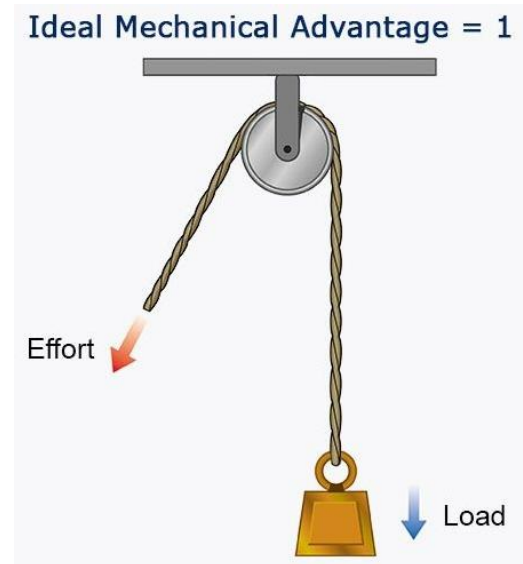




## Spring 2025 STEM Challenge

### Pulley Systems



**Challenge:** Can you create a pulley system that lifts the largest load with the least amount of effort?

**Standards:** New York State Next Generations Science Learning Standards; Engineering Design 3-5-ETS1-1.

Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

**Consideration:** A pulley is a basic mechanical device (a simple machine) that uses a wheel with a groove and a flexible rope, string, or cable. The rope loops over the wheel to help lift or move loads. Depending on the setup, pulleys can:

- Reduce the force needed to lift a load.
- Change the direction of force to make lifting more comfortable.

The object being lifted is called the load, and the force applied to the pulley system is the effort. By combining multiple pulleys, called a compound pulley, we can create a mechanical advantage, allowing us to lift heavier loads with a smaller force over a longer distance. By redirecting force, they reduce the strain on our muscles.

Did you know? The earliest evidence of pulleys dates back to Ancient Egypt, where they were likely used to build the pyramids. Today, pulleys are essential in cranes, flagpoles, clotheslines, and even window blinds.

Types of Pulleys:

- Fixed Pulley: Changes the direction of force but doesn't reduce the effort needed.
- Movable Pulley: Reduces the force required to lift an object.
- Compound Pulley: Combines fixed and movable pulleys for maximum mechanical advantage.

**\*Teachers may want to demonstrate a simple, one spool pulley system at the start of the stem challenge if the students have no experience with them.**

## What to do:

**Your challenge is to create a pulley system to lift the heaviest loads easily. You can use more than one or different sized wheels.**

### Items needed:

- String or flexible rope
- Flat, wide spacers to act as the wheel, such as thread spools, large straws, paper towel tubes, etc
- Cardboard
- Scissors
- Glue
- Cups
- Small objects such as marbles, metal washers, etc.to act as the load

1. Plan how to create a pulley system that fulfills the following criteria:
  - Include at least one wheel that a rope or string can be strung over
  - At one end of the rope/string will be a cup attached to it
  - A person should be able to pull one end of the string and easily lift the cup (on the other end of the string) that is filled with materials such as marbles without any of the items falling out.

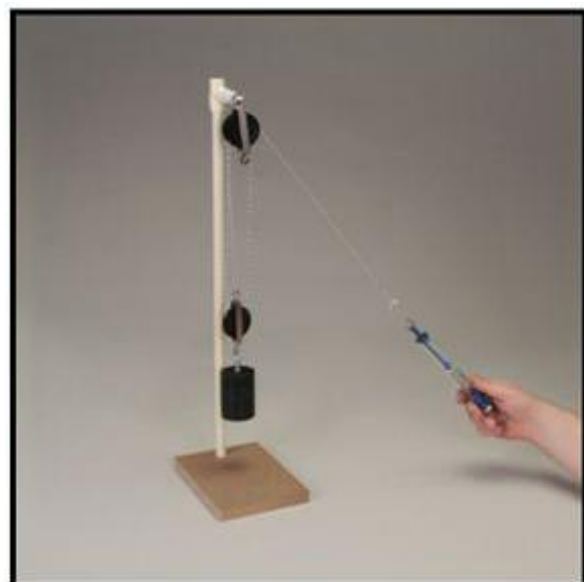
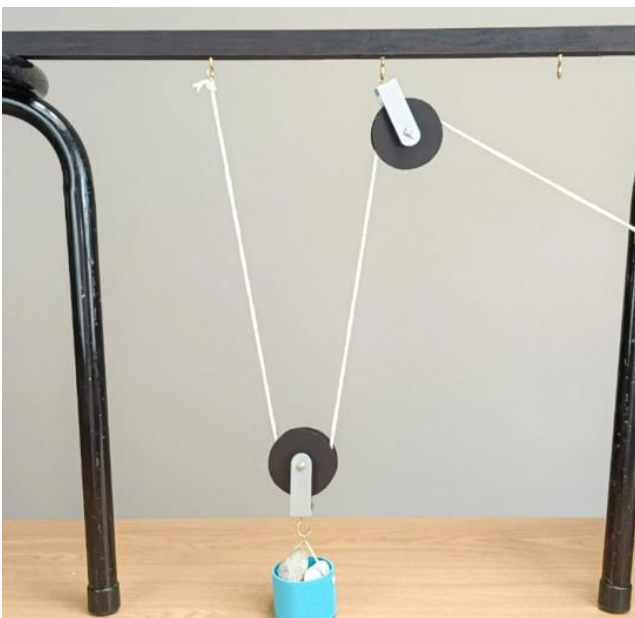


2. Keep in mind the following constraints while you design your system:
- The cup must be able to be raised 3 feet in the air without falling or dropping any objects.
  - All the wheels in the system must be able to be properly hung in the classroom allowing the cup to raise 3 feet.
  - Only items made available for this challenge can be utilized.
  - The system must be created and tested in the amount of time given.

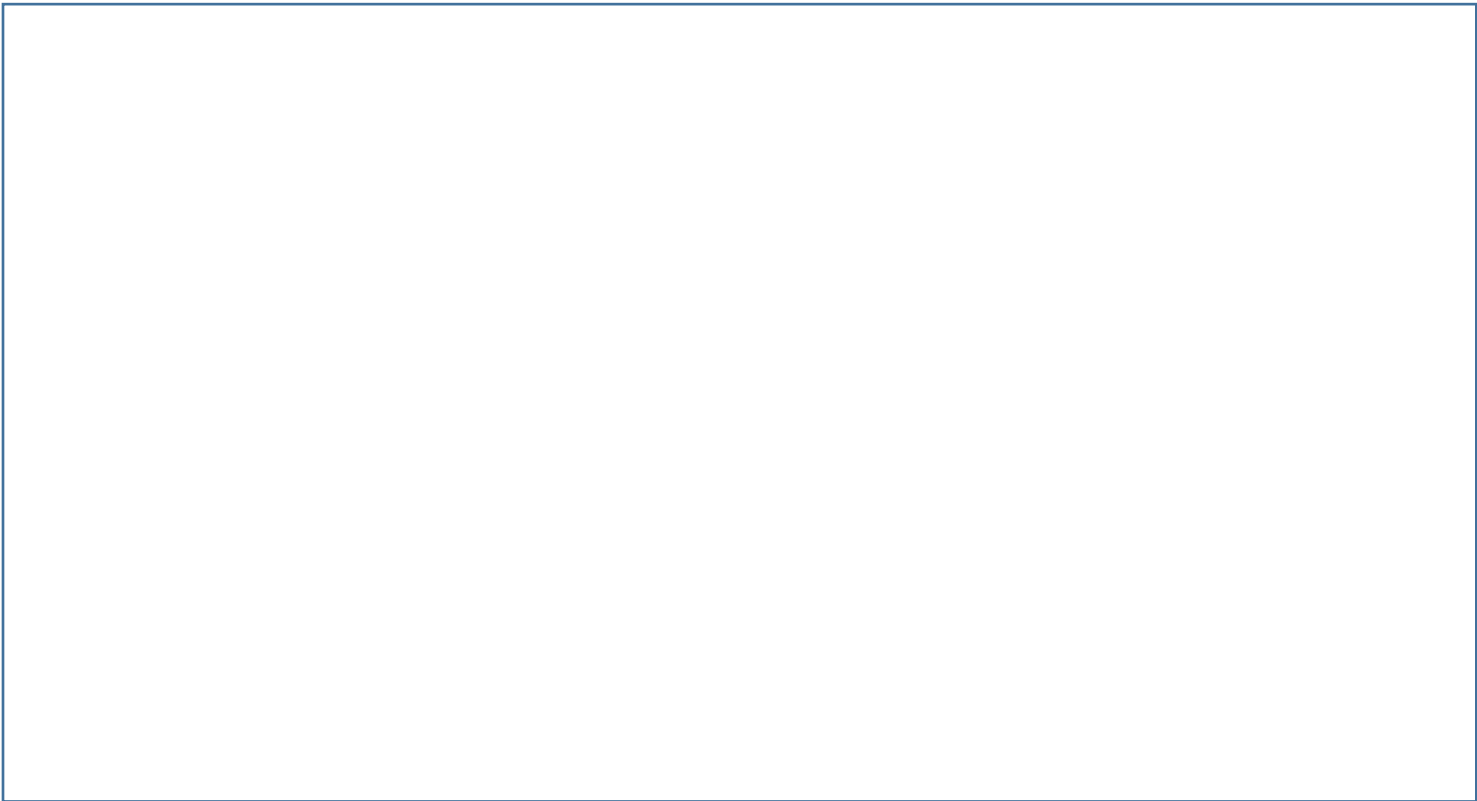
**\*Hint – think of creative ways to use the materials provided by your teacher, different sized wheels can lift different amounts. What happens when you use more or larger wheels?**

3. Record a diagram of your design in the space provided. Be sure to draw and label all the components including how & where the wheels will be hung in the classroom.
4. Create the prototype of your design using the materials provided, recording any changes made to the original design and quantity of materials used on your diagram.
5. Test your prototype given the criteria and constraints provided above. Record how many objects were lifted as well as an estimate of how much effort was needed to lift the objects with your pulley system. (easy, medium, difficult)
6. Revise your design, if needed, to ensure your system can lift the greatest loads.

Here are some examples:



Use this space to draw a diagram of the pulley system that you will create. Be sure to include how & where you will hang your pulley system and label where appropriate.



Record the item (load) quantity & combined weight (if possible) of the materials lifted by your pulley system.

| Trial # | Items in load | Quantity | Combined weight |
|---------|---------------|----------|-----------------|
|         |               |          |                 |
|         |               |          |                 |
|         |               |          |                 |

If you wanted to lift an object faster, what changes could you make?

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If you had to design a pulley system to lift a very heavy object a short distance, how would your design differ from one made for lifting a light object a long distance?

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What are some limitations to pulley systems and how could you address them in your design?

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How could you design a pulley system that is easy to assemble and disassemble?

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