ONTARIO COUNCIL FOR TECHNOLOGY EDUCATION

Grade 8 Systems in Action

ONLINE RESOURCE

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June 2020

Systems in Action Grade 8

Activity 1

Development of Curiosity and Wonder - Inputs and Outputs with Linkages

Scientific and Technological Concepts:
The Ontario Curriculum document defines a system as a group of interacting, interrelated, or interdependent elements forming a complex whole. In other words, a system is a group of elements that interact and work together to form a functioning unit. There are a variety of systems, including mechanical, optical, transportation, health care, body and cooling systems, to name a few.

An input in a system is any action that is introduced to a system. For example, the seeds, water and fertilizer in a garden system.

The output in a system is the action that results from the input. For example, the food and flowers from a garden system.

A lever is a simple machine that has a rigid bar that can be turned freely about a fixed point. A lever has a fulcrum, which is a point or support in which the lever pivots. There are fixed and moveable fulcrums. A moveable fulcrum is a fulcrum which changes its located position from one point to another.

A linkage is a system of interconnected elements, such as rods, springs, and pivots, used to transmit power or motion. It has a moveable fulcrum.

Learning Goal:
Students will
- Design and create mini-linkage systems
- Investigate how different pivot points aid in the construction of a linkage system
- Explore how the input and linkage mechanism affects the output of the linkage system

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Expectations (Overall & specific):

Overall:

Investigate a working system and the ways in which components of the system contribute to its desired function

Specific:

2.1 follow established safety procedures for working with apparatus, tools, materials, and electrical systems
2.4 use technological problem-solving skills to investigate a system (e.g., an optical system, a mechanical system, an electrical system) that performs a function or meets a need
3.2 identify the purpose, inputs, and outputs of various systems
3.3 identify the various processes and components of a system that allow it to perform its function efficiently and safely

Equipment & Materials	Personal Protective Equipment (PPE)
● Thicker-type paper, cardboard, construction paper, bristol board or cue cards ● Brass fasteners, paper clips or pins (something that will allow the paper to pivot) ● Scissors ● Tape and/or glue ● Hole punch (optional) ● "Investigating Inputs and Outputs with Linkages" handout. See Appendix A	● N/A

Safety Considerations:

- Students will need to be cautious cutting materials, especially thicker material like cardboard
- Students will need to be cautious and aware of what they are using to poke holes through the material
- A hole punch is best used for thicker materials.
- Loose hair tied back

What does the teacher do?	What do the students do based on the Technological Problem-Solving Skills Continuum?
Using the handout titled, "Investigating Inputs and Outputs with Linkages", refer to Appendix A, create your own first model. Show students the first sample	**Initiating and Planning** Using the first model, students need to identify a possible solution to make the linkage work. Students

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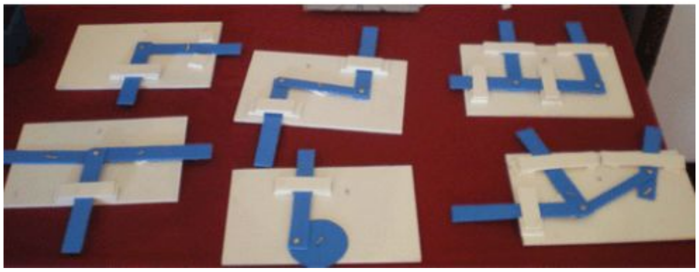
but only from the front view and demonstrate the movement. Give them an opportunity to use the materials and try to recreate the same movement as yours.

Possible Solutions:



Allow the students to show their project and reveal the back design.

Show the teacher's model back design to the students. Pose the question:
"Are they the same or different?"

When a different design occurs with any model it reveals there can be multiple solutions to any given problem. If possible, a discussion can develop around which designs require more time, materials, and or cost to produce.

Challenge students to recreate two or three more designs. Emphasize where the input and output of the system is to help them create their solution.

Extension: Have students use their solutions to create moveable cards, posters or animals with moving parts.

need to pay attention to where the input of the linkage is and what the output will be. Students might wish to sketch out their solution before starting to assemble it.

Performing and Recording
Designs, builds, and tests their linkage to match the model diagram

Analysing and Interpreting
If given an opportunity, compare their solution with the teacher's model or others in the class.

Explains how well their chosen solution worked compared to to the model and suggests possible changes

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Sample accommodations: Students can use a variety of materials to create these - even sticks for pivot points. Sample Troubleshooting: The stronger the material the better. Students are encouraged to either increase the thickness of their paper or use a material like cardboard.	

Opportunities for assessment (Links to assessment pieces, organizers):

Success Criteria

Criteria	Met	Not There Yet
Student creates a model that appropriately uses the input and output as shown in the model handout		
Students uses appropriate pivot points - fixed and moveable		
Student uses reinforcements appropriately and keeps the model aesthetically pleasing and neat		
Student uses appropriate materials, regardless of whether they are modified from the suggested list		

Cross Curricular Opportunities:
Language:
Oral Communication Overall:
1. listen in order to understand and respond appropriately in a variety of situations for a variety of purposes

References:
Lovell, C. (n.d.). Linkages.

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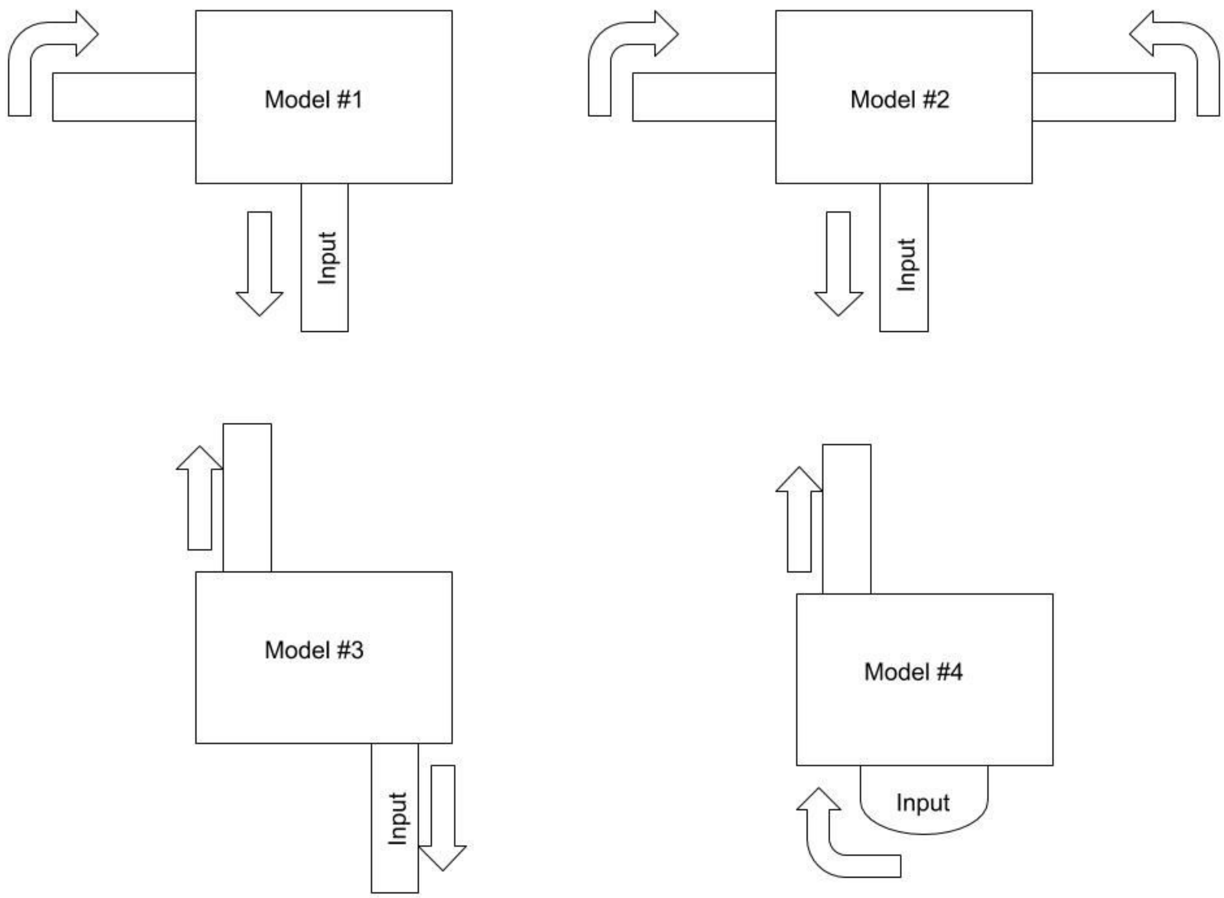
Appendix A

Investigating Inputs & Outputs with Linkages

Using a heavy paper, brass fasteners, tape and/or glue make the movements in each model shown below.



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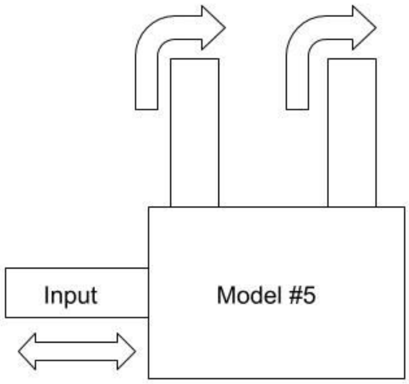

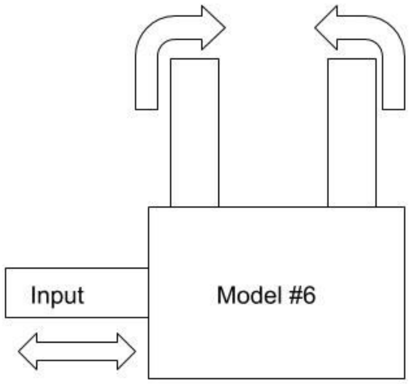

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Activity 2 - Catapult Craze

Structured to develop technological problem-solving skills

Scientific and Technological Concepts:
The function of a lever is to make moving objects easier. They are an example of a simple machine.There are three different types of levers: first-class, second-class and third-class. The difference between the types of levers is the placement of their components: the fulcrum, effort and load. The fulcrum is the pivot point in which the lever moves. The effort is where the force to move the lever is and the load is the weight of the object that lever is trying to move.

In a first-class lever, the fulcrum is located in between the effort and the load. The placement of the fulcrum is extremely important in this class of levers, as the placement will affect how well a load will be lifted. An example would be a catapult arm or a teeter-totter.

In a second-class lever, the load is in between the fulcrum and the effort. The effort and load will travel in the same direction, unlike a first-class lever. A wheel-barrow is a prime example of a second-class lever. The wheels of the wheel-barrow act as the fulcrum, the basin holds the load and the effort is where the handles are.

The last class of levers is a third-class lever. In this lever, the effort is in between the fulcrum and the load. Just like second-class levers, the load and effort travel in the same direction. A broom, a hockey stick or a fishing rod are examples of third-class levers. In a hockey stick, the fulcrum is at the top of the stick, your effort is where your hand is lower on the stick and the load is the puck.

Learning Goal:
Students will

- Create a working catapult using their own design that will either be designed to launch for distance, height or accuracy
- Students will explain the various components of their catapult and how it is specifically designed to launch for distance, height or accuracy
- Students will create a graph of their testing trials

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Expectations (Overall & specific):
Overall:
2. investigate a working system and the ways in which components of the system contribute to its desired function;
Specific:
2.1 follow established safety procedures for working with apparatus, tools, materials, and electrical systems
2.4 use technological problem-solving skills (see page 16) to investigate a system (e.g., an optical system, a mechanical system, an electrical system) that performs a function or meets a need
2.6 use appropriate science and technology vocabulary, including mechanical advantage, input, output, friction, gravity, forces, and efficiency, in oral and written communication
2.7 use a variety of forms (e.g., oral, written, graphic, multimedia) to communicate with different audiences and for a variety of purposes (e.g., using appropriate mathematical conventions, create a graph to represent changes in mechanical advantage when certain factors in a mechanism are manipulated)
3.2 identify the purpose, inputs, and outputs of various systems
3.3 identify the various processes and components of a system (e.g., robot, front-end loader/backhoe, heating system, transportation system, health care system) that allow it to perform its function efficiently and safely

Equipment & Materials	Personal Protective Equipment (PPE)

• Any collection of found items, including:
  ○ Popsicle sticks and/or tongue depressors
  ○ Spoons
  ○ Elastics
  ○ Bottle caps
  ○ Pencils
  ○ Sticks
• Hot glue
• Item to launch: ping pong ball, pompom, rubber toy, bead etc
• "Catapult Craze" handout, see Appendix A
	• Goggles if using a hot glue gun

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Safety Considerations:

- Students need to be cautious if using a glue gun to join materials. Glue gun use should be supervised and goggles need to be worn
- Loose hair and clothing tied back
- The object chosen to be launched should be soft and not an item that would inflict harm if caught in the crossfire

What does the teacher do?	What do the students do based on the Technological Problem-Solving Skills Continuum?
Introduce the project by introducing catapults to the students. Catapults were invented in Ancient Greece and were used for warfare. Show a variety of pictures and examples of catapults in everyday life. Provide an opportunity for students to explore the three different classes of levers. Simple materials include a ruler as the lever, an eraser for the load and something cylindrical, like a thick marker to be the fulcrum. Students explore what happens when the fulcrum is moved along the length of the lever. Introduce the assignment: Students build a catapult using materials found at home. Use the handout titled, "Catapult Craze" in Appendix A to help them design and test their catapults. Sample accommodations: ● Students may choose to use any material found at home. Students may use examples from the internet to help them to design their structures. ● Students may choose to take a picture of their device or record a video of themselves explaining their design and answering the	**Initiating and Planning** Using the handout titled "Catapult Craze", Appendix A, students choose appropriate materials for the task. Ensure that materials chosen will create the necessary force. Before building, it is recommended to investigate different materials and how they might function in their design. Using the handout, students sketch out either two possible designs or two different views of the same design. **Performing and Recording** Test out your design. Depending on what dependent variable students chose to design their catapult for, record the height, distance or distance from target in centimeters using the chart in the handout. **Analysing and Interpreting** Using the questions in the "Reflection" section of the handout, students use full sentences to reflect upon their design and creation. **Communicating** Students create a graph using the quantitative data

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reflection questions	from their trials.

Opportunities for assessment (Links to assessment pieces, organizers):

CRITERIA	LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4
Design Process Plan -at least two designs are drawn or at least two different views -measurements are given -appropriate materials are chosen	Develops an unfinished plan with various considerations missing Somewhat uses the design process (plan, build, test, evaluate, communicate)	Develops a workable plan with some steps missing Somewhat uses the design process (plan, build, test, evaluate, communicate)	Develops a clear workable plan using appropriate materials Uses the design process (plan, build, test, evaluate, communicate) as expected	Develops a workable plan and modifies the plan as necessary Demonstrates the design process (plan, build, test, evaluate, communicate) effectively
Model Translates plan to model	Design plans do not translate into a working model	Translates design plans into a working model based on some of the criteria Creates model that functions sometimes successfully according to specifications Predictable design and materials	Successfully translates design plans into a working model based on criteria required Creates model that functions successfully according to specifications Predictable design and materials	Successfully translates design plans into a working model based on criteria required Creates model that functions successfully according to specifications Care is taken with construction Unique and creative design
Communication and Reflection -terms are used -knowledge of levers is evident	Uses little appropriate terminology for grade level Does not communicate an basic understanding of the concepts	Uses some appropriate terminology for grade level Communicates understanding of some of the basic concepts	Uses most appropriate terminology Communicates understanding of most of the basic concepts	Uses all appropriate terminology Communicates understanding of all of the basic concepts

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	Reflects on design process and makes limited suggestions for improvement	Reflects on design process and makes some suggestions for improvement	Reflects on design process and makes necessary suggestions for improvement	Reflects on the process with an in-depth response. Makes necessary and insightful suggestions for improvement

Cross Curricular Opportunities:
Language:
Writing Overall:
1. generate, gather, and organize ideas and information to write for an intended purpose and audience
Math:
Data Management Overall:
• collect and organize categorical, discrete, or continuous primary data and secondary data and display the data using charts and graphs, including frequency tables with intervals, histograms, and scatter plots;

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Appendix A:

Catapult Craze

Situation: Understanding mechanical efficiency and systems leads to greater technological know-how. Being able to effectively use mechanics to aid human efforts has allowed us to build towers and bridges that were impossible to construct hundreds of years ago.

Problem: Design a catapult that either launches for height, distance or accuracy. Catapult designs may be designed to launch for one, two or all types of competition (dependent variables). Use your knowledge of levers and placement of the fulcrum, effort and load to help in your design. Use your knowledge of form and function from grade seven to also aid in your design and construction. Consider how you will create force using your chosen materials.

Materials Chosen: *Write down your chosen materials. Include size and quantity where necessary.*

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-
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Designs: *Create at least two different designs, or draw out one design with two different views. Ensure to include details like size and dimensions. Include the terms: fulcrum, load and effort in your design sketches.*

Design 1 or _____view:

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Design 2 or _____ view:

Observations: *Record your quantitative observations of your catapult. If you chose to focus on one dependent variable, just record your data in that row.*

Dependent Variable	Trial #1	Trial #2	Trial #3	Trial #4	Trial #5	Trial #6	Trial #7	Trial #8	Trial #9	Trial #10
Distance in cm										
Height in cm										
Accuracy - distance from target in cm										

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Graph: *Create a scatterplot graph of your trials. Your dependent variable will be along the y-axis. Your trial number will be along the x-axis.*

Reflection:

1. How did your catapult work? What design features do you have? Include information on:
   - *Inputs and outputs*
   - *Components of the catapult system*
   - *Placement of fulcrum, load and effort - what class of lever was it?*
2. Did you make any modifications from the original design? Please explain and use a drawing if necessary.
3. What made your catapult successful or how would you modify it further, if given the opportunity?
4. What would you like me to notice about your catapult?

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Activity 3 - Rube Goldberg and Mechanical Advantage

Guided development of technological problem solving skills

Scientific and Technological Concepts:
The goal of engineering is to create something that works effectively with efficiency and reliability. Typically, simple designs make better machines.

Rube Goldberg was an engineer and a cartoonist. Rube Goldberg's cartoons featured overly complex machines accomplishing simple tasks.

Building a Rube Goldberg machine takes patience. One modern-day example of a Rube Goldberg machine was done by the band, OK Go and needed 60 engineers working on it for one and a half months and needed 60 takes to get it right. It took over an hour to reset the phases of the machine after each take.

In a machine, mechanical advantage (MA) is the ratio of the output force to the input force (i.e., output force divided by input force). In other words, MA = force needed without a simple machine divided by force needed with a simple machine. Mechanical advantage does not have any units associated with it.

Learning Goal:
Students will
- Design and create their own Rube Goldberg machine with at least 8 steps
- Incorporate at least 3 different types of simple machines within their Rube Goldberg machine
- Calculate the mechanical advantage of at least three of their simple machines

Expectations (Overall & specific):
Overall:
2. investigate a working system and the ways in which components of the system contribute to its desired function;
3. demonstrate an understanding of different types of systems and the factors that contribute to their safe and efficient operation
Specific:
2.1 follow established safety procedures for working with apparatus, tools, materials, and electrical systems
2.3 use scientific inquiry/experimentation skills to investigate mechanical advantage in a variety of mechanisms and simple machines

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2.4 use technological problem-solving skills to investigate a system (e.g., an optical system, a mechanical system, an electrical system) that performs a function or meets a need
2.6 use appropriate science and technology vocabulary, including mechanical advantage, input, output, friction, gravity, forces, and efficiency, in oral and written communication
2.7 use a variety of forms (e.g., oral, written, graphic, multimedia) to communicate with different audiences and for a variety of purposes

Equipment & Materials	Personal Protective Equipment (PPE)

• Found materials from home:
  ○ Recycled materials like boxes and paper towel rolls
  ○ Found items from outside like sticks, bark and rocks
  ○ Connecting items like Lego, K'Nex, board game pieces
• Students should not be limited to using any material found in the home that does not pose a safety risk
	• Eye protection must be used when using a glue gun

Safety Considerations:
- Loose hair and clothing must be tied back
- Students need to exercise caution when cutting materials that are thicker like, cardboard
- Students need to be cautious if using a glue gun to join materials. Glue gun use should be supervised and goggles need to be worn

What does the teacher do?	What do the students do based on the Technological Problem-Solving Skills Continuum?
Calculating mechanical advantage must be taught prior to this lesson for students. Students should know how to and have had practice calculating the mechanical advantage of simple machines such as:	**Initiating and Planning** Students will choose a simple task in which their Rube Goldberg will accomplish. Students will outline in detail using the handout in Appendix A, sketch a

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inclined plane, pulley, lever and gear. Provide an opportunity for students to watch modern Rube Goldberg machines. Some examples are: https://safeyoutube.net/w/fp08 https://safeyoutube.net/w/Eq08 https://safeyoutube.net/w/ps08 https://safeyoutube.net/w/or08 Provide students with ample time to create and perfect their Rube Goldberg machines. Allow them to use the handout "Rube Goldberg Machine" (appendix A) to plan, build, investigate and calculate the mechanical advantage of three of their simple machines. **Sample accommodations:** Students will need sufficient time to complete their assignment. Phases may be reduced from 8 and the number of simple machines and the calculation of mechanical advantage may also be reduced in number to accommodate students.	diagram of each step or phase of their Rube Goldberg machine. The proposed sketch must take into account considerations such as function, aesthetics and environmental impact. Students will record the purpose of each step/phase and identify the three simple machines in their machine. **Performing and Recording** Students will build their Rube Goldberg machine based upon their design and test it. **Analysing and Interpreting** Students will then explain how well their Rube Goldberg Machine performed and suggest possible changes. **Communicating** Students will be expected to use appropriate vocabulary. Students will video record their Rube Goldberg machine.

Opportunities for assessment (Links to assessment pieces, organizers):

CRITERIA	LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4
Design Process Plan -sketch of the Rube Goldberg machine is drawn -each step is numbered -each simple machine is labeled -appropriate materials are chosen	Develops an unfinished plan with various considerations missing Somewhat uses the design process (plan, build, test, evaluate, communicate)	Develops a workable plan with some steps missing Somewhat uses the design process (plan, build, test, evaluate, communicate)	Develops a clear workable plan using appropriate materials Uses the design process (plan, build, test, evaluate, communicate) as expected	Develops a workable plan and modifies the plan as necessary Demonstrates the design process (plan, build, test, evaluate, communicate) effectively

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Model Translates plan to model	Design plans do not translate into a working model	Translates design plans into a working model based on some of the criteria Creates model that functions sometimes successfully according to specifications Predictable design and materials	Successfully translates design plans into a working model based on criteria required Creates model that functions successfully according to specifications Predictable design and materials	Successfully translates design plans into a working model based on criteria required Creates model that functions successfully according to specifications Care is taken with construction Unique and creative design
Communication and Reflection -terms are used -knowledge of simple machines is evident -calculations of mechanical advantage of three of the simple machines is present	Uses little appropriate terminology for grade level Communicates a limited understanding of the basic concepts Reflects on design process and makes limited suggestions for improvement Calculates mechanical advantage of some simple machines and/or shows limited work	Uses some appropriate terminology for grade level Communicates understanding of some of the basic concepts Reflects on design process and makes some suggestions for improvement Calculates mechanical advantage of some simple machines and/or shows limited work	Uses most appropriate terminology Communicates understanding of most of the basic concepts Reflects on design process and makes necessary suggestions for improvement Calculates mechanical advantage showing most work	Uses all appropriate terminology Communicates understanding of all of the basic concepts Reflects on the process with an in-depth response. Makes necessary and insightful suggestions for improvement Calculates mechanical advantage and shows all work

Cross Curricular Opportunities:
Language Arts
Media Literacy Overall:
3. create a variety of media texts for different purposes and audiences, using appropriate forms, conventions, and techniques;
Writing Overall:
1. generate, gather, and organize ideas and information to write for an intended purpose and audience

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References:

Home of the Official Rube Goldberg Machine Contests. (n.d.). Retrieved June 17, 2020, from https://www.rubegoldberg.com/

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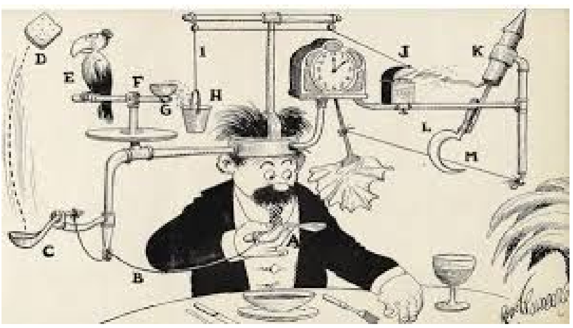
Appendix A:

Rube Goldberg Machine Assignment



“RUBE GOLDBERG (1883-1970) was a cartoonist, an inventor, and the only person ever to be listed in Merriam-Webster’s Dictionary as an adjective. Of the nearly 50,000 cartoons he drew in his lifetime, Rube is best known for the zany contraptions of Professor Butts. These inventions, also known as Rube Goldberg Machines, solved a simple task in the most overcomplicated, inefficient, and hilarious way possible.” - RubeGoldberg.com

Your Task:

Part A: Planning and building of machine

- Design and build your own Rube Goldberg machine that has at least 8 phases or steps that accomplishes a simple task like popping a balloon
  - Sketch out your proposed design using the space on the handout
- Your machine must include at least three different simple machines (e.g., gear, lever, pulley, inclined plane, screw)

Part B: Explanation and Calculations

- Identify each simple machine you have included in your machine, using the space on the handout
- Calculate the mechanical advantage of at least three of your simple machines. If you have two different inclined planes and two different pulleys, you may only repeat a calculation once, considering that you have different data for each machine

Part C: Recording of Rube Goldberg Machine

- Video record your Rube Goldberg machine and submit
- Ensure the video captures each phase/step of your machine
- Include any commentary that you believe will help explain the process

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1. **Sketch**
    - Draw a sketch of your Rube Goldberg Machine that shows the step-by-step operation of your machine
    - Make it neat and easy to follow by providing numbers of each step
    - Label the simple machines in your sketch

2. **Explanation of each phase/step**
    - Identify the purpose of each step of your machine (e.g., the marble knocks down the marbles)

Step #1:

Step #2:

Step #3:

Step #4:

Step #5:

Step #6:

Step #7:

Step #8:

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3. **Calculation of Mechanical Advantage**
    - Calculate the mechanical advantage for 3 simple machines in your Rube Goldberg machine.
    - Show your work: formula → substitution → answer

Simple Machine _________________________

Simple Machine _________________________

Simple Machine _________________________

4. **Reflection**

1. Taking into consideration that the purpose of a Rube Goldberg machine is for entertainment and to draw out the number of steps it will take to accomplish a simple task, what part of your system was efficient?

2. What makes your system non-efficient? What factors impacted its efficiency? (Friction, transformation of energy etc)

3. What types of modifications did you make from your initial sketch and why? Explain what modifications you would make and why, if given the opportunity and time?