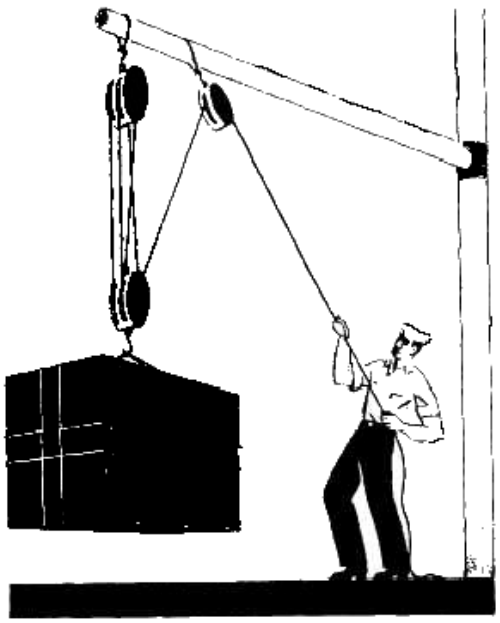
PULLEY POWER



A block and tackle is a system of two or more pulleys with a rope or cable threaded between them, usually used to lift or pull heavy loads. Although used in many situations, they are especially common on boats and sailing ships, where motorised aids are usually not available and the task must be performed manually.

A block is a set of pulleys or "sheaves" all mounted on a single axle. When rope or line is run through a block or a series of blocks the whole assembly is called a Tackle. The most common arrangement of block and tackle is to have a block attached to a fixed position (the fixed or standing block), and another block left to move with the load being pulled or lifted (the moving block).

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Goal:

Achieve the large mechanical advantage possible with your home built block and tackle; your set-up must lift a test mass (max. 100 kg) at least 1 cm with no more than a 50 N (5 kg $\times$ *gravity*) force.

Scoring:

Most Powerful **10** points maximum

Final score will be based on the greatest demonstrated mechanical (see equation below) advantage of your block and tackle. **10** points will be awarded for greatest demonstrated mechanical advantage and other designs are scored in comparison to that design, as a percentage.

Most Elegant **10** points maximum

Final score will be based upon the ratio of the largest demonstrated mechanical advantage to the mass of your black and tackle. **10** points will be awarded for the largest ratio and other designs are scored in comparison to that design, as a percentage.

$$mechanical\ advantage = \frac{mass\ lifted \times 9.81 m/s^2}{force\ necessary\ to\ lift\ test\ mass}$$

Rules:

The widget may be of any design or inspiration but must have the following basic capabilities (limitations):

- You must make the block and tackle yourself, you may use purchased pulleys.
- Your block and tackle must fit into a space not larger than 50 cm wide × 50 cm deep × 100 cm tall. This includes any apparatus necessary to mount the block and tackle to the testing frame and attach the test mass; please note that for implementation the parts may be spaced apart (this is not included in the size restriction). In other words, think of this requirement as the packing space available to you for your set-up.
- The mass of your block and tackle must not exceed 10 kg, including the rope or cable.
- The framing of the testing apparatus will be equipped with five large eye bolts to attach your block and tackle to, these are centered over the test mass. There are also two other eye bolts, external to the frame, from which to attach any parts to direct the line from the block and tackle to the test force (please refer to the schematic at the rear of this document).
- You should include at least 2 m of extra rope/cable to attach the test mass, and we reccommend a further 3 m to attach the counter weight apart from the length of rope/cable necessary to thread your block and tackle
- We will provide the 100 kg test mass and the 50 N (5 kg$\times 10\frac{m}{s^2}$). you will be able to adjust the test mass in increments of 1 kg and the test force in increments of 2.5 N.
- The dimensions, mounting and load attachment of each team's block and tackle will be checked prior to the assigned testing time slot. Any necessary modifications necessary must be made before the assigned time slot.

Testing:

- Each team will have approximately 6 minutes to test their block and tackle; you will be informed of the exact duration of the allotted time the day of the competition
- The block and tackle will be loaded with the help of one of the JPEC volunteers and attached to a 100 kg test mass with 10 N of force applied (one 1 kg mass)
- The maximum size of the test mass will 100 kg and the maximum test force applied will be 50 N
- One team member will add further masses (up to 4kg more) until the test mass moves the required 1 cm.
- Each extra mass (maximum increment 1 kg) may be dropped into the counter weight basket from a height not greater than 10 cm in the counter weight basket.

- If the test mass does not move the required 1 cm when 50 N is applied, the size of the test mass can be lowered (in multiples of 1 kg) by other members of the team and the above procedure repeated. The test force will remain at 50 N for the remainder of the test, but each team may lift the entire test force about 1.0 cm and then drop it to start the test.

  Mass can removed from the test weight until a successful lift of the test mass is demonstrated and/or time allotted is used up. Mass will not be replaced into the test weight!

Recommendations

- As a demonstration of the power of pulleys, thread together two broom handles and measure the necessary force to overcome two people attempting pull the broom handles apart. how would you improve on this simple design for your block and tackle
- Test your block and tackle prior to the day of the competition; if you have some idea of the achievable mechanical advantage of your block and tackle you will be able to more quickly test your apparatus. This can most easily be accomplished by simply dragging various masses across the floor - don't forget about friction!.
- Simply threading your pull line through the eye bolts will add significant friction to your system

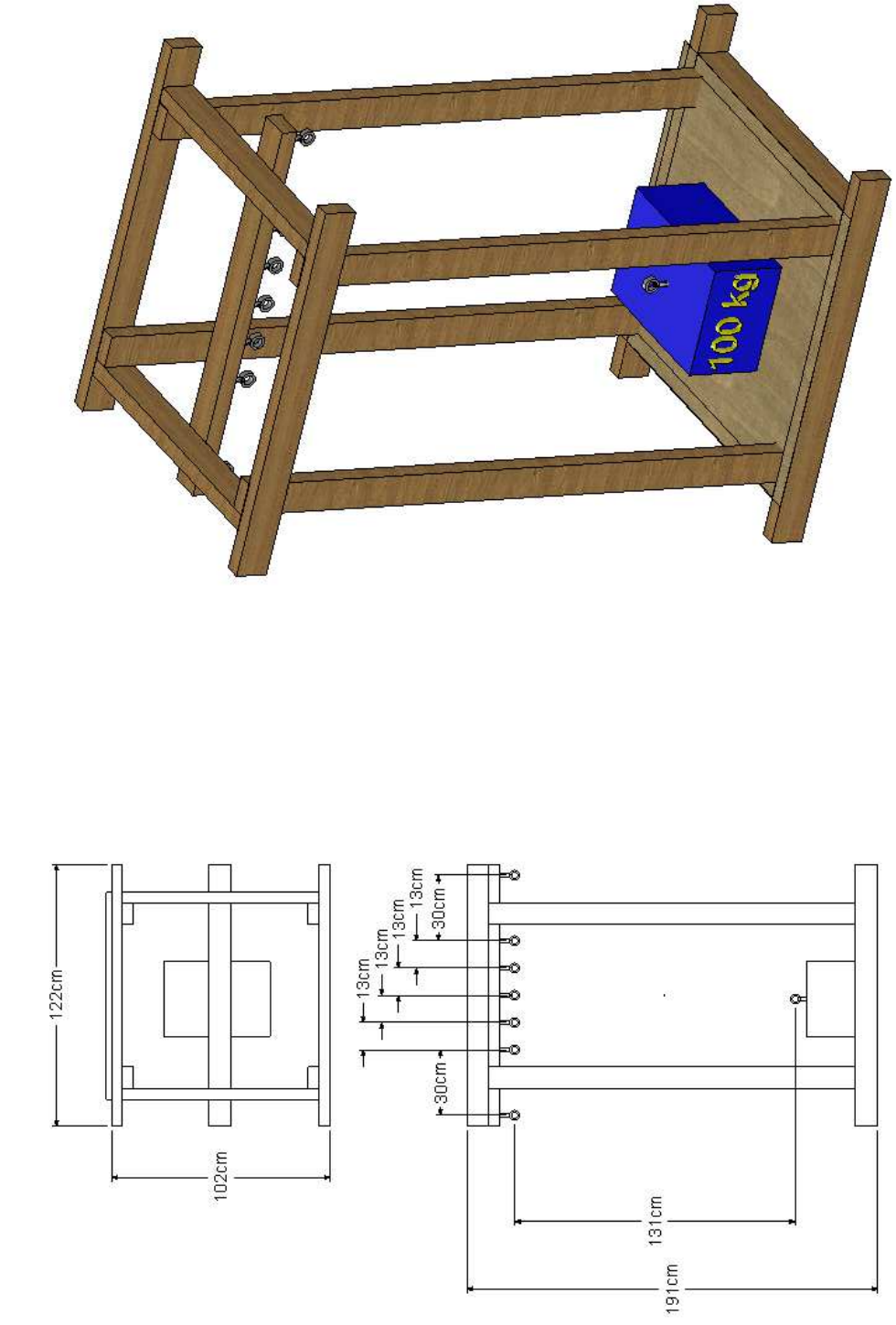

Figure 1: JPEC 2009 block and tackle testing frame