PERPETUAL MOTION: COULD THESE MACHINES WORK?

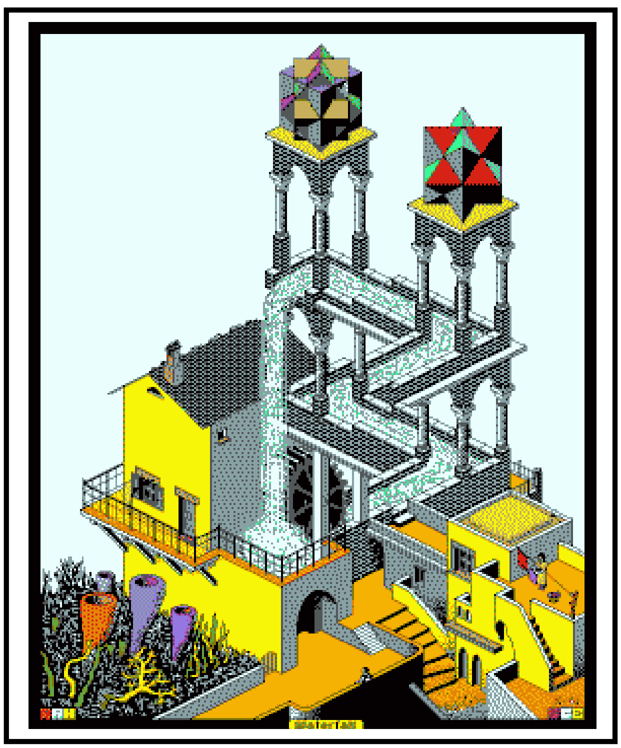
Day 1

"Production of useful work is limited by the laws of thermodynamics, but the production of useless work seems to be unlimited."
—Donald Simanek

The door to the classroom is closed. On the outside, there is a sign that reads:

Inside this room are some of the most breath-taking, law-defying and extraordinary machines ever designed!

Please enter quietly and



The image to the left is projected on the wall inside the dark classroom. Beneath it are the words:

Could this work?

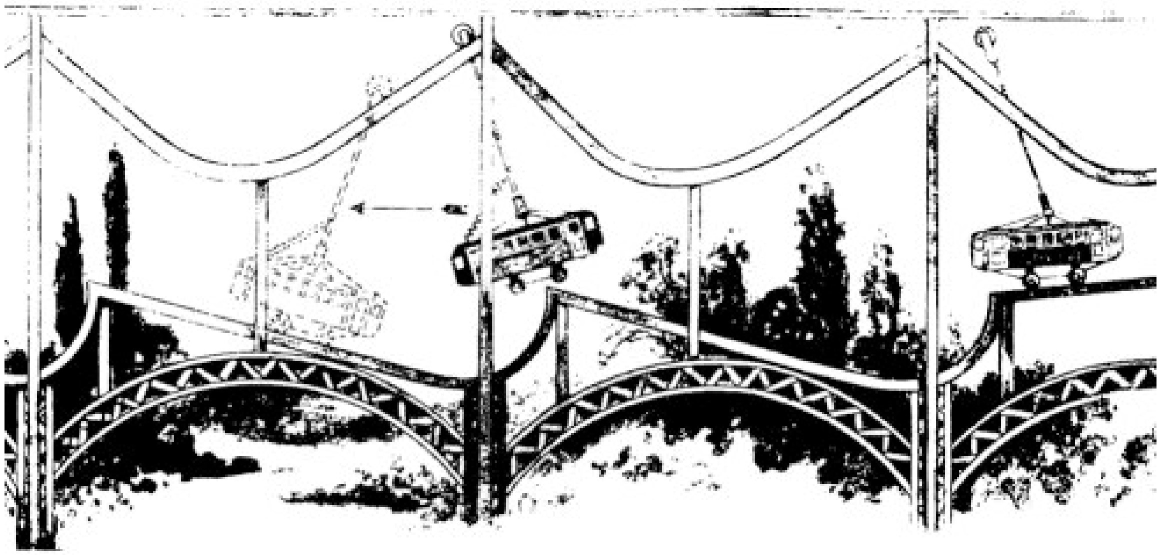
Take a few minutes to answer this question silently and independently in your journal. Be sure to explain how you think it works (or how it doesn't).

When everyone is ready, someone please click Enter for the next invention.

The teacher is seated at one of the tables when the students arrive; she has already begun to observe the first slide and to write in her journal. The students and teacher respond in their journals to the same question for 2 more machines:

The Aerial Railroad

The March 1925 issue of *Science and Invention* featured this Aerial Railroad.



By a combination of inclined ramps and overhead suspension from cleverly curved tracks the "trolley car" passenger vehicle could go forever without power. It falls while suspended in the air from the downward inclined track, swinging forward as it does. When it contacts the lower tracks its momentum carries it up the inclined track until the whole process repeats.

(Animated slide)

The woman doing jumping jacks never stops… she just goes on, and on, and on…

After independent journaling, students will break into 3 small groups; each group will discuss one of the machines. Students will share their thoughts from the journaling process and collectively try to answer the questions, “Could this work?” and “How could it work or not work?” The teacher listens in on the group conversations and may ask guiding questions, such as, “Do you know of any other machines that run forever?” or “What is it that makes machines run?” (The teacher’s role is to present examples that challenge the groups’ thinking.)

Lastly, each small group will report out their thinking (not all group members have to be in agreement). Groups will be encouraged to ask questions and to challenge one another. The teacher will capture their ideas and post them next to a picture of each machine on the wall or a bulletin board. There will be no revelations of whether these machines really work or not. The teacher will suggest that more will be learned tomorrow…

BREAKDOWN	
TIMING	**~20 min. Independent journaling** **~15 min. Small group conversations** **~15 min. Whole-class discussion**
GOALS	*** Students will reveal their initial ideas about what it takes to run a machine in perpetuity.**
OBJECTIVES	
ASSESSMENT COMPONENTS	*** Independent journaling** *** Participation in small group and whole class discussions**

THE ENERGY LAWS

Day 2

The classroom is once again dark. The teacher is already seated at one of the tables. Images of the 3 perpetual motion machines from yesterday's class and the question, "Could these work?" are projected onto the wall. When all of the students arrive, the teacher asks, "Did anyone happen to check our hint jar yesterday when we were discussing this question?" Encourage one or two volunteers to check the jar now, and to describe to the class what they find.

Inside the hint jar is a sealed envelope, with the U.S. Patent Office's logo in the top left corner. The envelope is addressed to the class, at the school's address. There is a folded sheet of paper inside the envelope that looks like this:

(Ask a student to read and follow with a few minutes for comments/processing before transitioning to the mini-lecture that introduces the unit.)

UNITED STATES PATENT AND TRADEMARK OFFICE

A patent gives an inventor or a scientist the right to prevent others from making, using, or selling an invention in the United States.

From: Q. Todd Dickinson,
Director of the U.S. Patent and Trademark Office
(Excerpted from his graduation speech at Franklin Pierce Law Center, May 20th, 2000.)

One of the most eminent physicists of the 20th century, Stephen Hawking recently noted that "The world has changed far more in the past 100 years than in any other century in history. The reason is not political or economic -- but technological."

At the start of the last century, fully one-third of all patent applications filed in our Patent Office concerned one particular transportation technology, very important at the time: bicycle technology.

We had stopped requiring the submission of working models, except for two categories of invention which were thought to be so outlandish and impossible that we made you literally demonstrate to us that they worked. One of these we still require today: perpetual motion machines.

The other, almost equally unbelievable at the time, was heavier than air, machine-powered aircraft. Then, in 1903, two bicycle mechanics from Dayton, Ohio named Wright submitted such an application, and the science

“Let’s Do It The Hard Way”
Mini-lecture: supplemented with slides

Think for a moment about how many elaborate machines are at work in our everyday lives: the microwave, the computer, the car, the X-ray machine, the can-opener (show images of these and other machines; also invite students to shout out machines). What makes these machines so different from the machines that we observe here (show the perpetual motion machines again)? …pause for short discussion…What makes them run? Can they run forever? Hopefully we will arrive as a class at the concept of ENERGY.

Everything that works needs a supply of energy.

Energy has been studied and observed by many people throughout history for many different reasons. People like Newton, Celsius, Franklin, Diesel, Marconi, Ohm, Dalton, Joule, Edison, and Einstein, to name a few (show slides of these scientists), helped shape our understanding and invented uses for all sorts of energy. Some names may even sound familiar…you’ve heard of diesel gas?…the Celsius scale?…anyone heard of ohms or joules? …they are units of measuring energy.

What each and every person studying energy has found out is that energy behaves in a particular way. ***Everything we know about energy today can be summed up in two ideas…*** ideas that have shown up time and time again. In fact, scientists are so certain of these ideas about the behavior of energy that they refer to them as LAWS. And to understand these laws helps us know how energy works: in machines, in nature, and even in our bodies.

We must understand these laws if we are to design machines and take good care of our bodies. Designs that need energy, and all of them do, must obey these 2 laws.

SO, what are these two laws? ***The first law is that Energy cannot be created or destroyed.*** What this law also says is that although energy cannot be created or destroyed, it does change form – energy gets transferred from one form to another. The food you eat turns into the fuel you need to function and do things. The energy in a gallon of gas can be changed into a form that can make the parts of a car move so that you can get from one place to another.

The second law states that not all energy is available to do the work we intend it to do. We know that a car not only takes us from one place to another, but it also gets really hot. We know that your walkman will play a CD but it also gets hot, and eventually needs new batteries. We know a light bulb gives us light but it too gets really hot. This heat takes energy away from the work we really want done. And the energy loss is called ***entropy***. Ideas about efficiency come from this law. A car is actually only 30 percent efficient due to entropy. Meaning that only 30 percent of a gallon of gas is used to move your car forward. The other 70 just gets lost making all the parts of your engine hot, which doesn’t help get you anywhere.

We keep designing more and more things that require energy to run, and in order for those things to work well, we need to understand these laws of energy. So far, no device, invention or scheme has ever been shown to violate these two laws.

In this unit, we will be exploring these laws of energy – putting them to the test in designing, building, and running our own machines.

For the remainder of the class, the teacher will introduce the Rube Goldberg challenge*, hand out the macro-narrative, macro-graphic, assessment rubric, and challenge board. This time may include the following activities:

- Watching a Rube Goldberg-inspired Honda commercial: “Cog”
  http://www.videoclipstream.com/akamai/h-l/honda/
  (It’s only 2 minutes and is very cool…check it out.)

- Breaking into small groups to review the unit materials and to formulate questions about them; the groups will then pose these questions to one another at the end of a designated “review” period.

- Independent journaling on the Cog video and how it works, and/or initial thoughts and questions on what this unit is about.

* The macro-narrative doesn’t reveal all of the parameters for the Rube Goldberg challenge…for instance, one of the expectations is that students will demonstrate their understanding of different forms of energy by incorporating as many as possible into their RG machines. The teacher will have to elaborate on these details, or perhaps design a separate sheet with the expectations for this final project.

BREAKDOWN	
TIMING	**~10 min. Reading/responding to the Patent Office letter** **~15 min. Mini-lecture** **~25 min. Introducing the Rube Goldberg challenge, Exploring the unit’s materials, Cog video, small groups, and independent journaling**
GOALS	*** Students will be introduced to the big ideas and the challenge for the unit.**
OBJECTIVES	
ASSESSMENT COMPONENTS	*** Independent journaling** *** Participation in small group and whole class discussions**

ENERGY EXPLORATIONS:
Everyday Objects with the Potential To Do Work

Day 3

(Note to Conveners: We are still in the process of crafting our "Energy Explorations" lessons on days 3-5. What's presented below should give you a sense of the essence of one of these lessons. n&b)

When students arrive for class, they find an assortment of ramps set-up around the room. Some of the ramps are short and others are long. Also, some of them are propped up much more steeply than others. There are several different kinds of balls in the room as well, varying in size and weight. The following instructions are on the board:

> You will find your name on one of the ramps. With the others in your group, you have 15 minutes to complete this challenge: move a ball up and over the top of your ramp. There's only one catch...you cannot move the ball directly using your hand, your foot, or any other body part. Good luck.

At the end of 15 minutes, the whole class will group together. Small groups will have an opportunity to report out on their mini-challenge work with questions, quandaries, and successes. The teacher will guide the class to consider where the energy for work comes from (through both questioning and short demonstrations). The students will be challenged to expand their ideas about what has energy and to begin to differentiate forms of energy into: potential, kinetic, mechanical, chemical, heat, gravitational, spring, electrical, magnetic, nuclear, light, etc. The exploration and understanding of these different energy forms, and how energy changes between forms, will be the focus of days 3-5 and Monday's Energy Fair.

With the remainder of time in class, the students may return to and revise their approaches to the ball/ramp mini-challenge.

BREAKDOWN	
TIMING	**~15 min. Initial work on the ball/ramp mini-challenge** **~25 min. Whole-class discussion, Demonstrations** **~10 min. Re-visiting the ball/ramp mini-challenge**
GOALS	*** See description above**
OBJECTIVES	*** Students will work in teams to solve the ball/ramp mini-challenge.** *** Students will begin to identify and demonstrate different forms of energy and the energy transfers that occur in the process of doing work.**
ASSESSMENT COMPONENTS	*** Participation in small group mini-challenge and whole class discussion**

CHALLENGE BOARD

Please select 1 of the challenges below to complete during the course of this unit.
Your final project presentation will be due in class at the end of 4 weeks.
At the end of 2 weeks, we will have a Challenge Board Consultation Day.
(As always, presentation formats are suggested, but flexible.)
Have fun!

Interview the owner of an establishment in your community – an ice cream shop, a restaurant, a hair salon, a toy store, a supermarket, a dry-cleaner, or any other. Find out about their energy needs and systems. What kinds and how much energy does it take to run the business? Where do the energies come from? What would happen if they had a power failure? Prepare a short (~10 min.) and interesting presentation for our class.	2 CHOICES: Create a representation of how a particular appliance works, describing as many of the energy forms and energy transfers as possible. Draw (or artistically describe) your ideas BEFORE you begin your research and after you complete it. Present your artistic before & after pieces and describe what you learned to our class. OR… Complete the project above by creating a representation of how electricity finds its ways from its source to your home.	Design a way to measure how much energy you use in a day and come up with a plan to halve it. Your presentation to our class may take several forms, including an artistic piece, charts and graphs, a slide show, or an essay.
Energy in nature – discover the energies in an avalanche, storm, or other natural phenomenon. Describe as many of the energy forms and energy transfers as possible. How are the laws of energy at work in nature? Present what you learn as a short skit or photo collage. Also consider embellishing your presentation with music.	Design a community-based energy exploration of your own! Also decide how you will present what you learn in an informative and interesting way to our class.	Interview a grandparent or grandfriend to find out what energy meant when they were young and how energy usage has changed over time. Present what you learn in an essay, short-story, or film clip.

LET'S DO IT THE HARD WAY
ASSESSMENT RUBRIC

You will have many opportunities to demonstrate your skills and knowledge throughout this unit. Use this rubric to inform yourself of the criteria for excellent work. You and I will both be required to assess your performance based on these criteria, so please refer to this rubric often to check in on your own progress.

If the "big ideas" of the unit are not becoming clear to you, then please talk with me so that we can explore how to make our lessons more effective for you.

Summary of Verifications for your Personal Portfolio: independent journaling, small group conversations and mini-challenges, whole class discussions, 1 challenge board assignment, participation in the Energy Fair, participation in the Rube Goldberg challenge AND documentation of your learning and design processes.

Goal	Description of Excellent Work
Conceptual Understanding	You demonstrate an understanding of the big ideas (you can find them on our unit overview page!) through completion of the in-class challenges, the Rube Goldberg project, and the other verifications that make up your personal portfolio. Your portfolio clearly communicates the evolution of your thinking process over the course of this unit in words and sketches. *Comments:*
Collaborative Efforts	Your Rube Goldberg work, from drawings to models, exhibits a group effort. Excellent group effort shows instances of group assessment, collaborative project revision, and honoring the efforts and ideas of each group member. Leadership may take the form of teaching or tutoring someone in your group. Getting extra help may take the form of asking a fellow group member for guidance or assistance. *Comments:*

Participation	You participated fully in class work and discussions, adding your own insights and making connections with ideas presented in lectures, from fellow classmates, from readings, and from reflections on your own learning process. *Comments:*
Problem-Solving	You were able to translate your drawn design of your Rube Goldberg machine into a working model that reflects your current understanding of energy and the energy laws. *Comments:*