Pulley Block: Mechanical Advantage, Velocity Ratio and Efficiency

Mechanical advantage, velocity ratio and efficiency of a pulley block or tackle from the load, effort and number of supporting rope falls, with the effort needed.

Method: Textbook mechanics (machines: MA = η VR; tackle efficiency (1 − η^n)/(n(1 − η)) with sheave efficiency η)

Input parameters

Unit system: SI

Parameter	Value	Unit
Load	10.000	kN
Rope falls supporting the load (velocity ratio)	4.0000	
Efficiency per sheave	96.000	%
Hauling line	Pulled straight off the last moving sheave	

Calculated results

Parameter	Value	Unit
Efficiency of the block	94.158	%
Mechanical advantage η n	3.7663	
Effort W/MA	2.6551	kN
Ideal effort W/n	2.5000	kN

Notes for this case

- The hauling line is taken straight off the last sheave of the falls; if it passes over a further (lead) sheave choose that option, which divides the efficiency by one more η_s.
- Each sheave passes on η_s of the rope tension; the block efficiency is the average over the falls.

Formula and method

$$VR = n, \quad \eta = \frac{1-\eta_s^n}{n(1-\eta_s)} \ (\times \eta_s \text{ with a lead sheave}), \quad MA = \eta VR, \quad P = \frac{W}{MA}$$

Variables

W	Load	N
n	Rope falls supporting the load (velocity ratio)	-
η_s	Efficiency per sheave	-
lead	Hauling line (straight off, or over a lead sheave)	-
η	Efficiency of the block	-
MA	Mechanical advantage η n	-
P	Effort W/MA	N
P_i	Ideal effort W/n	N

Method and standards

Machine relations with sheave friction.

Assumptions and limits

- Equal sheave efficiency.
- The falls carry P, P η_s, …, P η_s^(n−1). With the hauling line pulled straight off the last sheave a single fixed pulley shows 100 %; choose the lead-sheave option when the line passes over a further sheave.

References

- Textbook mechanics (machines: MA = η VR; tackle efficiency $(1 - \eta^n)/(n(1 - \eta))$ with sheave efficiency η)

Report details

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Release checks	4 reference cases of this calculator, computed independently, are checked on every release

Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

This calculator online

https://calc.firecad.com/mechanical/statics-dynamics/pulley-block-efficiency

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Reopens the calculator with the inputs of this report.