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Using Simple Machines to Make Overly Complex Compound Machines

Overview

Einstein is quoted as saying, “Everything should be made as simple as possible, but not simpler.” Simple machines are classic examples of what Einstein claims. They are classified in six types, and they can be found everywhere—often in some very surprising places and things. Simple machines offer mechanical advantages, which makes it easier to do work. The six simple machines are levers, inclined planes, wedges, screws, wheels and axles, and pulleys.

Design Rationale

It is important to understand the principles, functions and application of simple machines. The workings of simple machines are central to most of our significant accomplishments in buildings, tools, and technologies.

When simple machines are combined into another machine, they are called compound machines. For example, a bicycle is made up of levers (shifters, derailleurs, handlebars, freewheel assembly, brakes); wheels and axles (the wheels, pedals, crankset); pulleys (parts of the shifting mechanisms, braking mechanisms, and the chain on gears); screws that hold parts together; and wedges (the teeth on the gears). When all the simple machines on a compound machine like a bicycle work well together, riders gain a mechanical advantage of traveling faster than they could if they were walking.

Compound machines can be highly technical like airplanes or relatively simple such as a hand powered can opener. The master of making compound machines profoundly complicated, highly whimsical, quirky, and fun was Rube Goldberg (1883–1970), an engineer and cartoonist who invented contraptions that made every day, simple tasks more complicated. His contraptions are the absolute opposite of Einstein’s ideal.

To this day, Rube Goldberg Contraptions delight us (<https://www.rubegoldberg.org/>). However, at the heart of every contraption is a collection of interdependent simple machines.

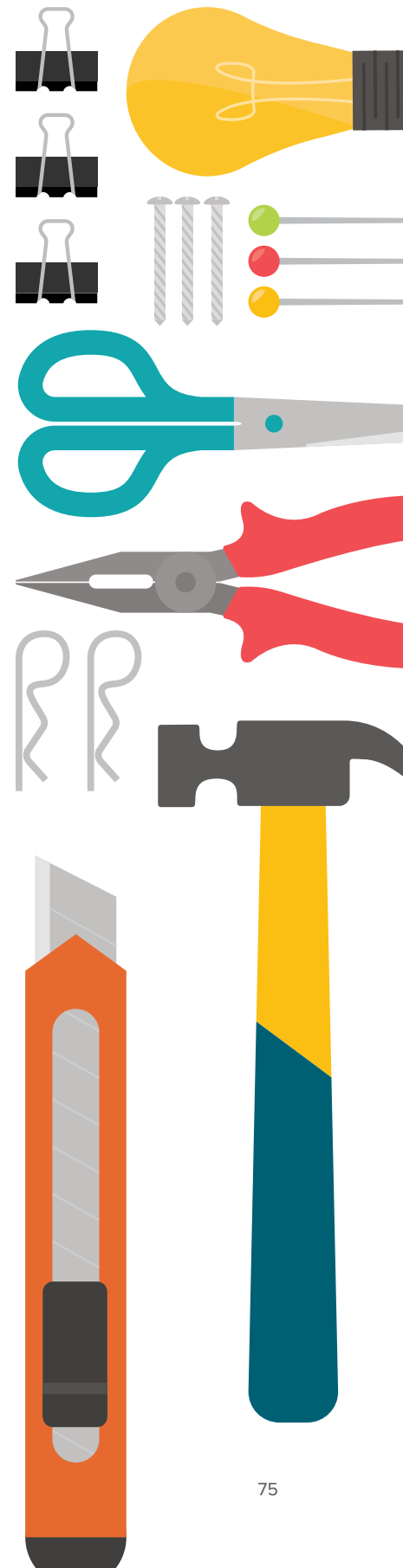
Problem Scenario

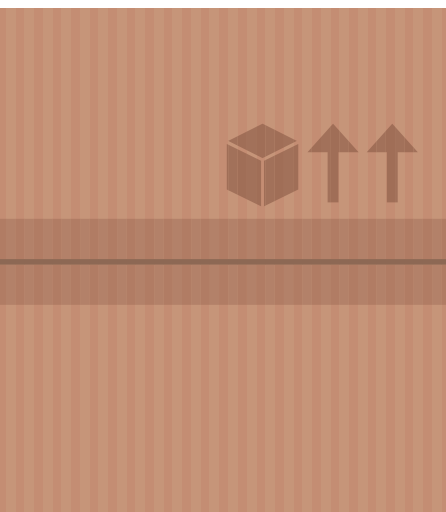
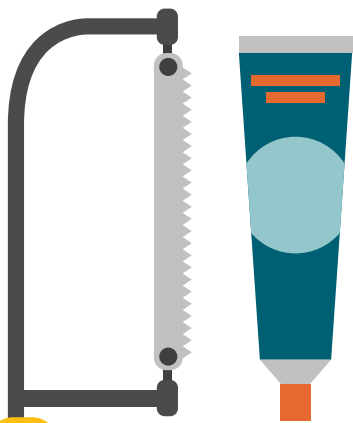
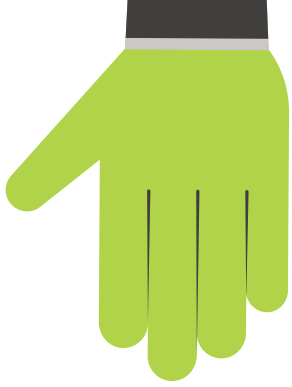
Your team has been selected to develop the ultimate Rube Goldberg contraption capable of moving the marble—found in the participant group kit provided—the furthest distance, over the longest period of time, in the most complex manner.

Success Determinants

Success will be determined by the degree to which your design solution:

- Is accompanied by a highly elaborate sketch illustrating functionality
- Addresses the design challenge
- Uses the provided materials, resources, and tools





- Shows evidence of your group’s understanding of the mechanical advantage provided by the six simple machines
- Is whimsical and makes us smile
- Has a clear theme or story (i.e. maybe the marble is a metaphor for a creature that is trying to escape)
- Has a high degree of absurd complexity (very, very unnecessarily complicated)
- Is aesthetic and well constructed
- Is reliable—the marble can be put on its journey multiple times

Parameters

- Plan how to use something of every consumable item in the participant group kit provided.
- You can use items from the pantry.
- You can use any of the tools that have been provided.
- Your contraption can be no larger than 2 feet x 2 feet x 2 feet square.
- You must use all six simple machines at least once within your contraption.

Suggestions for Use

- *The Kids’ Book of Simple Machines: Cool Projects & Activities That Make Science Fun* by Kelly Doudna is a terrific resource for this design challenge (https://www.amazon.ca/The-Kids-Book-Simple-Machines/dp/1938063597?ie=UTF8&*Version*=1&*entries*=0).
- Rather than a Rube Goldberg machine, think about designing a vending machine for a specific purpose. The Japanese are recognized as being the best of vending machines.
 - <http://kotaku.com/the-world-of-japanese-vending-machines-5988536>
 - *40 Things You Don’t Expect to Find in Vending Machines*—including live crabs and fresh baguettes <http://www.hongkiat.com/blog/bizarre-vending-machines/>
- Obvious curricular connections can be made to British Columbia’s Science Learning Standards.
- Please use the rubric on the following pages for summative assessment of the machine. This rubric was generated using Rubistar and is available online as #2614115 (<http://rubistar.4teachers.org/index.php>).

| Rube Goldberg Rubric | 4 | 3 | 2 | 1 |
|--------------------------------------|---|--|---|---|
| Function | Structure functions extraordinarily well, holding up under atypical stresses. | Structure functions well, holding up under typical stresses. | Structure functions pretty well, but deteriorates under typical stresses. | Fatal flaws in function with complete failure under typical stresses. |
| Scientific Knowledge | Explanations by all group members indicate a clear and accurate understanding of scientific principles underlying the construction and modifications. | Explanations by all group members indicate a relatively accurate understanding of scientific principles underlying the construction and modifications. | Explanations by most group members indicate relatively accurate understanding of scientific principles underlying the construction and modifications. | Explanations by several members of the group do not illustrate much understanding of scientific principles underlying the construction and modifications. |
| Plan | Plan is neat with clear measurements and labeling for all components. | Plan is neat with clear measurements and labeling for most components. | Plan provides clear measurements and labeling for most components. | Plan does not show measurements clearly or is otherwise inadequately labeled. |
| Construction, Materials | Appropriate materials were selected and creatively modified in ways that made them even better. | Appropriate materials were selected and there was an attempt at creative modification to make them even better. | Appropriate materials were selected. | Inappropriate materials were selected and contributed to a product that performed poorly. |
| Construction, Care Taken | Great care taken in construction process so that the structure is neat, attractive and follows plans accurately. | Construction was careful and accurate for the most part, but 1–2 details could have been refined for a more attractive product. | Construction accurately followed the plans, but 3–4 details could have been refined for a more attractive product. | Construction appears careless or haphazard. Many details need refinement for a strong or attractive product. |
| Evidence of 6 simple machines | Evidence of use of all 6 machines, at least once in the contraption. | Evidence of use of 5 machines, at least once in the contraption. | Evidence of use of 4 machines, at least once in the contraption. | Evidence of limited use of fewer than 4 machines in the contraption. |

| Rube Goldberg Rubric | 4 | 3 | 2 | 1 |
|--------------------------------|--|---|---|---|
| Participant Group Kit | Evidence of use of something of everything from the participant group kit. | Evidence of use of something of almost everything from the participant group kit. | Limited use of the majority of items from the participant group kit. | Relevance on only a few items from the participant group kit. |
| Shared Pantry | Evidence of thoughtful use of shared pantry items. | Evidence of use of shared pantry items. | Evidence of over use of shared pantry items. | Excessive or wasteful use of shared pantry items. |
| Whimsy and Aesthetics | High degree of whimsy and aesthetics. | Good degree of whimsy and aesthetics. | Moderate degree of whimsy and aesthetics. | Little or no whimsical or aesthetic values. |
| Absurdity and Narrative | Contraption is absolutely absurd in its illustration of a good story. | Contraption is adequately absurd in its illustration of a good story. | Contraption is marginally absurd in its illustration of a good story. | Contraption has little or no absurd qualities told in an unclear story. |