WIND STUDY

Wind Study is intended for grades 5-8 and 8-11
Questions posted on: Monday Answers posted on: Friday
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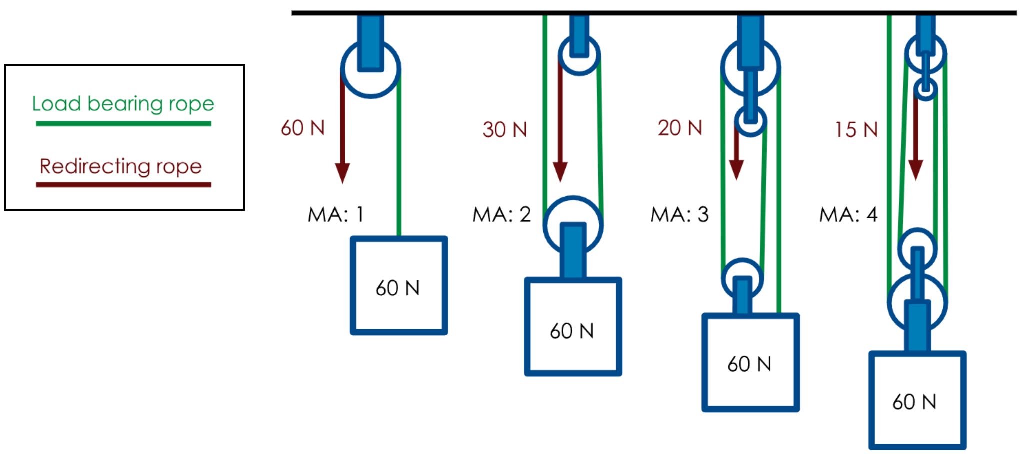
2024Q5

PULLEY RATIOS

Wind turbine components can weigh up to 100,000lbs (45,000kg). Because of this, the cranes that lift these parts need to be able to exert a huge amount of force, enough to lift turbine parts hundreds of feet off the ground! Today, let's explore how they achieve such feats through the clever use of pulley ratios and mechanical advantage.

Cranes employ multiple pulley systems known as Block and Tackle systems to amplify the lifting capacity using a given force. These systems create a *mechanical advantage* (MA) by multiplying the number of times a rope applies force on a block - note how the required balancing force goes down by the same factor as the MA. However, there's a tradeoff: achieving this increased lifting power requires pulling the rope over a longer distance.



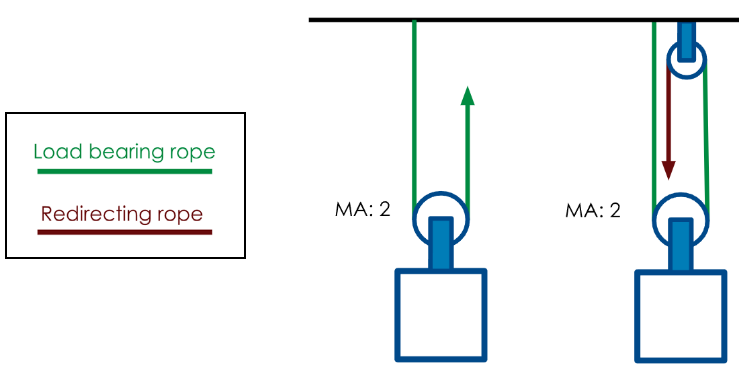
Two main equations will be needed to solve these problems: the equation of Newton's second law and the equation of mechanical advantage. When an object is being held up, a force must be applied to counteract gravity's effect on its mass. Note that in the metric system, acceleration, due to gravity (*a*), is equal to 9.81 meters per second squared.

$$Force = mass * acceleration$$

$$F_{Newtons} = m_{kilograms} * a_{meters/second^2}$$

$$* \qquad =$$

An important point to note is that a rope only adds to the MA if it is a load supporting rope. For example, in the diagram below, both pulleys have the same MA even though there aren't the same number of rope sections, since one section doesn't directly support the load.



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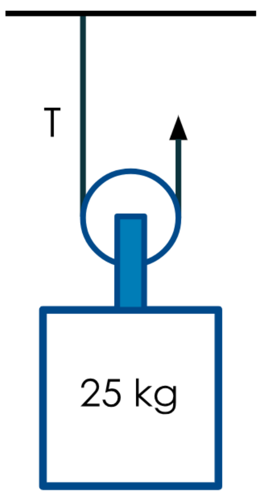
PULLEY RATIOS

Level 1: The block in the diagram below has a mass of 25 kg and is suspended by a rope with one end anchored to the ceiling and the other end being pulled by some force. If the rope is being pulled in the direction of the arrow, do you think there's a mechanical advantage here? If so, what is the mechanical advantage? How much force must be used to pull on the rope's end to keep the block suspended? (Note: $g = 9.81\ m/s^2$.) Assume the pulley is massless and frictionless.



Level 2: In the diagram below, the mass of the block is 70 kg, and there is a pulling force on the rope in the direction of the arrow. What is the mechanical advantage of the pulley system? Is the MA here the same number as the total number of rope sections. Why or why not? Lastly, with the MA in mind, how much force is required to hold the block in the air? Assume the pulleys are massless and frictionless.