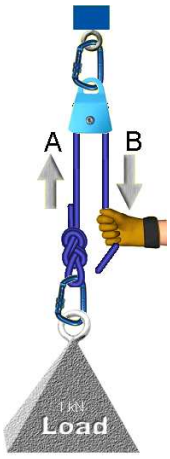
The School For
Mountain Leadership

HIGH ANGLE RESCUE TRAINING HANDOUT
No 4 : THE T-METHOD

NEED MORE INFO?
SML
P. O. Box 2094
Wingate Park
0153

Tel: 082-652-1490
Fax: 0866-79-0777
Email: info@sml.co.za
Web: http://www.sml.co.za/

When using pulley systems (mechanical advantage systems) it is possible to calculate the ideal-world (zero friction) output of the system using a methodical approach. One of these approaches applies the concept of balancing of tension (or 'T') in the system.

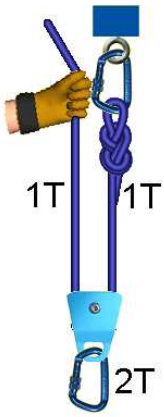


There is one primary principle that needs to be understood in order to implement this method:

- Newton's Third Law states that for every action there is an equal and opposite reaction.

In an ideal (frictionless) world a pulley allows a rope to change direction without loss of effectiveness. Applying Newton's Third Law, this means that whatever force (Tension) is applied on the rope going into a pulley will be the same coming out of the pulley. In the illustration on the right this means that the force (Tension) at A is the same as the force (Tension) at B. In order to lift a 1kN load we need to apply 1kN of force.

Next, looking at the illustration on the left we see that the load is supported by two anchors: (1) the physical anchor with the rope tied to it and (2) the hand. This means that each anchor is supporting half the load. If the hand exerts a force of 1T then the anchor point is also exerting a force of 1T , so the load must weigh 1T + 1T = 2T. This shows that the pulley effectively adds the tension of each rope together (1T + 1T = 2T). We can apply this principle to analyse any mechanical advantage system to determine the **I**deal **M**echanical **A**dvantage (IMA) of the system. IMA implies no losses caused by friction.



To do this we start at the point where a hand would grasp the rope. The hand applies tension (1T) to the rope. We then move through the system, calculating the tension input and output at each pulley. We can then calculate the ratio of resulting tension that we would get for the 1T of input we get at the hand. Looking at our system on the left again and applying the T-method we get:

- 1T at the hand
- 1T on the other side of the pulley

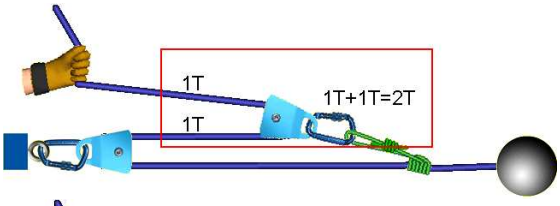
=

- 2T at the pulley

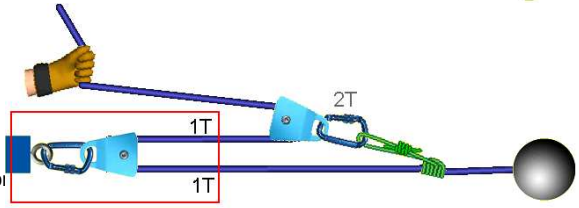
Since this is the whole system we can say that we get a 2T result for the 1T of input we give, which makes it a 2T:1T ratio, or a 2:1 system.

We can use this method to analyse the components of a more complicated system:

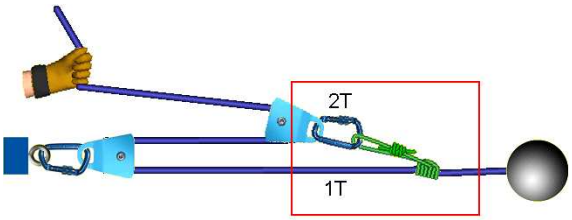
Step 1: Start at the hand and work out what the first pulley does. We see that our first pulley has an input of 1T and an output of 1T, giving a resulting tension of 2T.



Step 2: Proceed through the next pulley. We see that this has an input tension of 1T and therefore an output tension of 1T. This means that 2T goes to the anchor.

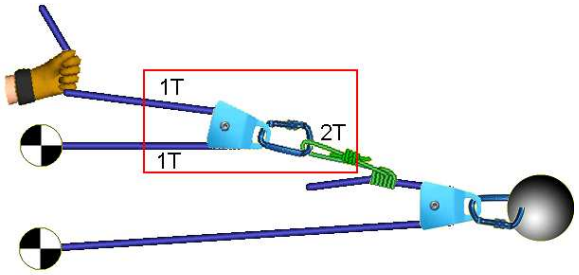


Step 3: Look at where a pulley connects to a rope. Add the tensions together at that point. In this case we have the 2T applied to the green Prussik added to the 1T that came through the rope. Adding this up we get 2T + 1T = 3T applied to the load. We therefore have a resulting 3T from a 1T input, or a 3:1 system.



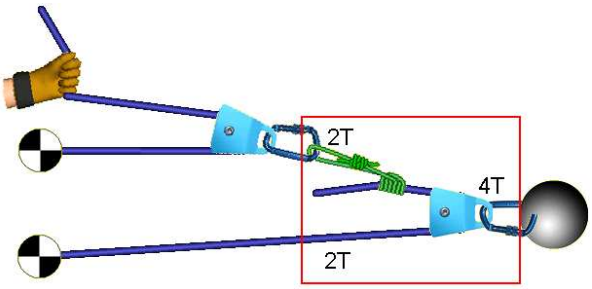
The same principle applies to ***complex pulley systems***:

Step 1: Start at the hand and give a tension of 1T. Work out what the first pulley does. We see that the first pulley gives a resulting tension of 2T.

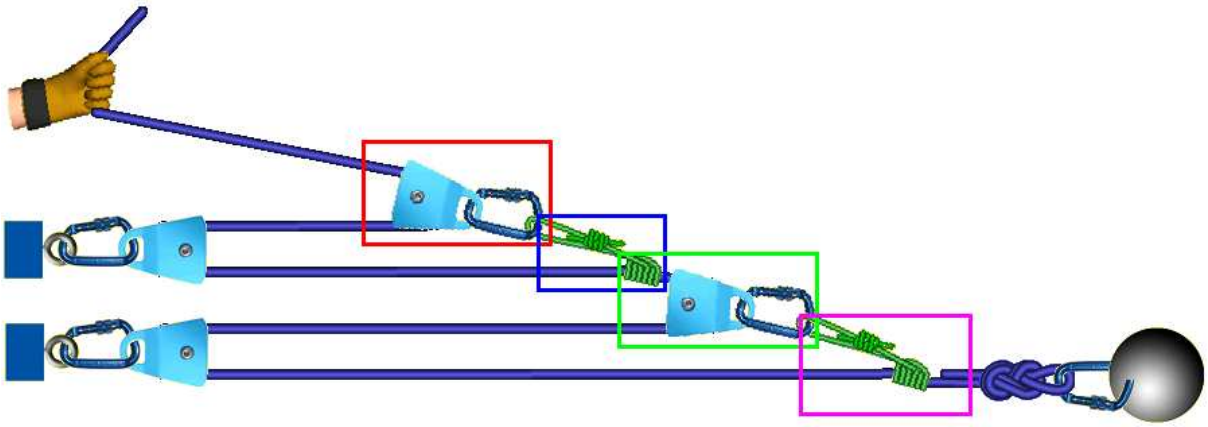


Step 2: Follow the system. We now take the resulting 2T from the first pulley and use it as input into the second pulley. Since we know that the output of a pulley is always the same as the input, it follows that this second pulley has an output of 2T. Adding these up give us a result of 2T + 2T = 4T at the load.

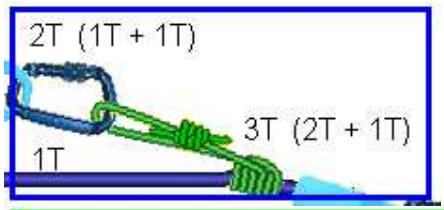
We have therefore obtained a result of 4T from an input of 1T, giving a 4:1 system.



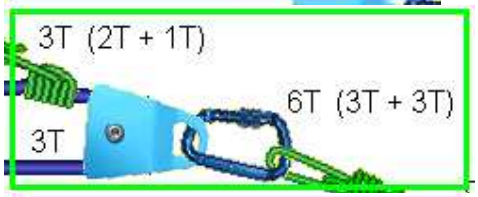
Let's have a look at something more complex, broken down step by step:



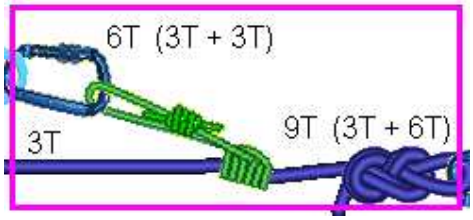
Starting off at the hand we have a 1T input. Going through the first pulley we have 1T in and 1T out giving a result of 2T at the Prussik.



Where the Prussik connects to the rope we have 2T from the Prussik plus 1T still on the rope. This gives us a result of 3T.

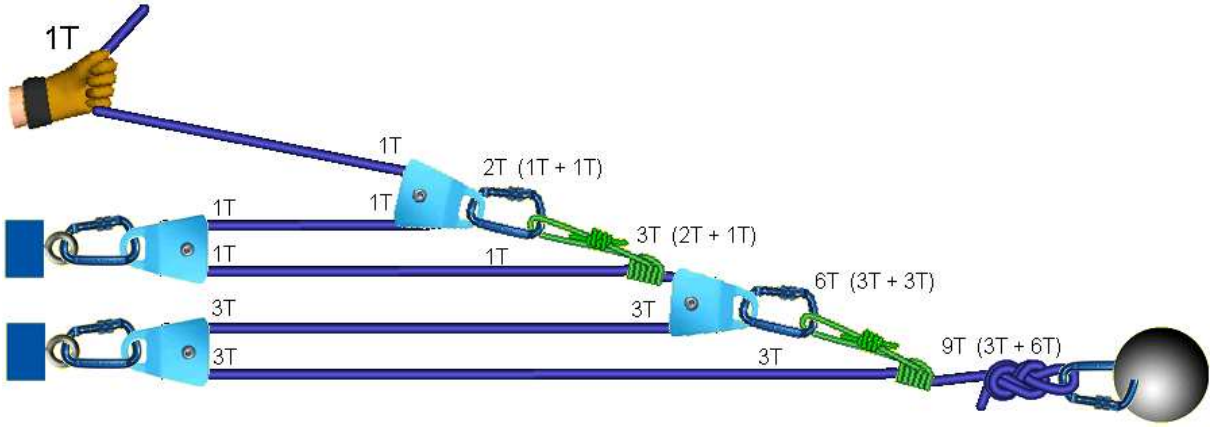


Since we have 3T where the last prussic attaches to the rope it means we now have 3T in and 3T out of the pulley, giving the pulley a result of 6T. It also means that our main rope going back to the anchor from the pulley carries 3T.



If we now look at our last Prussik connection we will have the 6T from the Prussik plus 3T from the rope, giving us 9T pulling on the load.

Looking at the bigger picture we get:



Since we have a final result of 9T for an input of 1T at the hand we can say that the ratio of effort to result is 9T to 1T or 9:1.

This logical approach makes it a lot easier to work out the IMA of any system we might need to analyse.

Please contact us at the above addresses for further information.
