



Curiosity Guide #402

Pulleys

Accompanies Curious Crew, Season 4, Episode 2 (#402)

Movable and Compound Pulleys

Investigation #5

Description

Learn how to make the work easier by creating and testing a compound pulley system.

Materials

- 2 step ladders, or you could use a wooden frame made of 2 by 4's
- One wooden board, 2 inches by 4 inches by 42 inches long
- 4 single-sheave pulleys
- Rope
- 3 screw eyes, $\frac{1}{2}$ -inch size
- 4 shackle bolts
- Drill
- Drill bit
- Pliers
- Bucket
- Bricks
- Spring scale

Procedure

1. Pre-drill three pilot holes in the 2 by 4 wooden board, 16 inches in from each end and one in the center.
2. Use the pliers to screw in the screw eyes.
3. Suspend the 2 by 4 board through the openings of one of the higher steps in the two step ladders or use the wooden frame.

4. The board should be level, with the screw eyes facing down, and are beyond the ladder steps.
5. Tie one end of the rope to the left screw eye.
6. Attach one shackle bolt to a pulley. Clip the handle of the bucket into the shackle bolt and set this assembly aside.
7. Attach another shackle bolt to another pulley and connect the pulley to the next screw eye. Don't connect the rope to this pulley yet.

Trial 1

1. Place the bricks in the bucket.
2. Ask a friend to lift the bucket. Is it heavy?

Trial 2

1. For this trial, the rope should be attached only to the left screw eye.
2. Loop the rope through the pulley with the bucket and lift the bucket by pulling on the rope. What do you notice?
3. Attach the spring scale to measure the force applied.

Trial 3

1. Now loop the rope through the second, hanging pulley.
2. Pull down. What do you notice now?
3. Continue using the spring scale to measure the force applied.

Trial 4

1. Add another fixed shackle-bolt pulley to the board.
2. Add another movable shackle-bolt pulley on the handle of the bucket.
3. Pull down. How does this change the action? What does the spring scale tell you about the force applied?

My Results

Explanation

When you used the one movable pulley to hoist the bucket, two ropes were supporting the load. The mechanical advantage is 2, so only half the force is necessary to lift the bucket. The spring scale will register about half of the weight of the bucket and bricks.

Looping the rope through the second fixed pulley creates a compound pulley system because the system combines both movable and fixed pulleys. This system still has a mechanical advantage of 2, but pulling down on the rope with gravity rather than pulling up against gravity makes the work easier.

Adding two more pulleys to the compound system means that four lines are now supporting the load, so the force needed to lift the load is one-fourth the weight of the bucket of bricks. The mechanical advantage is 4, but you must pull a lot more rope to hoist the bucket. There is a tradeoff of force for distance.

Extend your thinking: You may be surprised to discover that pulleys are all around us. When you open the window curtains or mini-blinds, you pull on a cord that goes around small pulleys. This action causes the curtains to move. The same is true for the big curtains at a stage play. The stage hands pull on large ropes attached to pulleys to open and close the curtains or to lower something onto the stage. The flag you see flying outside the school is hoisted with a pulley, and every time you ride in an elevator, you're moved by another pulley system.

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