Rube Goldberg Machines

Submitted by: Edward Gunkle, 8th Grade Science
Miff-West High School, Middleburg, PA

Target Grade: 8th Grade, Science

Time Required: 6 days, 40-50 minute lessons

Standards

Next Generation Science Standards (NGSS):

- MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
- MS-PS3-5: Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.

Lesson Objectives

Students will be able to:

- Identify and describe the 6 basic simple machines.
- Explain the mechanical advantage of simple machines.
- Analyze and explain the relationship between potential, kinetic, and mechanical energy present in a compound machine.
- Apply understanding of simple machines and energy transfer to design and build a compound machine to complete a predetermined task.
- Write a Rube Goldberg machine explanation to describe the machine's actions.

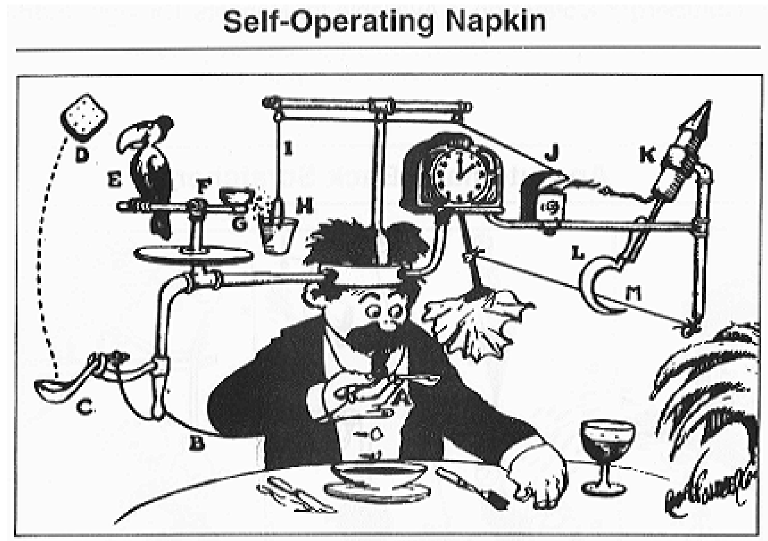
Central Focus

This lesson can be used as hands-on practice with simple machines and the concepts of energy transfers. Students will be collaborating together to design a working Rube Goldberg machine to complete the simple tasks of popping a balloon or stapling papers together. In the project, they will use their knowledge of different types of energy, how energy is transferred, and simple machines to design their multi-step machine.

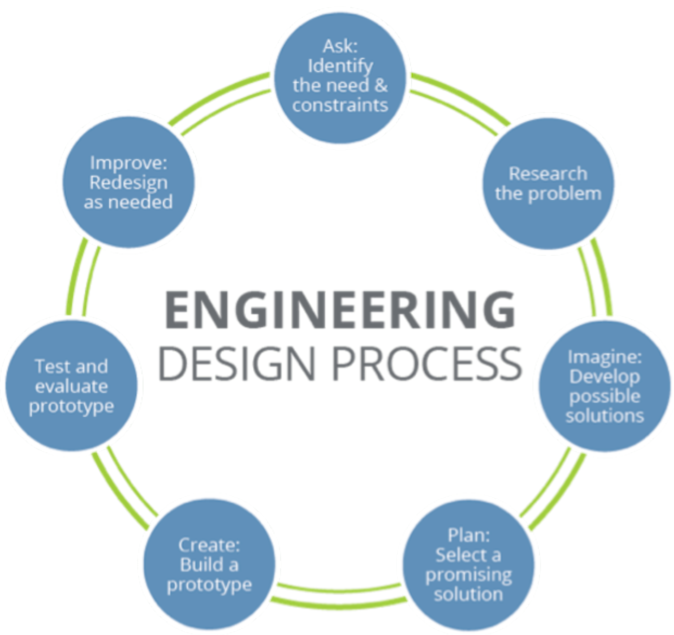
Key Words: physics, create, makerspace, blueprints, engineering design process, potential energy, kinetic energy, mechanical energy

Background Information

A Rube Goldberg (RG) machine is a machine intentionally designed to perform a simple task in an indirect and overly complicated way, relying on chain reactions. In this lesson, students will use the six simple machines to design and create their own machines. Prior to the lesson, students should be aware of the six simple machines: lever, wedge, wheel and axle, pulley, inclined plane, and screw. Furthermore, the work equation (work = force applied x distance) should already be mastered by the students.



Students should be aware of the engineering design cycle prior to this lesson. These steps include the following: Define the Problem, Collect Information, Brainstorm Solutions, Develop a Solution, Build a Prototype, Present Your Ideas to Others for Feedback, Test and Redesign. The process is never really complete, as there can always be additional redesign. Students also need to be aware of the safety precautions in using some of the makerspace materials. It is advisable that the teacher does not introduce new tools in this lesson, but instead uses only the tools students are familiar with already, as a safety precaution.



https://i2.wp.com/media.premiumtimesng.com/wp-content/files/sites/2/2017/02/Engineering-Design-Process.png

Students should also have background knowledge of the following:

- Different types of energy
- Different types of simple machines
- The Law of Conservation of Energy

For Teachers:

- Print out the worksheets or have digital copies so that students can follow the lessons for days 1-2.

Materials

- Rube Goldberg PowerPoint
- Team rubric worksheet
- STEM reflection sheet
- Peer evaluation form
- Rube Goldberg Project—Parts 1 and 2 worksheet
- Rube Goldberg comics sheet
- Balloon
- Stapler
- *The Difference Between Mechanical and Kinetic Energy* article
- Makerspace supplies and tools
    - Supplies for the machine can vary depending on students' designs. Some possible materials the teacher may want available for the students are the following:
        - Tubing
        - Piping
        - Dominos
        - String
        - Gears
        - Pipe cleaners
        - LEGO bricks
        - Pulleys
        - Duct Tape
        - Marbles
        - Cardboard
        - Rubber bands

Instruction

<u>Day 1 Simple Machines (50 minutes):</u>

Teacher Preparation: Students will need copies of the Rube Goldberg Project-Part 1. Day 1's lesson follows the provided PowerPoint as the students follow along with the worksheet.

Introduction:

- Have students complete the bell ringer.
    - Bell ringer: What is the best way to get rid of a mouse in your bedroom?
        - Student responses will vary; use responses to lead into RG cartoon.

Discussion:

- Discuss student responses to the mouse question. Share the Rube Goldberg "How to Remove a Mouse" cartoon.
- From the PowerPoint, have the students write out responses to the following questions on their worksheet:
    - What is a Rube Goldberg machine?
        - It is a comically involved, overcomplicated invention designed to perform a simple task that involves chain reactions.
    - Who is Rube Goldberg?
        - Rube Goldberg (1883-1970) graduated from the University of California, Berkley with a degree in engineering and became Pulitzer Prize winning cartoonist. He is best known for his zany invention cartoons.
- The teacher may take time to discuss questions with the students before revealing the answer.
- Discuss the RG machine challenge with the students. Emphasize that they will need to incorporate 5 simple machines, 6 steps, and 3 energy transfers in their machine.

Task:

- The teacher will have students brainstorm and discuss what the 6 simple machines are (lever, wedge, wheel and axel, pulley, inclined plane, screw).
- After a short brainstorming session, the teacher will reveal the 6 simple machines and show the short video clip within the slide show.
- After the video, the teacher will lead a short class discussion about the following question and answer:
    - What is the mechanical advantage of a simple machine?
        - Simple machines change the amount of force to perform a task.
- Explain to the students that work = force applied x distance.
- After the explanation of work, the teacher will lead the class in the final group discussion of the following question and answer:
    - Does a simple machine (lever) reduce the amount of work required to do a task?
        - No, the work is the same because you are still doing the same job, but the amount of force necessary to do the work changes. The mechanical advantage is that less force is needed to accomplish a task.

Closure:

- Students will work with a partner or group to identify examples of simple machines used in the Rube Goldberg cartoon found on the PowerPoint and turn in their final answers.

Day 2: Energy Transfer (50 minutes):

Teacher Preparation: Students will need copies of the Rube Goldberg Project Part 2. Day 2's lesson follows the provided PowerPoint as the students follow along with the worksheet.

Introduction:

- Have students complete the bell ringer.
  - Bell ringer: What is the mechanical advantage of a simple machine?
    - Simple machines change the amount of force needed to perform a task.

Task:

- Have the students answer the following questions on their worksheet to the best of their abilities.
  1. What does the Law of the Conservation of Energy state?
  2. In order for work to be performed, what 3 requirements must be met?
  3. Explain the difference between potential energy and kinetic energy through an example.
  4. Define mechanical energy.
  5. Identify the various forms of energy.
  6. Identify the type or form of energy present in the images below.
- After answering the worksheet questions, have students read the attached article to check for accuracy in their answers.

Discussion:

- Once the students have finished their worksheet, the teacher can use the PowerPoint and go through each question. Have a short discussion with the class before revealing the answers.

Closure:

- As an exit ticket, have students identify examples of potential and kinetic energy and energy transfer in the cartoon and write them down on a sheet of paper to turn in as they leave.

Day 3 Sketch (50 minutes):

Introduction:

- In groups, students will choose to make a Rube Goldberg machine with the task of popping a balloon or stapling papers.
- Each group will be given the attached rubric for what their project must include.
- The teacher should take some time to review the rubric with the class to check for understanding and clarity.

Task:

- Students will spend the rest of the class planning and sketching their design.
    - The teacher can require students to conduct research on different design ideas if time allows.
- Groups will gather the supplies they will use for their project from the makerspace.
    - Students may have to change designs depending on available materials.

Closure:

- Groups will submit their Rube Goldberg machine "blueprints" to the teacher.

<u>Day 4-5 Construction (80-100 minutes):</u>

Introduction:

- Students will set up their workspace and gather materials while the teacher hands back each group's blueprints with constructive comments.

Task:

- Students will review strategies, challenges, solutions, and ideas for their design.
- After a short group meeting, students will begin constructing their Rube Goldberg machine.
- Once students have constructed their prototype, they will test and revise as needed.
- Once the group has a working prototype that correlates to the rubric, the group will write a description of their machine, explaining the simple machines and energy transfers in each step.

Closure:

- As an exit ticket on the last day, groups will identify the at least 5 simple machines and 3 energy transfers in their machine.

<u>Day 6 Presentations (50 minutes):</u>

Introduction:

- Have students set up their machines for the group demonstration.

Task:

- Groups will take turns presenting their machines to their peers. Before they run the machine, the groups should describe their design process, including what problems they encountered and what improvements they made. The groups should also identify the required components in their machine and then run the machine for the class to watch.
- After each presentation, the teacher should allow time for feedback and discussion from class.

Closure:

- Students will end the lesson and project by completing the STEM reflection sheet and a peer evaluation.
- For homework, each student will sketch a new design of an RG machine that completes the task their group did not choose (stapling paper or popping a balloon). This machine must have at least 3 simple machines, 4 steps, and 3 transfers of energy. They will turn in their sketch with a written explanation of their design that describes each component of the machine.

Differentiation

English Language Learners:

- Google translate and speech-to-text is available online and may be utilized for ELL or special needs students.
- ELL students will be grouped with students who have a good understanding of the project and are familiar with supporting these students.
- The videos and photos of example Rube Goldberg machines will help these students understand the goal of the project.
- Copies of the worksheets, articles, and the rubric can be provided in the student's L1.

Students with disabilities:

- Students may choose to create their blueprint on websites like SmartDraw or the sketch option in Microsoft Word.
- For students who have visual impairments, larger font sizes can be utilized as well as speech-to-text technology. They will be seated near the front of the class.
- For students with hearing impairment, they can use headphones to listen to the videos, which will be watched with closed captioning. They will be seated near the front of the class.
- Example machines can be shown to students who may need extra support as they start the design process.

Advanced Learners:

- Students who need more of a challenge can design their machines with extra steps and more complicated processes.
- Students can research unique contraptions that they can then incorporate into their designs.

Assessment

Summative assessment:

- The STEM reflection sheet will allow the teacher to see what individual students understand and do not understand at the end of the project.
- The final homework will show the teacher whether students can identify and utilize simple machines and energy is transfers in a new design.

Formative assessment:

- The teacher can use worksheets and peer evaluation scores to assess student understanding.
- The teacher can check for understanding throughout the lesson by using the class discussions as a gauge of the students understanding.
- The bell ringers will allow for a quick check for each students thought process for the given days activity.
- Exit tickets will allow the teacher to gauge students understanding.
- The project rubric will allow teachers to score the machines on topics like functionality, creativity, and presentation.

Bell Ringer:

How would you get rid of a mouse in your bedroom?

How to Get Rid of a Mouse

Drawn for Newsweek by Rube Goldberg

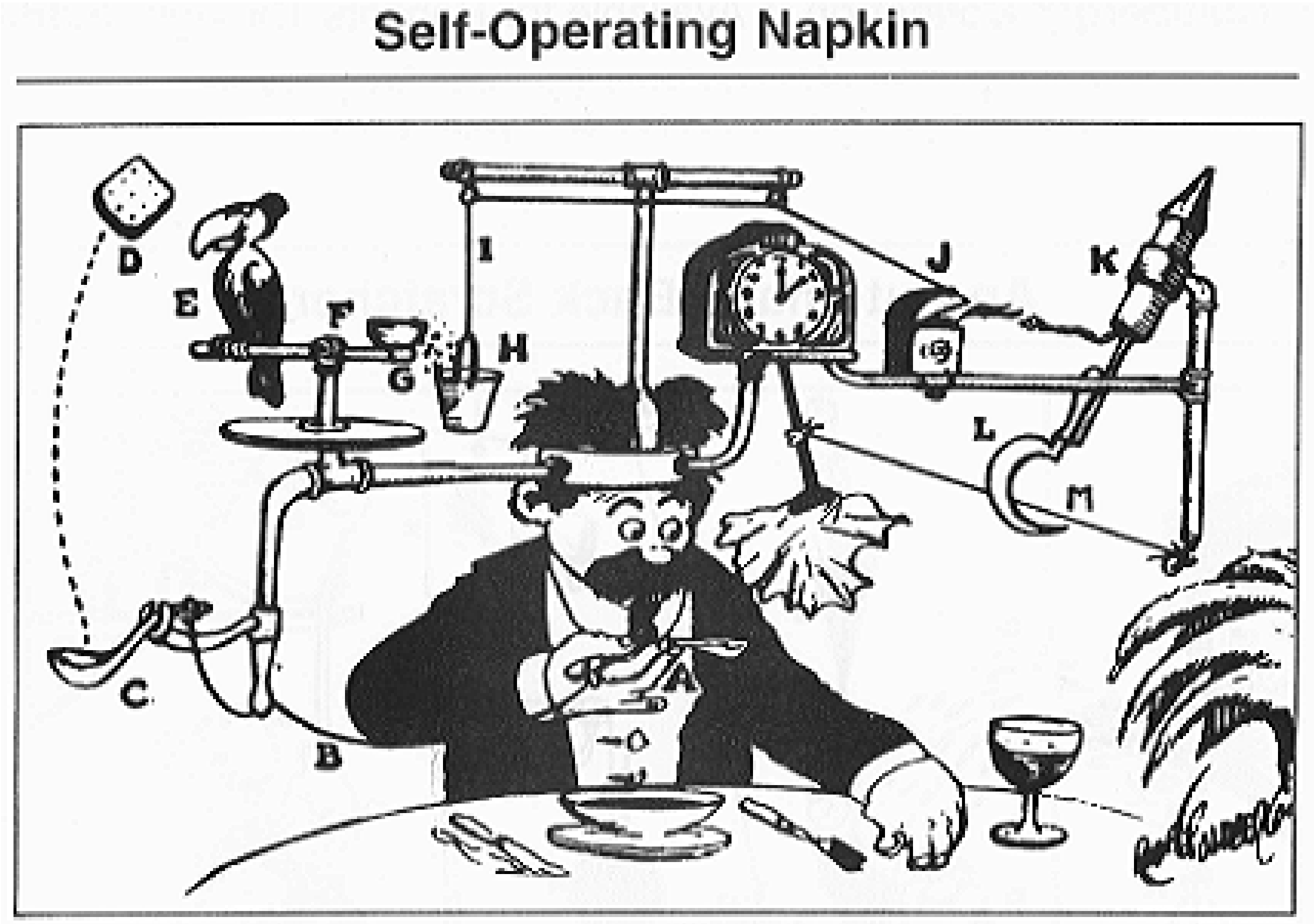
The best mousetrap by Rube Goldberg: Mouse (A) dives for painting of cheese (B), goes through canvas and lands on hot stove (C). He jumps on cake of ice (D) to cool off. Moving escalator (E) drops him on boxing glove (F) which knocks him into basket (G) setting off miniature rocket (H) which takes him to the moon.

https://www.rubegoldberg.com/site/wp-content/uploads/2015/05/Get-rid-of-mouse-1200x712.jpg

Objectives:

1. Identify and describe the 6 basic simple machines.
2. Explain the mechanical advantage of simple machines.
3. Analyze and explain the relationship between potential, kinetic, and mechanical energy present in a compound machine.
4. Apply understanding of simple machines and energy transfer to design and build a compound machine to complete a predetermined task.
5. Write a Rube Goldberg style machine story using descriptive words to describe the machine's actions.

What is a Rube Goldberg Machine?



https://en.wikipedia.org/wiki/Rube_Goldberg_machine

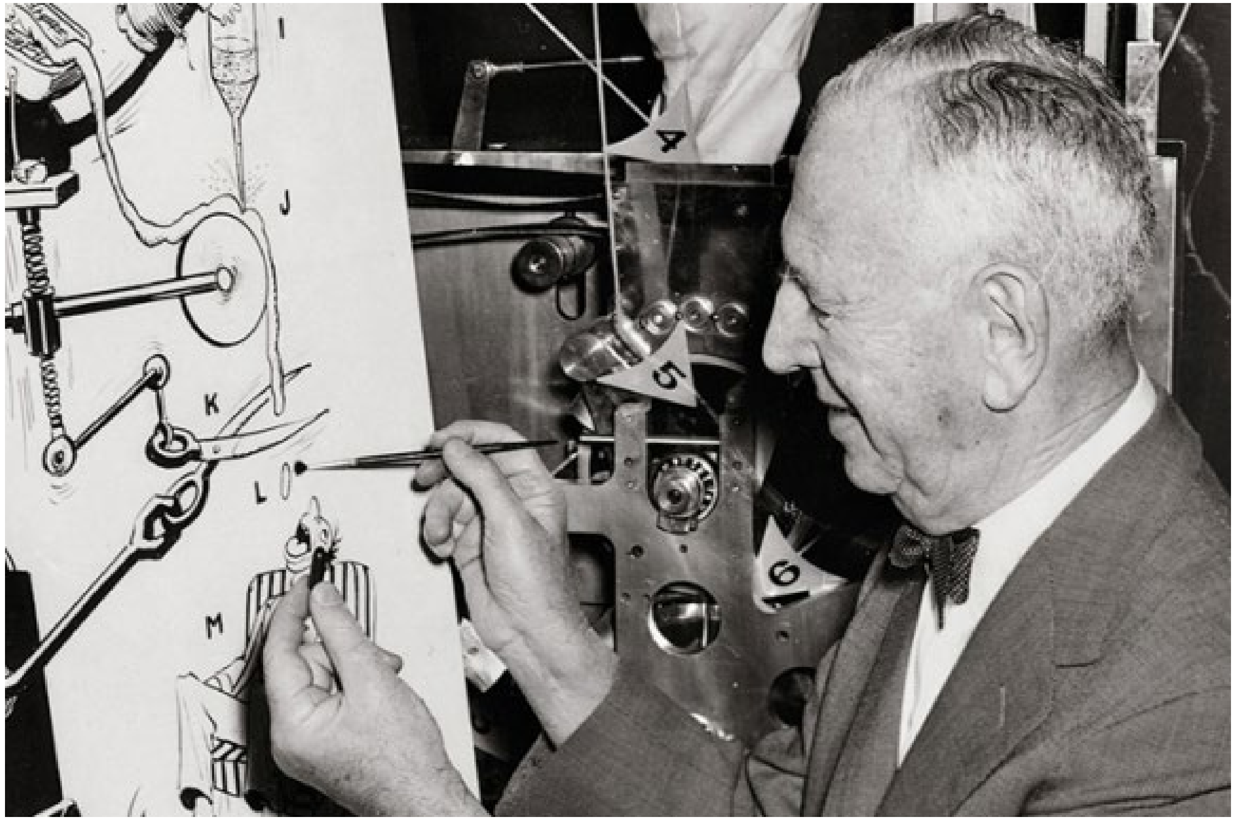
What is a Rube Goldberg Machine?

Def: It is a comically involved, overcomplicated invention designed to perform a simple task. Rube Goldberg machines rely on chain reactions to transfer energy.

Video Example

https://www.youtube.com/watch?v=X3vXwWfEfGM

Who is Rube Goldberg?



https://www.illustrationhistory.org/artists/rube-goldberg

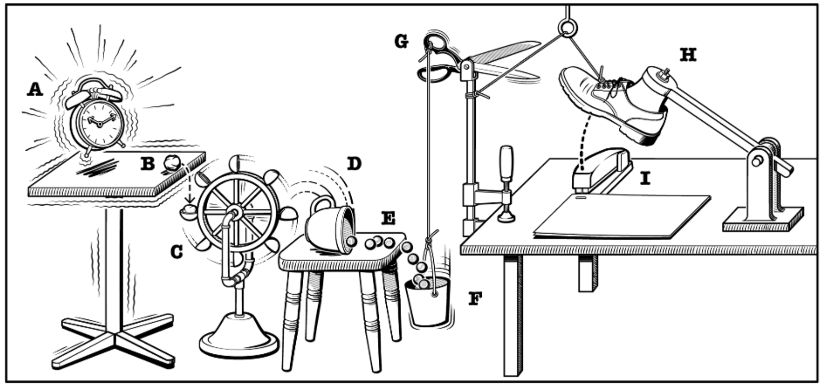
Who is Rube Goldberg?

- He graduated from the University of California, Berkley with a degree in engineering.
- He was a Pulitzer Prize winning cartoonist best known for his <u>zany</u> invention cartoons.

Zany:

- amusingly unconventional and idiosyncratic
- eccentric, peculiar, strange, odd, unique, individualistic

https://www.vernier.com/experiment/pep-16_rube-goldberg-machine/



The Challenge

- Build a Rube Goldberg machine to demonstrate your understanding of simple machines, energy, and energy transfer.
  - Use <u>at least 5</u> simple machines.
  - Use at <u>least 6 steps</u> and <u>3 energy transfers</u>.
- Write a description of the machine's steps that identifies and explains each required component of the machine.
- Present your Rube Goldberg machine to your peers.

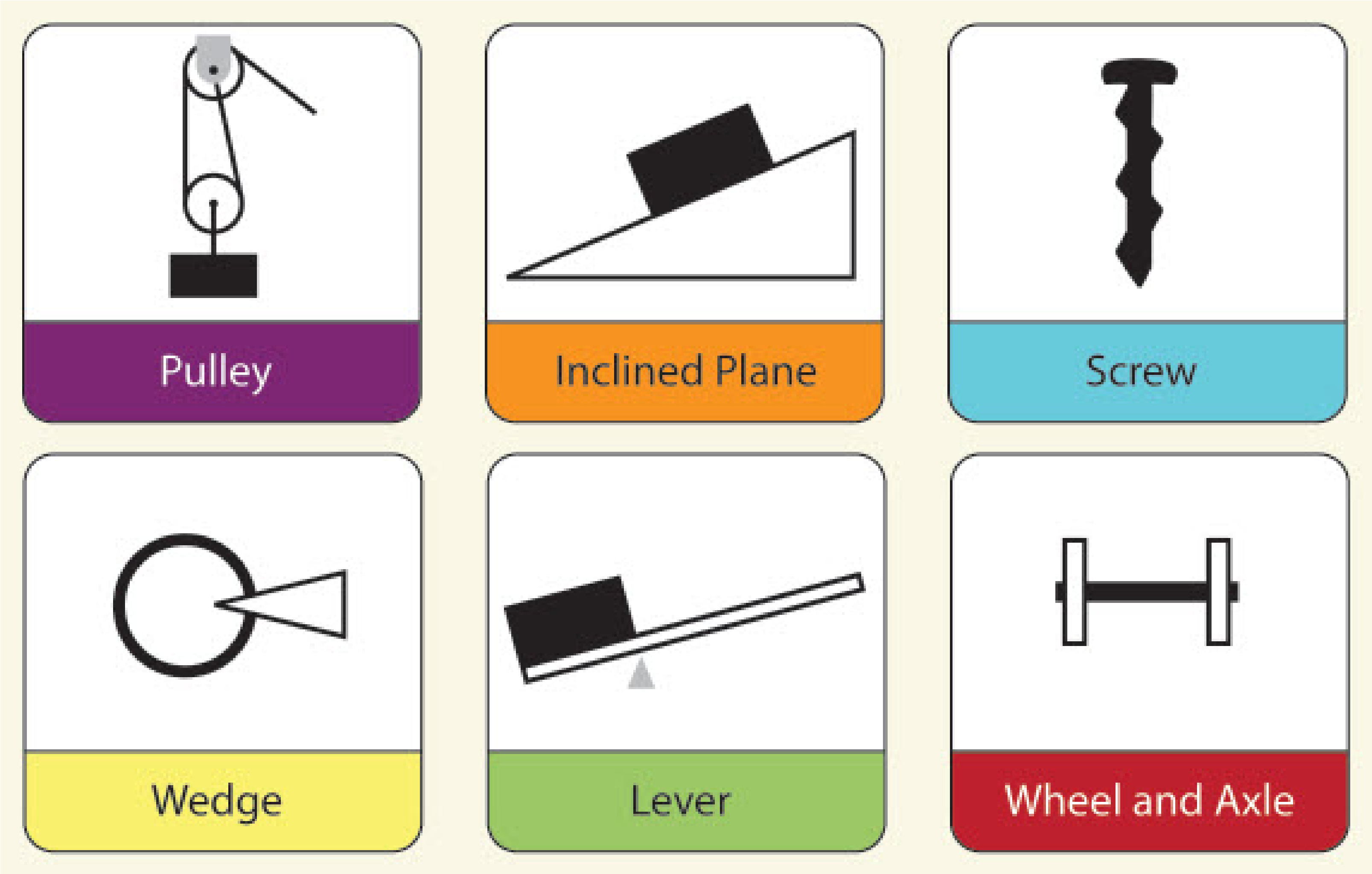
Timeline

- Day 1: simple machines
- Day 2: energy transfer
- Day 3: sketch a design of the machine
- Day 4-5: construct the machine and write explanation of the steps
- Day 6: presentations

But first, identify:

What are the 6 simple machines?

What are the 6 simple machines?



https://uhc.dextroseammaye.pw/img/452391.jpg

Identify:

What is the mechanical advantage of simple machines?

Video Clip

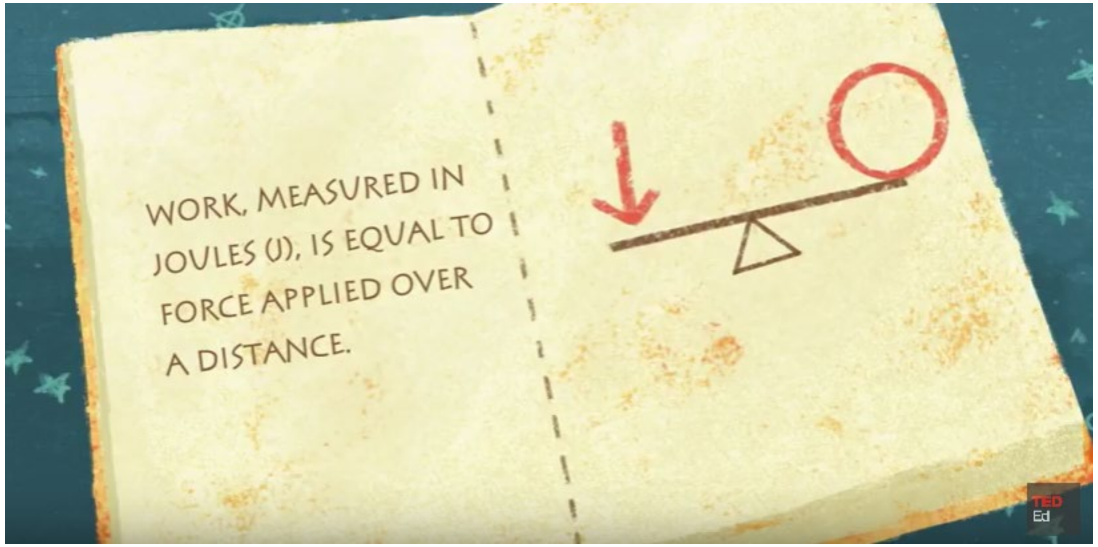
https://www.youtube.com/watch?v=YlYEi0PgG1g

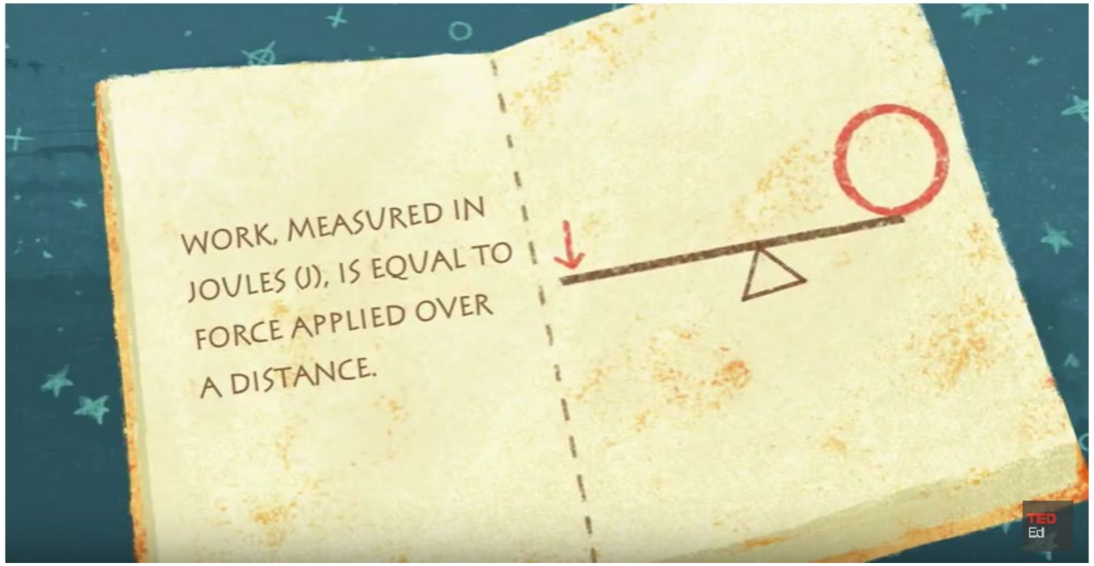
What is the mechanical advantage of simple machines?

What is the mechanical advantage of simple machines?

Simple machines change the amount of force needed to perform a task.

Work = force applied x distance





https://www.youtube.com/watch?v=YlYEi0PgG1g

Does a simple machine reduce the amount of <u>work</u> required to do a task?

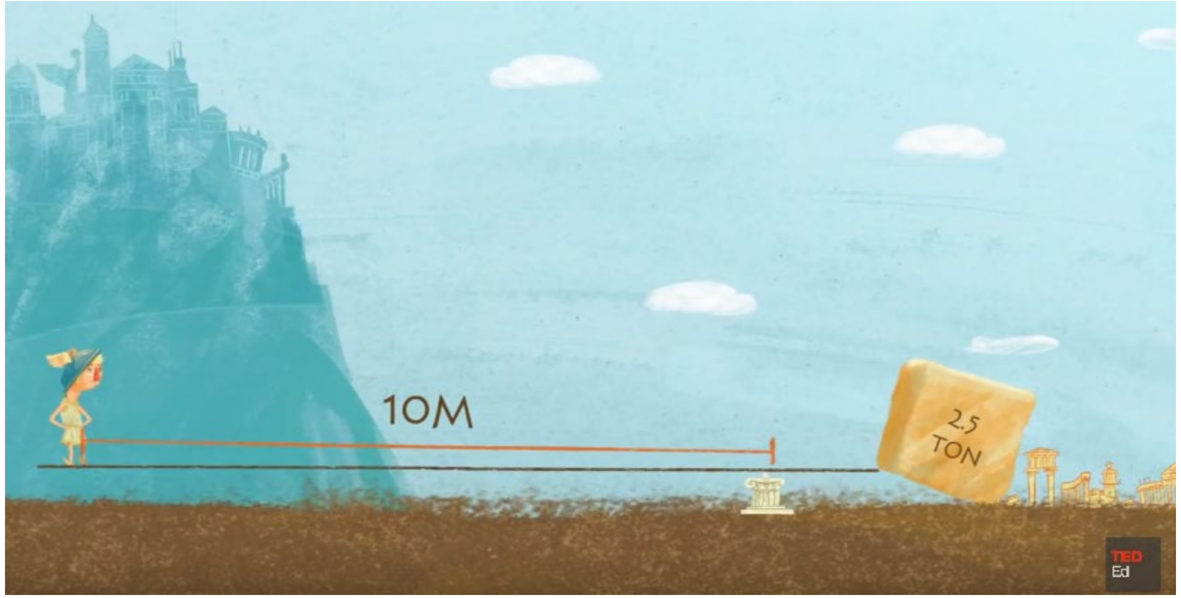
Provide an example to support your answer.

Does a simple machine reduce the amount of work required to do a task?

A: No, the work is the same because the job is the same, but the simple machine allows less force to be used to accomplish a task.

The block still weighs the same, but less force is needed to lift it using the machine versus trying to lift it directly.

The nail is stuck the same way but requires less force to remove using the hammer versus pulling directly.



https://www.youtube.com/watch?v=YlYEi0PgG1g

Closure: Identify examples of simple machines used in the Rube Goldberg cartoon.

How to Get Rid of a Mouse

Drawn for **Newsweek** by Rube Goldberg

The best mousetrap by Rube Goldberg: Mouse (A) dives for painting of cheese (B), goes through canvas and lands on hot stove (C). He jumps on cake of ice (D) to cool off. Moving escalator (E) drops him on boxing glove (F) which knocks him into basket (G) setting off miniature rocket (H) which takes him to the moon.

Terms

- Machine: any device that uses energy to do work
- Work: force exerted over a distance
  - W = F x D
- Simple Machine: any mechanical device that changes the direction or magnitude of a force
- Mechanical Advantage: the ratio of the output force and input force

Bell Ringer:

What is the mechanical advantage of a simple machine?

What is the mechanical advantage of a simple machine?

Simple machines change the amount of <u>force</u> needed to perform a task.

What does the Law of the Conservation of Energy state?

- Energy is neither created or destroyed.
- Energy is transferred from one type of energy to another, or from one form of energy to another.

In order for work to be performed, what 3 things must be present?

In order for work to be performed, what 3 things must be present?

1. A force

In order for work to be performed, what 3 things must be present?

1. A force
2. Displacement

In order for work to be performed, what 3 things must be present?

1. A force
2. Displacement
3. A cause

Explain the difference between potential energy and kinetic energy through an example.

Explain the difference between potential energy and kinetic energy through an example.

- A book on a shelf has potential energy as it sits in a fixed position; if the book is pushed off the shelf it posses kinetic energy as it falls.

Define mechanical energy.

Define mechanical energy.

Mechanical energy is the ability of an object to do work.

Identify the various forms of energy.

Identify the various forms of energy.

- Mechanical

Identify the various forms of energy.

- Mechanical
- Chemical

Identify the various forms of energy.

- Mechanical
- Chemical
- Nuclear

Identify the various forms of energy.

- Mechanical
- Chemical
- Nuclear
- Electromagnetic

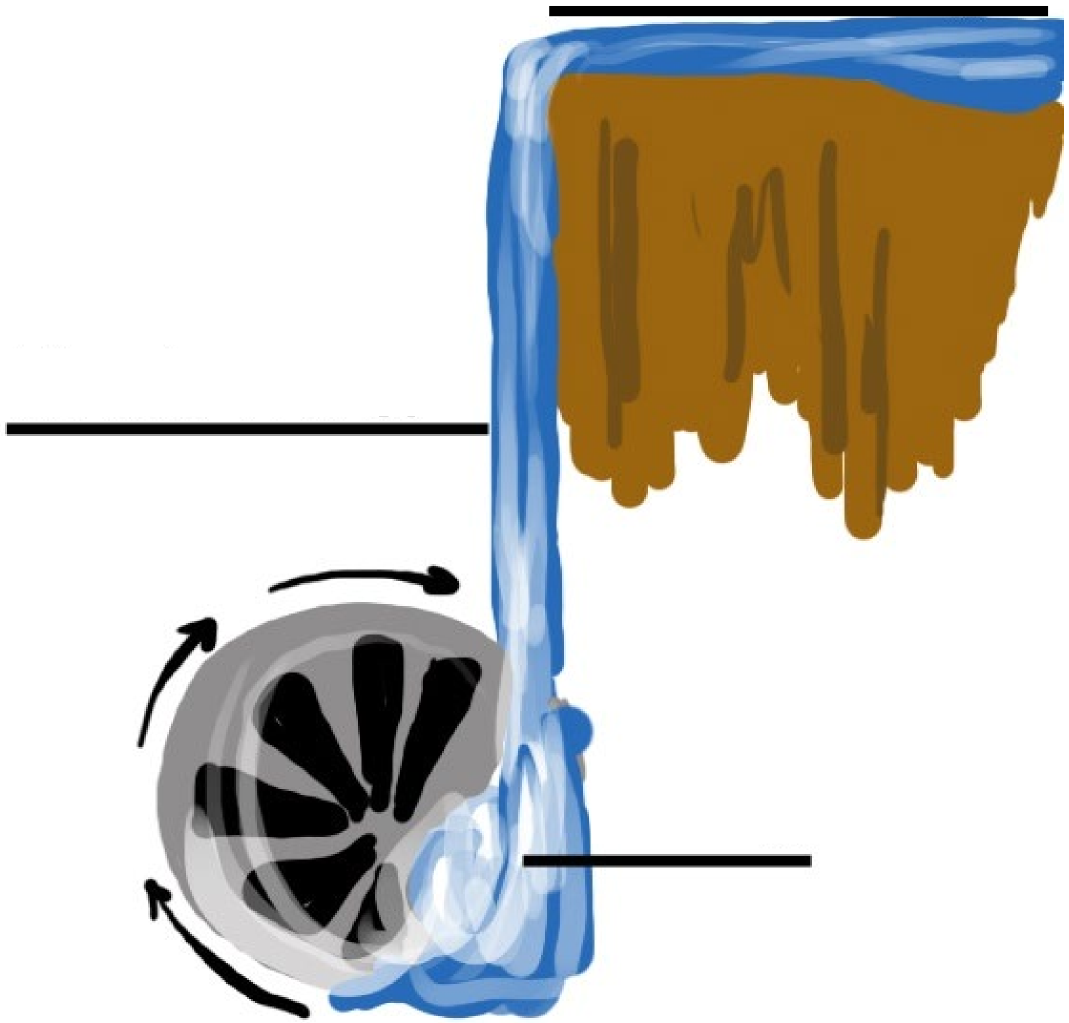
Identify the various forms of energy.

- Mechanical
- Chemical
- Nuclear
- Electromagnetic
- Thermal

Identify the various forms of energy.

- Mechanical
- Chemical
- Nuclear
- Electromagnetic
- Thermal
- Sound

Identify the type or form of energy present in the images below.



https://studiousguy.com/examples-mechanical-energy-everyday-life/

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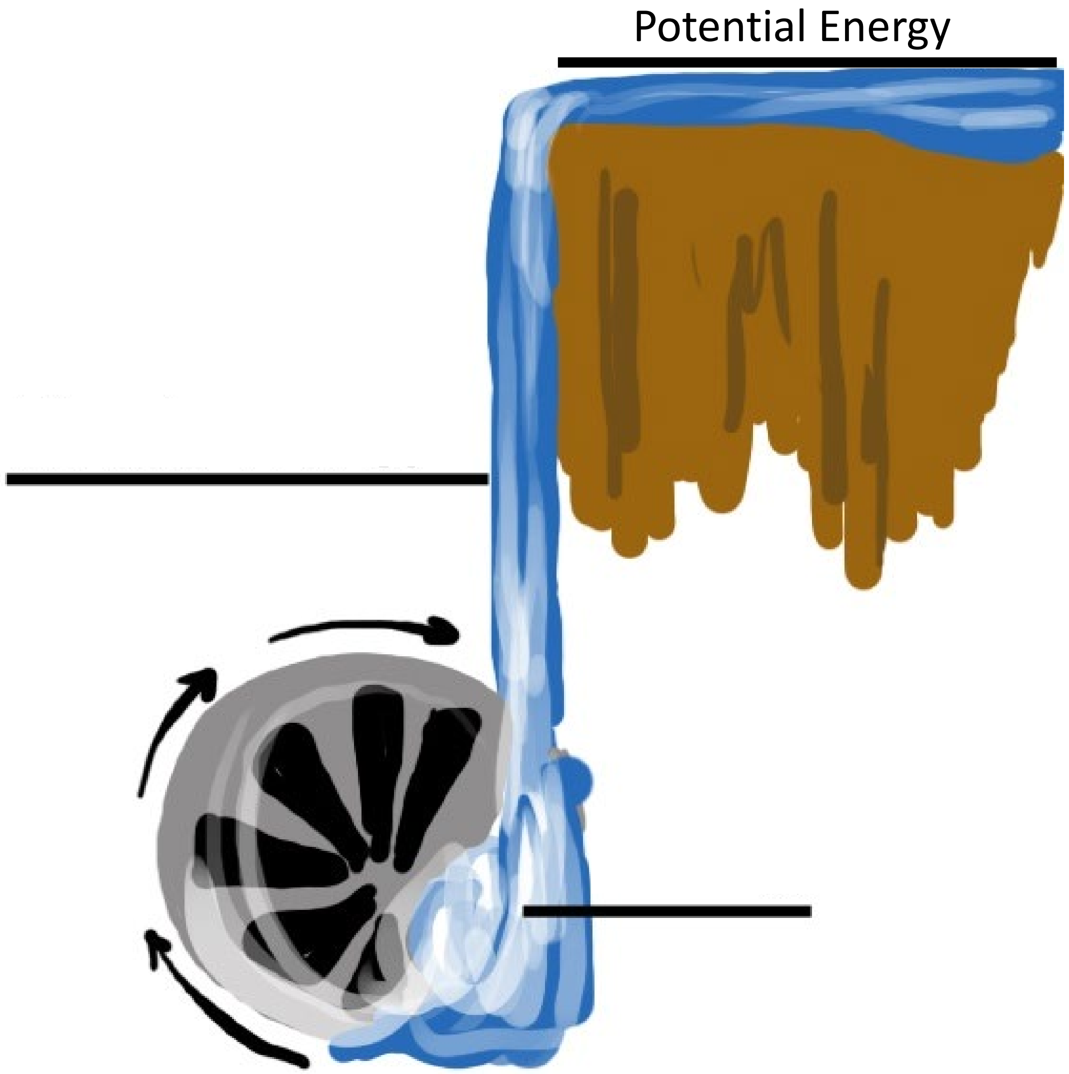

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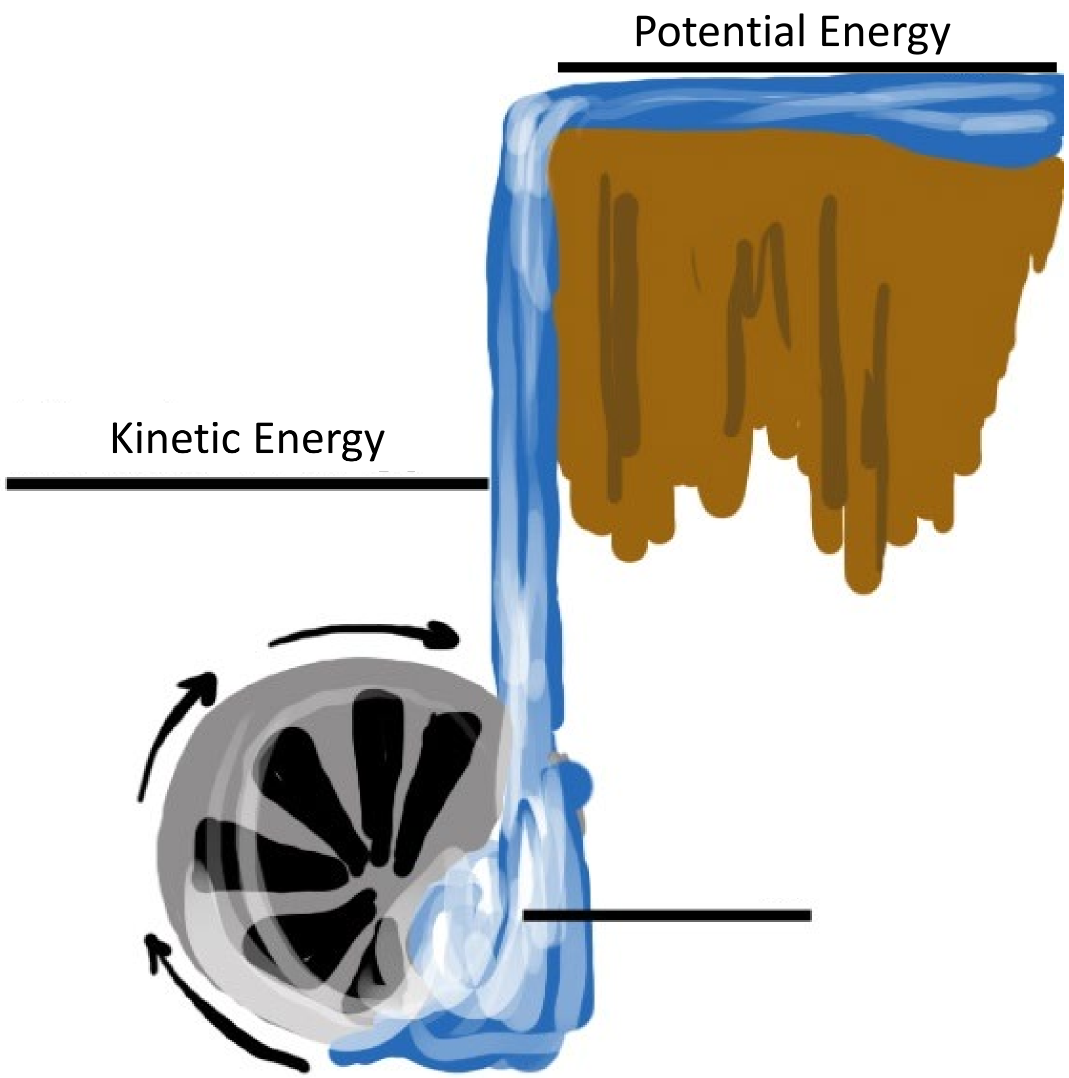

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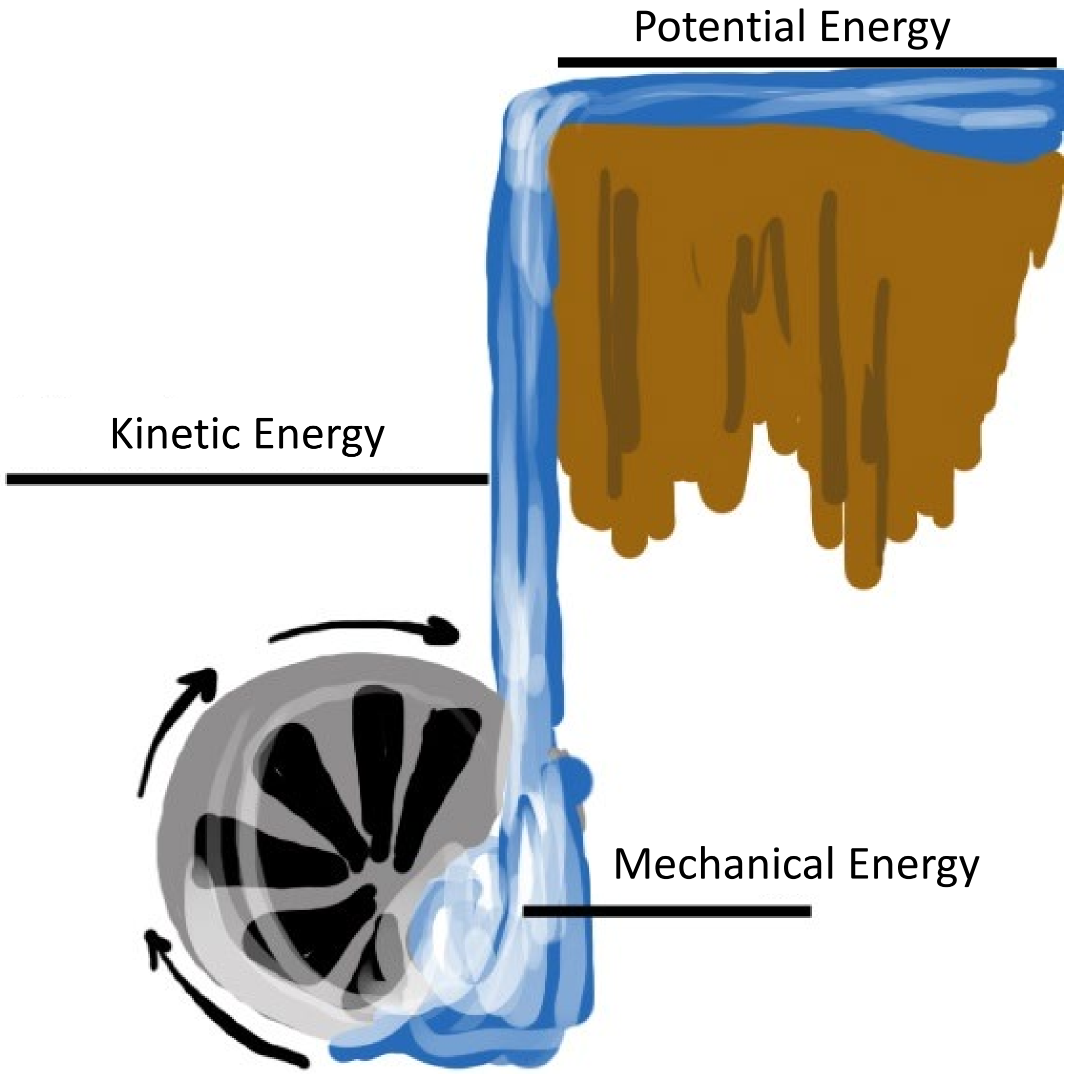

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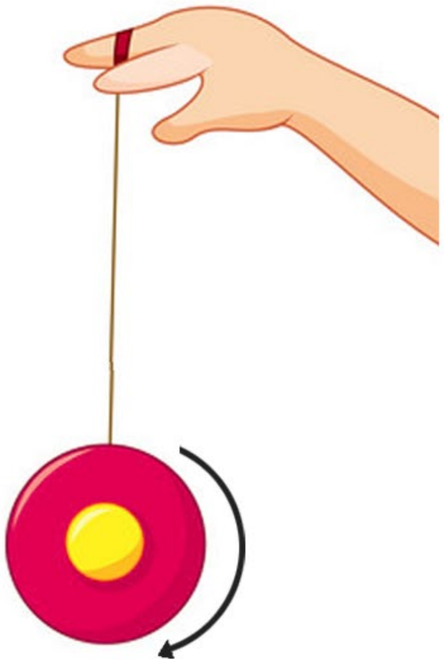
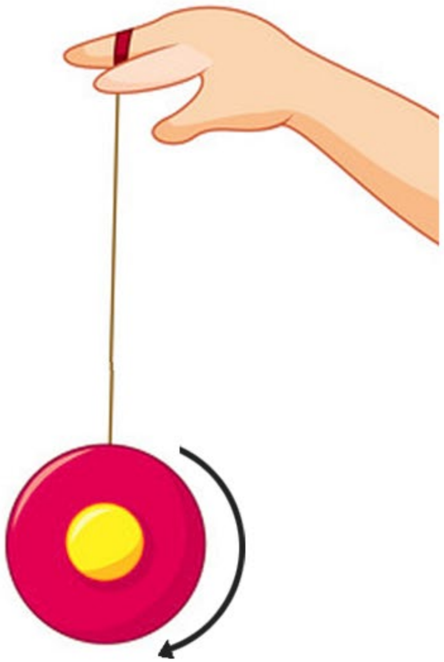


https://www.scienceabc.com/nature/universe/can-you-yo-yo-in-space.html

Identify the type or form of energy present in the images below.

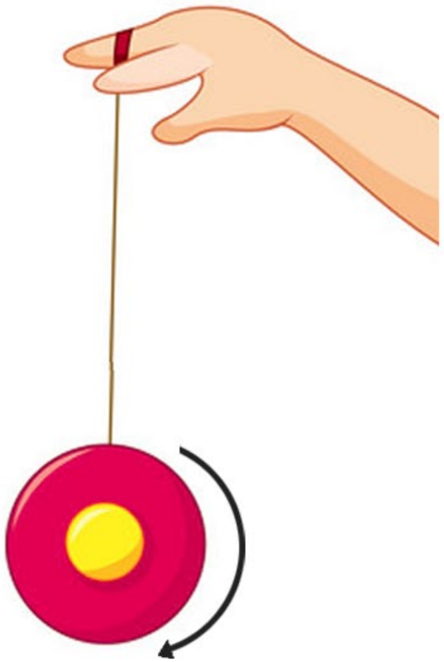


Potential Energy

https://www.scienceabc.com/nature/universe/can-you-yo-yo-in-space.html

Identify the type or form of energy present in the images below.

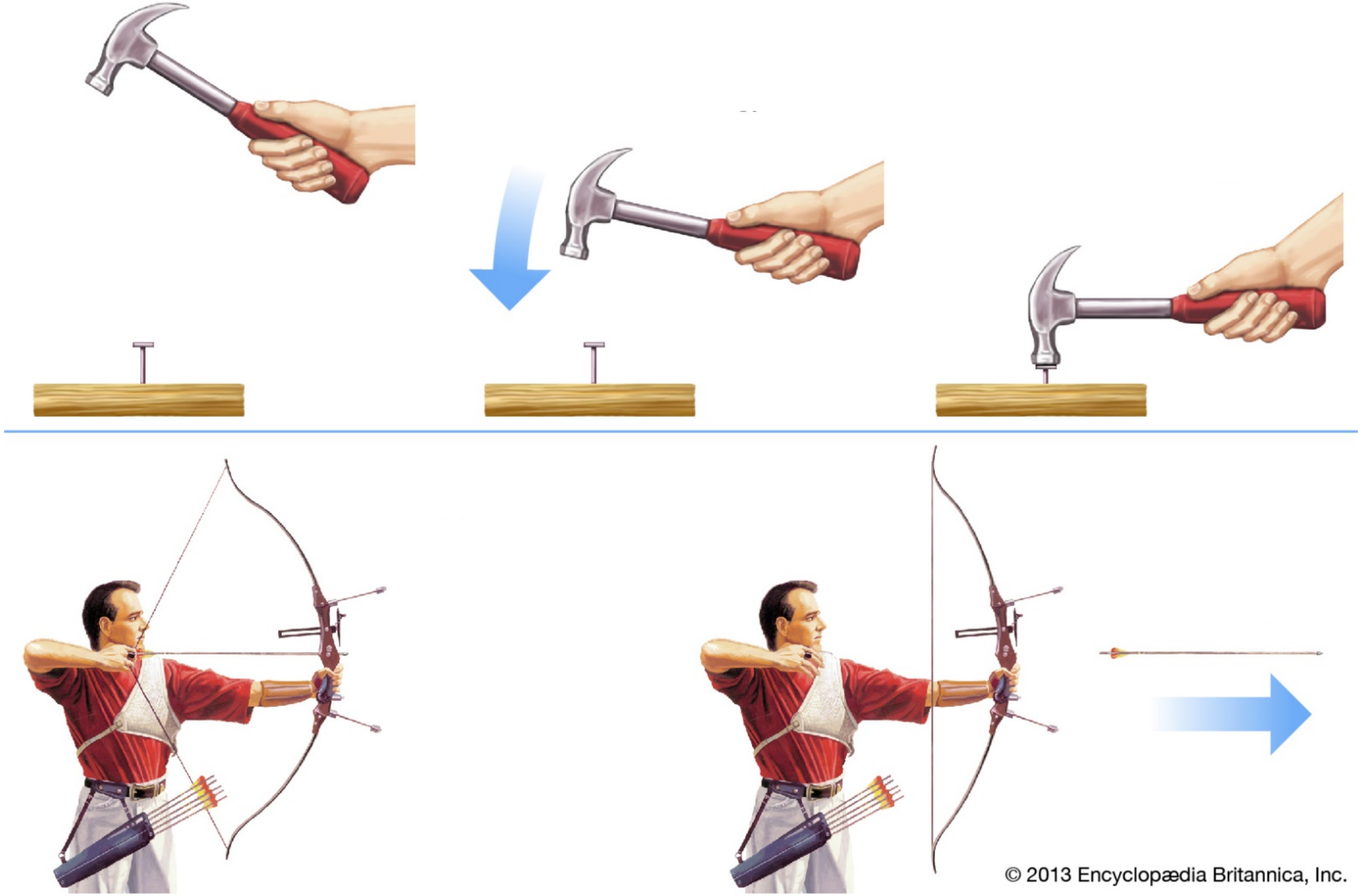
Potential Energy



Kinetic Energy (of rotation)

https://www.scienceabc.com/nature/universe/can-you-yo-yo-in-space.html

Identify the type or form of energy present in the images below.



https://kids.britannica.com/kids/article/mechanical-energy/628738

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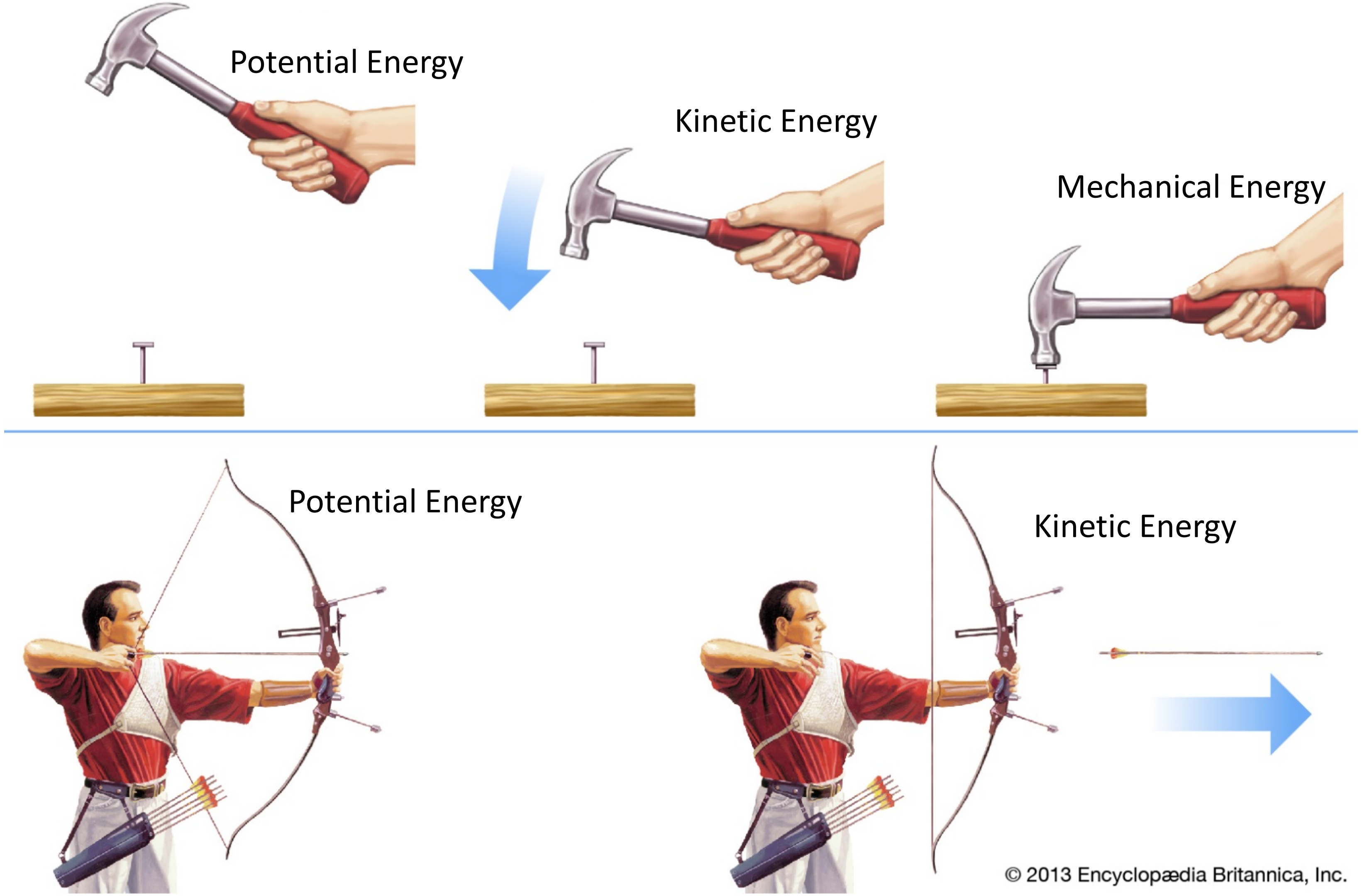
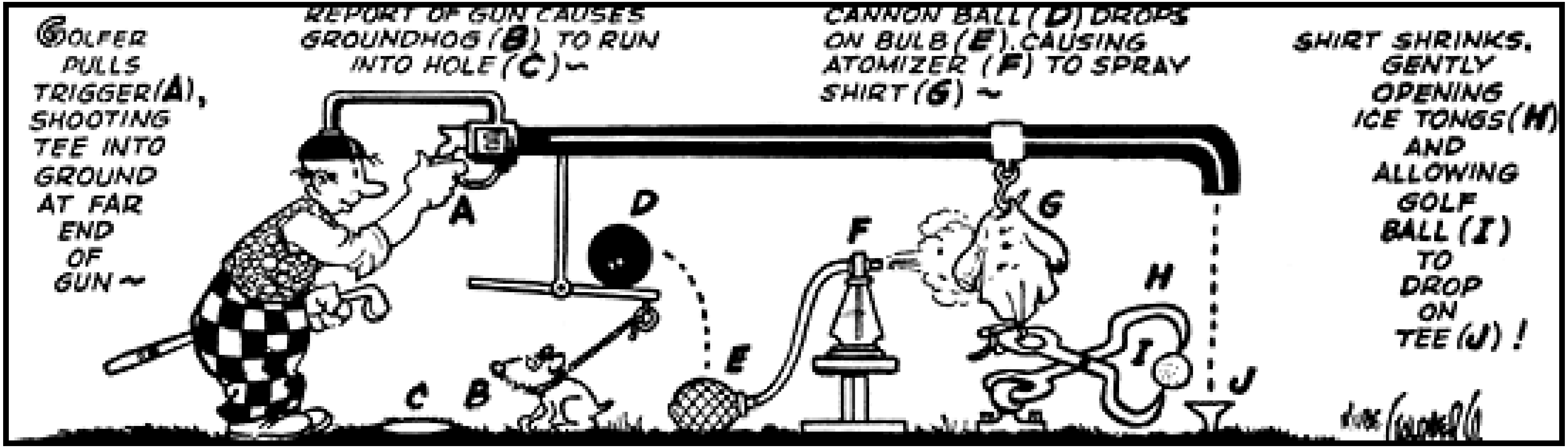


https://kids.britannica.com/kids/article/mechanical-energy/628738

Closure:

- Identify examples of potential and kinetic energy present in the RG cartoon.
- Identify examples of energy transfer in the RG cartoon.



http://piratesandrevolutionaries.blogspot.com/2010/12/moved-function-of-disjunction-rube_31.html

Name: ____ Date: ____________

Rube Goldberg Project – Part 1

Bell Ringer Q: A:

Class Discussion/Activity

What is a____?

A:

Who is____?

A:

What are the six____?

Video Clip

What is the____?

A:

Does a____________________________reduce the amount of________required to do a task?

A:

Provide an example to support your answer.

Closure Identify the____cartoon.

Rube Goldberg Project – Part 2

Bell Ringer Q: What is the mechanical advantage of a simple machine? A:

Class Discussion/Activity -- Directions:

Step 1: Answer the following questions the best you can based on prior knowledge.

1. What does the Law of the Conservation of Energy state?

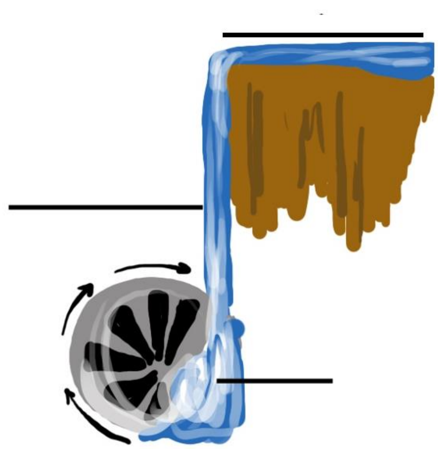
2. In order for work to be performed, what 3 requirements must be met?

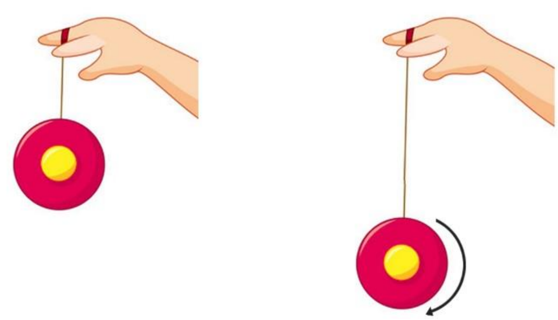
3. Explain the difference between potential energy and kinetic energy through an example.

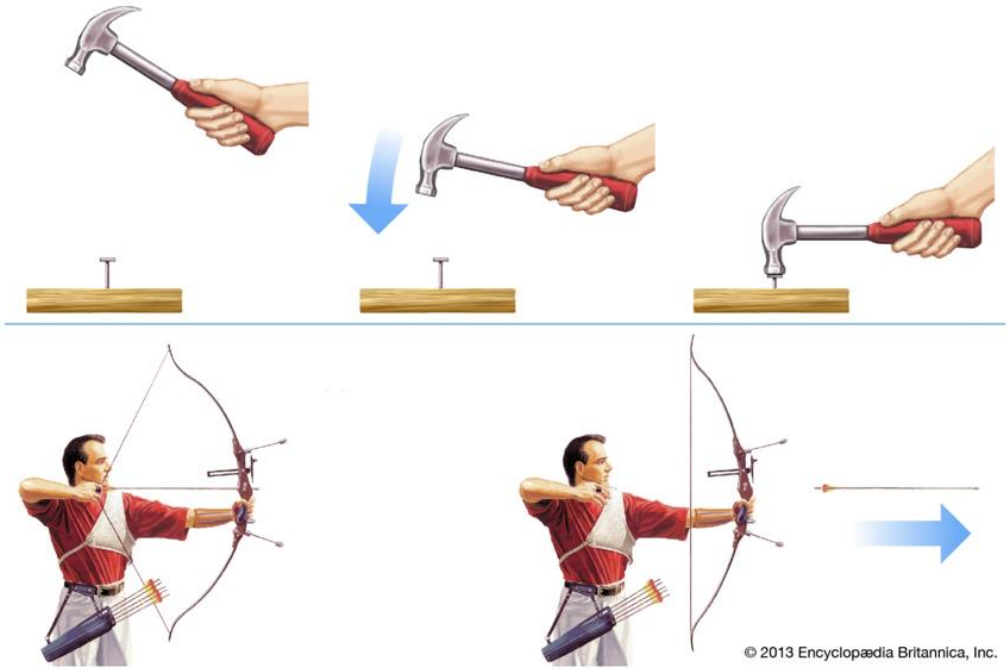
4. Define mechanical energy.

5. Identify the various forms of energy?

6. Identify the type or form of energy present in the images below. Use the article on types of energy to help you.





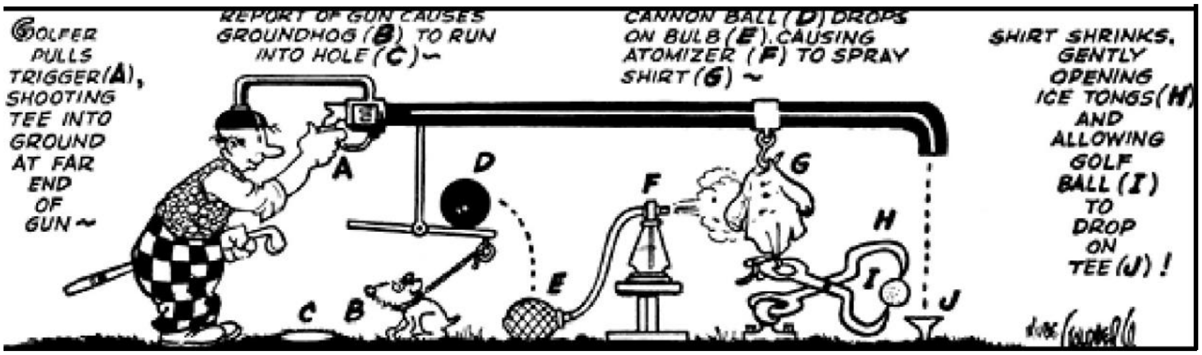


Closure

1. Identify examples of potential and kinetic energy present in the RG cartoon.
2. Identify examples of energy transfer in the RG cartoon.

How to Get Rid of a Mouse

The best mousetrap by Rube Goldberg: Mouse (A) dives for painting of cheese (B), goes through canvas and lands on hot stove (C). He jumps on cake of ice (D) to cool off. Moving escalator (E) drops him on boxing glove (F) which knocks him into basket (G) setting off miniature rocket (H) which takes him to the moon.


GOLFER PULLS TRIGGER (A), SHOOTING TEE INTO GROUND AT FAR END OF GUN ~
REPORT OF GUN CAUSES GROUNDHOG (B) TO RUN INTO HOLE (C) ~
CANNON BALL (D) DROPS ON BULB (E), CAUSING ATOMIZER (F) TO SPRAY SHIRT (G) ~
SHIRT SHRINKS, GENTLY OPENING ICE TONGS (H) AND ALLOWING GOLF BALL (I) TO DROP ON TEE (J)!
A
D
F
G
H
I
E
C
B
J

The Difference Between Mechanical and Kinetic Energy

By Doug Bennett; Updated March 13, 2018

https://sciencing.com/difference-between-mechanical-kinetic-energy-8677343.html

The law of the conservation of energy states that energy is neither created nor destroyed. Instead, it is simply transferred from one type of energy to another, or from one form of energy to another. The difference between mechanical energy and kinetic energy is that kinetic energy is a type of energy, while mechanical energy is a form of energy.

Energy Transfer

Work can be defined as the process of energy transfer whereby a force acts upon an object to cause a displacement. If an object is moved, then work has been performed. Work requires three things: a force, a displacement and a cause. For example, if you picked up a book and placed it on the top shelf of a bookshelf, the force would be you lifting the book, the displacement would be the movement of the book and the cause of the movement would be the force you applied.

Types of Energy

There are two types of energy: potential and kinetic. Potential energy is energy that is stored in an object due to its position. This type of energy is not in use but is available to do work. For example, the book possesses potential energy when it is stationary on the top of the bookshelf. Kinetic energy is energy that is possessed by an object due to its motion. For example, if the book were to fall off the shelf, it would possess kinetic energy as it fell. All energy is either potential or kinetic.

Forms of Energy

Mechanical energy is a form of energy. It represents the energy that is possessed by a mechanical system or device due to its motion or position. Stated differently, mechanical energy is the ability of an object to do work. Mechanical energy can be either kinetic (energy in motion) or potential (energy that is stored). The sum of an object's kinetic and potential energy equals the object's total mechanical energy. Other forms of energy include chemical, nuclear, electromagnetic, thermal and sound.

Kinetic vs. Mechanical

The difference between kinetic and mechanical energy is that kinetic is a type of energy, while mechanical is a form that energy takes. For instance, a bow that has been drawn and a bow that is launching an arrow are both examples of mechanical energy. However, they do not both have the same type of energy. The drawn bow is an example of potential energy, because the energy necessary to launch the arrow is only being stored in the bow; while the bow in motion is an example of kinetic energy, because it is doing work. If the arrow strikes a bell, some of its energy will be converted to sound energy. It will no longer be mechanical energy, but it will still be kinetic energy.

Rube Goldberg Project Rubric

Team Name:

				Score
Rube Goldberg Story	0 points: Incomplete; not turned in	7 points: Well written but lacks sophisticated vocabulary throughout; may not describe each step; may contain some grammatical errors	10 points: Well written with accurate use of sophisticated vocabulary throughout; describes each step thoroughly; free of conventional errors	_____/ 10
Oral Presentation	0 points: Incomplete; evidence of lack of preparation	7 points: Good explanation of the machine; identifies the simple machines used; identifies 3 transfers of energy	10 points: Well organized; evidence of thorough preparation; clearly explains the machine and identifies the simple machines and 3 energy transfers	____/ 10
Simple Machines	0 points: No simple machines used or identified	6 points each: ___ inclined plane ___ pulley ___ wheel & axel ___ screw ___ lever ___ wedge		____/ 30
Number of steps	0 points: No steps identified	5 points each: ___ 1 step ___ 2 steps ___ 3 steps ___ 4 steps ___ 5 steps ___ 6 steps	Bonus: +1 for each additional step	____/ 30
Design and Functionality	5 points: Little to no effort put in to making the machine work. No design improvements were made.	7 points: Group discusses their design process and includes limited information on problems they had and how they fixed them.	10 points: The group thoroughly discusses their design process, including problems they identified and fixed to improve functionality.	____/10
Creativity	5 points: Little evidence of complex thought in the project. The final product is basic and does not catch the viewer's eye.	7 points: The design shows good planning and craftsmanship and is interesting in appearance and action.	10 points: The design shows thorough planning and craftsmanship. The final product is polished and captivating in action. The group incorporated a unique step.	____/ 10
Total				_____/ 100

Additional Bonus:

Each Judge will be given 1 “Golden WOW” worth 5 bonus points to award to any team they choose for any reason they feel they were wowed.

PEER EVALUATION

TEAM NAME:

TEAM MEMBER'S NAME:	
WHAT THEY DID WELL:	
HOW THEY CAN IMPORVE:	
CONTRIBUTION TO THE GROUP ON A SCLE 1-10:	
TEAM MEMBER'S NAME:	
WHAT THEY DID WELL:	
HOW THEY CAN IMPORVE:	
CONTRIBUTION TO THE GROUP ON A SCLE 1-10:	
TEAM MEMBER'S NAME:	
WHAT THEY DID WELL:	
HOW THEY CAN IMPORVE:	
CONTRIBUTION TO THE GROUP ON A SCLE 1-10:	

STEM REFLECTION

Name:
Date:

WHAT DID I LEARN?

WHAT PARTS WORKED WELL?

WHAT PARTS OF THE DESIGN DID NOT WORK?

WHAT WOULD I DO DIFFERENTLY?