GENERAL MOTORS

MESA in Collaboration with General Motors 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 turns on a light as a last 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 team presentation and overall contraption design as well as the complexity and flow of the steps will affect the overall score.

MATERIALS: Hazardous material, except for batteries, are not allowed.

BACKGROUND: A contraption machine is an over-engineered machine that completes a series of steps to complete a simple everyday task. These designs are generally created to make life easier by automating a process. Contraption 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.

This competition will challenge the team to use their creativity to design the most complex contraption. The concept of this contraption and the cycle and interaction of moving parts can be implemented into an infinite number of engineering applications. Some examples of these cycles are 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 used while sustaining with the appropriate supports will be an advantage.

By participating in this competition students will have the ability to learn how to give a short presentation effectively, use common materials to invent, analyze data to optimize a design, enhance artistic skills, and document findings.

The "It's Complicated" Contraption Challenge
Event Specifications
MESA Day 2019

DESIGN PARAMETERS:

1. Any hazardous or potentially hazardous materials except for batteries **must not** be included as part of the contraption.
2. Must be clearly labeled with the school name for identification purposes.
3. The contraption **must** fit within a 4ft x 4ft square except for a power cable, if applicable.
4. Contraptions **must** have at least 5 steps.
    a. A step is only a step if it contributes to the last step. (e.g. a ball triggering multiple contraptions is a single step)
    b. Only unique steps will be taken as steps. (e.g. two sets of the same dominos in different areas is a single step)
    c. Steps **must** relate to the overall theme. (e.g. school, game, brand, sports team)
5. An electronic device can be anything that uses electricity. (e.g. motor, Arduino, toaster)
6. A 3D printed object can be anything made from rapid prototyping or additive manufacturing.
7. Turning on the light **must** be the last step. Access to electricity is not guaranteed.
8. Teams must submit a budget not to exceed $60.00. Teams that go over budget or have an incomplete budget will be disqualified.
    a. Purchased items or commercially available materials or kits (i.e. legos, k'nex, arduino) must have a price listed in the budget.
    b. Salvaged items do not need to have a price but should be listed in the budget. Salvaged items are defined as items that were designed as single-use (straws, soda bottles, paper towel tubes) or would otherwise be thrown away (scrap lumber, pvc, metal).
9. 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.
10. Students are encouraged to upload a video of their fully functioning contraption to YouTube prior to the competition.

SPECIFICATION CHECK:

1. Teams will go through the registration and specification check with a judge. The contraption will receive a specification check to verify acceptable materials and dimensions are used.
2. If team fails to pass specification check the team will be allowed to test if materials are safe to use but will not be able to compete. The team may still get notebook and video points.
3. Teams must submit their engineering notebooks upon team registration.
4. Team must submit their budget upon registration.
5. Approved teams will proceed to a designated area to assemble and test their contraption.

TESTING PARAMETERS:

1. At least two (2) team members must be present during testing.
2. Each team has 30 minutes 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 may interact with the contraption to resume the run; however, this will incur a penalty.

JUDGING:

1. If anyone other than the students registered for the competition participates or helps the team during the competition the team will be penalized or disqualified.
2. When the assembly/testing time limit of 30 minutes is up the team will be asked to step back.
3. The team is given time before the first trial to provide an introduction of themselves and their contraption.
4. Each team is given three (3) trials with 10-minute intervals to return the contraption to its original state.
5. Judges take the best two (2) of three (3) trials to be used for the final score.
6. Scoring is based on number of steps, the team's theme execution, the complexity and flow of the contraption, whether a light was turned on, and penalties are given if the contraption stops in the middle of the run, if materials go out the 4ft square, or exceeds the time limit of 5 minutes.

SCORING:

Points

1. Each step is two (2) points if a step relies on 3D printed material or electricity (outlet/battery) the step is two (2) additional points.
2. The theme and flow of the design is evaluated with a maximum of sixteen (16) points.
   a. An introduction of the team members as well as the project theme and description of steps is required to achieve a good introduction.
   b. The steps should be tied back to the overall theme.
   c. The contraption must be decorated as to represent the theme
   d. The use of non-intuitive materials/steps and systems should be used. (e.g. pulleys, electronics)
   e. Each contraption should have a smooth transition. (i.e. A too many marbles going off in different directions does not create a smooth transition.)
3. A total of ten (10) points will be awarded for turning on the light. Four (4) points will be awarded for a light that flickered and zero (0) points for a light not turned on.
4. A total of three (3) trials will be conducted and the best two (2) will be added, these will result in the total score.

Penalties

1. If there is any external help the team may be penalized or disqualified.
2. No objects permitted outside of the 4ft x 4ft boundaries.
   a. If objects exit the boundaries during a run one penalty point will be added.
3. No runs longer than 5 minutes, any run longer than 5 minutes will result in a penalty.
4. The team has the option to trigger a step when the contraption comes to a stop. If a team member triggers a step to resume the run a penalty point will be added.
   a. Only one penalty point per step may be added. (i.e. Only one penalty point is added if a team member attempts to trigger the next step but fails and then retries.)

Total

1. The total score for each run will be the total number of points from the number of steps and steps with electronics, the theme and flow, and points from turning on a light divided by the number of penalties, if any.
2. The total score for the competition will be the added scores from the top two runs.
3. If the teams shared a video of their fully functioning contraption they will have five (5) points added to their total score.
4. Budgets score will be added to the total score. Budget will be given a score as follows:
   - Contraptions with a budget of less than $20 will receive a 5 points
   - Budget of $20-29 will receive 4 points
   - Budget of more than $30-39 will receive 3 points
   - Budgets of $40 or more will receive no additional points.
5. Engineering Design Notebooks will be scored on a scale of 0-10 points and will be added to the total score.

$$Total = \frac{2 * (Steps) + 2 * (Electronic\ or\ 3D\ Printed) + (Theme\ \&\ Flow) + (Light\ Points)}{(Penalties\ if\ any)} + (Notebook) + (Video)$$

RESOURCES:

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

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

Contraption Example: https://www.youtube.com/watch?v=qybUFnY7Y8w

Hazardous materials: https://ehs.research.uiowa.edu/list-hazardous-materials-and-disposal-contacts

Follow General Motors: https://www.gm.com/

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Event Specifications
MESA Day 2019

School: _____

Student Names: _____

_____

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Specification Check:	**Pass**	**Fail**
Fits in a 4ft x 4ft square?	Yes	No
Materials are safe to use?	Yes	No
Team has a light source?	Yes	No
Team has a complete budget?* *No budget or over budget = Disqualified	Yes	No

Performance:

	Complete	**Average**	**Fair**
Theme & Flow	Good Team introduction. Contraption uses complex materials. Decoration aligns to theme/story. Runs smoothly. **(16 points)**	Average job/missed at least one of the following: Introduction, complex, decorated, and runs smooth. **(6 points)**	Fair job in three of the following: Introduction, complex, decorated, runs smoothly. **(2 point)**
Light Points	Light stays on. **(10 points)**	Light flickered. **(4 points)**	Light did not turn on. **(0 points)**

	Trial 1			**Trial 2**			**Trial 3**		
Number of Steps		x 2			x 2			x 2	
Number of Electronics or 3D printed Material		x 2			x 2			x 2	
Theme and Flow									
Light Points									
Summation of Points									
Number of Penalties*									
Total = $\frac{\text{Summation of Points}}{\text{Number of Penalties}^{**}}$									

*Penalties are given if external help is utilized, intervention per step, used space beyond the 4ft x 4ft square, time exceeds 5 minutes.
**Only divided if penalties exist.

Notebook Score (max 10 points): _____

Video Score (5 points): _____

Budget Score (max 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: