of the book must **not** be less than 5 inches each with a thickness no less than 0.5 inch. Opening the book **must** be the final step. Teams must provide their own book.
5. Steps in the contraption **must** relate to an overall theme. This can be anything you like (e.g. school mascot/name, a game, sports team, job).
6. Contraptions **must** be clearly labeled with the school name for identification purposes.
7. Use of Engineering Design Notebook with design notes and drawings, reports of results, iterations attempted, and bill of materials is required. Any other relevant information about the design, build, and test process is a plus. See attached rubric for more information.
8. Students are encouraged to upload a video of their fully functioning contraption to YouTube prior to the competition. The video should include a quick introduction which includes the name of the school. It is recommended that a sign that clearly states the name of the school be shown at the start of the video.

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. If the team fails to pass specification check the team will be allowed to test but will not be able to compete. The team will receive a performance score of zero, but can still receive points for their video and engineering design notebook.
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 the 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 execution, the complexity and flow of the contraption, whether book was opened, and penalties are given if the contraption stops in the middle of the run, if materials extend beyond the 4ft square, or exceeds the run time limit of 5 minutes.

SCORING:

1. No objects permitted outside of the 4ft x 4ft boundaries. If objects exit the boundaries during a run one penalty point will be added.
2. The theme and flow of the design is evaluated with a maximum of fifteen (15) points. This requires a great introduction of the team, how the steps refer to the overall theme, the use of non-intuitive materials, and smoothness from step to step.
3. Each step is two (2) points if a step relies on electricity (outlet/battery) the step is two (2) additional points. If a step is repeated throughout the run (e.g. two sets of dominos in different areas, a ball triggering multiple contraptions) it is recorded as a single step.
4. A total of ten (10) points will be awarded for opening the book more than half way (90 degrees). Five (5) points will be awarded for opening the book more than 1 inch and one (1) point for having a book with the specified measurements.
5. Any run longer than 5 minutes will result in a penalty.
6. 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 (maximum one per step). If the team completes a Perfect Run, a run without interferences, an additional ten (10) points will be added to the run score.
7. A total of 3 trials will be conducted. The best 2 trials will be added to determine the total score.
8. If the team, shared a video of their fully functioning contraption they will earn five (5) points in addition to their total score.
9. Engineering Design Notebooks will be scored on a scale of 0-10 points and will be added to the total score.
10. Final Scores will be calculated using the following equation:

$$Total = \frac{2 * (Steps) + 2 * (Electronic) + (Them\&Flow) + (Opened\ Book) + (Perfect\ Run)}{Penalties + 1} + (Notebook) + (Video)$$

Resources:

Design a Contraption: http://contraptionmaker.com/

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

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

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

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MESA Day 2017

School: _____

Student Names: _____

_____

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Specification Check:	**Pass**	**Fail**
Materials are safe to use?	Yes	No
Book is at least 5" x 5" x 0.5"?	Yes	No
Contraption is clearly labeled with the school's name?	Yes	No
Contraption fits within a 4' x 4' square?	Yes	No

Performance:

	Complete	**Average**	**Fair**
Opened Book	Opened Book more than 90 degrees. **(10 points)**	Opened book more than 1 inch. **(5 points)**	Opened book less than 1 inch. **(1 point)**
Theme & Flow	Great introduction from the team. Contraption uses complex materials, step decoration aligns to theme/story, and runs smoothly. **(15 points)**	Did a fair job/missed at least one of the following: Introduction, complex, decorated, runs smoothly. **(5 points)**	Poor job in 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
Opened Book						
Theme and Flow						
Perfect Run (10 points)						
Summation of Points						
Number of Penalties*						
Total = $\frac{\text{Summation of Points}}{\text{Number of Penalties}+1}$						

*Penalties are awarded if time exceeds 5 minutes, intervention per step, and if objects go beyond the 4ft x 4ft square during run.

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: