WTP-ME Rube Goldberg Machine Challenge 2007

PROJECT DESCRIPTION

Rube Goldberg Machines are "absurdly-connected machines functioning in extremely complex and roundabout ways to produce a simple end result[1]." They were depicted in cartoons by Reuben Lucius Goldberg (July 4, 1883 - December 7, 1970), who was one of the most famous cartoonists in history, and have subsequently been brought to life by a range of inventers and tinkerers. Great machines create suspense and anticipation by accomplishing a task in a highly wacky and convoluted manner.

Purpose:

In this activity you will be working in assigned teams of four to build a Rube Goldberg Machine with a final step that changes the energy of some quantity of matter by a meaningful amount specified in advance. For example (numbers below are just for illustration), the final step could:

- increase the elastic potential energy of an object by 0.3 joule.
- increase the kinetic energy of some quantity of matter by 1 joule.
- increase or decrease the thermal energy of some quantity of matter by 100 joules
- increase the pressure energy (pressure×volume) of a fluid by 1 joule.

The exact goal of your machine is up to you but must be approved by WTP-ME staff.

Basic Requirements: (without these, you are disqualified)

1. Only use kit materials or extra materials pre-approved by a staff member.
    a. Sensors may be requested to verify energy change of steps
2. The device must be actuated by a person (this does not count as a step), and the last step must fulfill the pre-approved purpose as described above.
3. Your machine must have a minimum of 10 total steps[2] that include concepts from the WTP-ME curriculum as described under the Concepts Explanation below
    - Each of the following three concepts must be included in at least one step: fluids, heat transfer/thermodynamics, and electrical energy/electric circuits.
4. The device must take at least 15 seconds to run from initiation to completion of the final step.
5. Please obey our basic safety regulations:
    a. No open flame
    b. No damage or permanent alteration of any kind to contest area or bin
    c. Obey the "Naked Telephone Booth" Rule[2]
6. The system must stay within specified area for the entire running time (no flinging!)

[1] http://www.rube-goldberg.com/
[2] Definitions found at the end of this document.

Deliverables

- Rube Goldberg machine – operational by Tech Review, B period on Thurs July 19. No revisions after Tech Review without staff approval.
    - Public Demonstration is B period on Friday July 20
- Poster board with calculations and drawings – completed by A period on Friday July 20
- Lab Notebooks – turn in A period on Friday July 20
    - Keep track of your progress in your lab notebook, including records of brainstorms, experiments, analysis, and building progress.
- "Materials Used" checklist – turn in one copy per team in A period on Friday July 20.

Prizes

Prizes will be awarded in numerous categories, including, but not limited to:

- most creative achievement of goal (using gravity for the final step is not creative)
- most complete analysis of system
- most reliable
- most creative individual step
- most stable structure
- best use of mechanisms
- best use of materials
- best use of fluids
- best use of heat/thermodynamics
- best use of electrical energy/circuits
- best Solidworks drawings
- best MATLAB calculations

Prizes may not be awarded in all listed categories.

Concept Explanation:

Design

Design is a very broad concept that you utilize in your machine when you develop clever or ingenious mechanisms to accomplish the task. ***Prizes:*** most creative achievement of goal, most reliable, most creative individual step, best Soldworks drawings.

Analysis

An essential part of mechanical engineering is analysis of system behavior, both during the design process and in the testing phase. Analysis should include free body diagrams, calculations of energy transfer, and any other computations necessary to follow the energy transfer through the device. ***Prizes:*** most complete analysis of system, best MATLAB calculations

Statics

Statics is the study of systems in equilibrium that are either not in motion or are moving with constant velocity. To use this concept, you need part of your machine to be designed in order to balance forces. ***Prize:*** most stable structure

Mechanisms

Mechanisms are mechanical devices that transform one motion into another. Examples were observed on the Museum of Science field trip. ***Prize:*** best use of mechanisms

Materials

Every type of material has a specific set of characteristics and properties. In order to use this concept in your design you must use a material such that its particular properties are exploited, i.e. thermal or electrical conductivity, modulus of elasticity or tensile strength, hardness, etc. ***Prize:*** best use of materials

Fluids (Required step)

Studying fluids requires examining and predicting how they behave in different situations and under different sets of forces. Using fluids in your machine means you must incorporate your understanding of how fluids behave into your design. ***Prize:*** best use of fluids

Heat Transfer/Thermodynamics (Required step)

Thermodynamics and heat transfer describe the effect of changes in temperature, pressure, and volume on a system, and how heat energy moves between objects from direct contact, through a fluid, by radiation, or some combination of these mechanisms. You use this concept in your machine when you transfer heat using one of these mechanisms. ***Prize:*** best use of heat transfer/thermodynamics

Electrical Energy/Circuits (Required step)

Electrical power and electronic circuits provide a non-mechanical means to transfer energy. You will be provided with voltage sources and switches to allow you to design electrical concepts into your machine. ***Prize:*** best use of electrical energy/circuits.

Contest Procedure:

Your team has a 15-minute window to present your system and to get the device to work. The recommended breakdown is to use 5 minutes for your presentation and 10 minutes to run your machine.

The presentation should use your poster board to correctly and completely describe the device you have built, explain how it functions using the concepts we have learned in class, account for force/energy transformations, analyze external work, and discuss possible sources of error. Your presentation must include a description with supporting calculations of the energy change of the final step.

The machine should perform consistently with your presentation and design. You are allowed as many runs as you can fit into that time frame. If there are unanticipated errors, your team will have a chance to confer briefly and then explain the sources of unanticipated errors and what would be done differently to solve the problems.

Definitions:

Step

- A discrete action that contributes to the completion of the Rube Goldberg task by transferring or releasing energy and forces.
- The machine must not be able to complete the Rube Goldberg task if the action fails. No action in a series of irrelevant side events will qualify as a step.
- Repeating actions will not qualify as more than one step.[3]

"Naked Telephone Booth" Rule

- Obeying this rule means that you could be naked and in a telephone booth with your working machine and walk out intact and unharmed.
- Could also be called the "No Humans Will Be Seriously Harmed in Close Proximity of Your Machine" Rule.

[3] Source: http://web.mit.edu/museum/rubegoldbergcontest/2006/contestrules.html