Blocks and Tackles

A block consists of one or more pulleys or sheaves fitted in a wood or metal frame. It is constructed for use with either fibre rope or wire rope. Wire rope blocks are heavier, with larger sheaves and deeper grooves than fibre rope blocks, to prevent the sharp bending of wire rope. Two blocks reeved together to gain lifting power are called Tackle or Purchase. The two types of tackle systems are simple and compound. The simple system uses only a single line, the compound, more than one line.

The power gained by tackle is also known as **Mechanical Advantage**, referred as the relationship between load being lifted and power required to lift it. The mechanical advantage can be determined by counting the number of ropes led out from a moving block, including the hauling rope. As seen in the figures below, the Two-Fold Purchase is used two ways, one with the hauling rope led out from standing block, when the mechanical advantage is 4, the other with the hauling rope led out from the moving block, when the mechanical advantage is 5. The first case is known as **rove disadvantage**, where the pull on the rope is away from the direction in which the load is moved. The second case is known as **rove advantage**, where the pull on the rope is towards the direction in which the load is moved. The amount of power required to lift the load can be determined by dividing the weight of the load by the mechanical advantage. For example, to lift a 600 kg load by using the Luff Tackle roving disadvantage, the mechanical advantage is 3; disregarding friction, then 200 kg power is required to lift a 600 kg load. If the Luff Tackle has rove advantage, the mechanical advantage is now 4; disregarding friction, then 150 kg power is required to lift a 600 kg load.
If the friction, which is caused by rubbing between the lines and the sheaves, is taken into consideration, roughly 10% is allowed for each sheave. For a load of 600 kg, each sheave will create a friction force of 60 kg; the Luff Tackle consists of 3 sheaves, so the total friction force is 180 kg, and in this case of rove disadvantage, at least 380 kg is required. Using Luff Tackle with rove advantage and 10% allowance, 330 kg is required for the job.

Reeve Blocks

There is more than one method of reeving the blocks, but the “right angle method” is preferred. With the right-angle method, the blocks are laid in such a way that the sheaves are at right angles to each other; this will reduce the chances of chafing of the rope or turning of the blocks. The main procedure for reeving the blocks follows:

1. Place blocks with the sheaves at right angles to each other, with becket bends pointing toward each other;

2. Lead the standing part of the falls through one sheave of the block that has the greatest number of sheaves. If both blocks have the same number of sheaves, then start with the one fitted with a becket. The rope should start with the sheave near the centre of the block;
3. Pass the standing part of the falls around the sheaves from one block to another; make sure no line crosses another until complete with all sheaves;

4. Secure the end of the standing part at the becket; usually, the block with the fewer number of sheaves will help to keep the strain at the centre of the block.

**Single Whip**  
The Single Whip consists of a single fixed block with a rope passing over the sheave. It has a mechanical advantage of 1, so this rigging has no power gain.

**Double Whip**  
The Double Whip consists of two single blocks with the upper block fixed (standing block); the lower is a moveable block. A standing part of the fall is made fast near the upper block. It has a power gain of 2.

**Runner**  
The Runner also consists of a single sheave moving block with the weight attached to the block supported by the rope, with one end secured to the fixed support and the other end as the hauling part. The mechanical advantage is 2.

**Gun Tackle**  
The Gun Tackle consists of two single-sheave blocks; depending how it is rigged, the mechanical advantage is either 2 if rove to disadvantage, or 3 if rove to advantage.
**Luff Tackle**  
The Luff Tackle consists of a double- and a single-sheave block, with the standing part made fast to the single block. Luff Tackle is known as a Jigger when it is a smaller size, such as from 2 to 2.5 inches. The mechanical advantage is 3 if rove to disadvantage, or 4 if rove to advantage.

**Two-fold Purchase**  
The Two-fold Purchase is made up of two double-sheave blocks. The mechanical advantage is 4, if rove to disadvantage, or 5 if rove to advantage.

**Gyn Tackle**  
This consists of a triple- and a double-sheave block with mechanical advantage of 5 or 6, depending how it is rigged. This type of tackle can be rove in two ways, with the blocks either at right angles or parallel to each other. The advantage of the right angle method is to reduce chafing of the ropes on each other.

**Three-fold Purchase**  
The Three-fold Purchase consists of two triple-sheave blocks. It is used for heavy lifting, with a power gain of 6 or 7 depending whether it is rigged to disadvantage or advantage. Similarly to the Gyn tackle, it also has two ways of reeving the purchase: blocks at right angles, or parallel to each other.
Mechanical Advantage Summary

<table>
<thead>
<tr>
<th></th>
<th>P (Disadvantage)</th>
<th>P (Advantage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gun Tackle</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Luff Tackle</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Two-fold Purchase</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Gyn Tackle</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Three-fold Purchase</td>
<td>6</td>
<td>7</td>
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</tbody>
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When two tackles are used, as for example one tackle pulling the hauling of another, then the approximate power gain will be the product of both purchases.

Example: Three-fold purchase is rove to disadvantage (6) to lift a weight, and gun tackle is rove to advantage (3) to pull on the hauling part of the three-fold purchase. The approximate total power gain is:

\[
\text{Total Power Gain} = 6 \times 3 = 18
\]
Stress on Hauling Part

The approximate stress on the hauling part can be calculated as follows:

\[
S \quad : \text{Stress on hauling part} \\
W \quad : \text{Weight} \\
\Sigma W \quad : \text{Total weight} \\
F \quad : \text{Friction} \\
\Sigma F \quad : \text{Total friction} \\
P \quad : \text{Mechanical Advantage} \\
n \quad : \text{Number of sheaves}
\]

Friction allowance for each sheave is 10% of the weight

\[
F = \frac{W}{10} \quad \therefore \Sigma F = n \times F = n \left( \frac{W}{10} \right) = \frac{nW}{10}
\]

\[
\therefore \Sigma W = W + \Sigma F = W + \frac{nW}{10} = \frac{10W + nW}{10} = \frac{W(10 + n)}{10}
\]

\[
S = \frac{\Sigma W}{P} = \frac{\frac{W(10 + n)}{10}}{P} = \frac{W(10 + n)}{10P}
\]

Example 1

A weight of 10 tonnes is lifted by Gyn tackle, roved disadvantage and advantage. Find the stress on the hauling part for both methods of rigging:

Disadvantage method:

\[
S = \frac{W(10 + n)}{10P} = \frac{10(10 + 5)}{10 \times 5} = 3 \text{ tonnes}
\]

Advantage method:

\[
S = \frac{10(10 + 5)}{10 \times 6} = 2.5 \text{ tonnes}
\]
Example 2  What is the smallest purchase rove disadvantage that could be used to lift 8 tonnes with a wire rope having SWL 3.5 tonnes?

\[ S = \frac{W(10 + n)}{10P} \]

and by using disadvantage, therefore \( P = n \)

\[ \therefore S = \frac{W(10 + P)}{10P} \]

\[ \Rightarrow 10PS = W(10 + P) = 10W + WP \]
\[ \Rightarrow 10PS − WP = 10W \]
\[ \Rightarrow P(10S − W) = 10W \]
\[ \therefore P = \frac{10W}{10S − W} = \frac{10 \times 8}{10 \times 3.5 − 8} = 2.96 \therefore P = 3 \]

A Luff Tackle will do the job.