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# Lifting Machines Formulas

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# List of 33 Lifting Machines Formulas

## Lifting Machines

## Machine Design Characteristics

### 1) Efficiency of Machine given Mechanical Advantage and Velocity Ratio



$$fx \quad \eta = \frac{M_a}{V_i}$$

[Open Calculator !\[\]\(3211b5d1d968fc1665909b34f9f16010\_img.jpg\)](#)

$$ex \quad 0.833333 = \frac{5}{6}$$

### 2) Effort Required by Machine to Overcome Resistance to Get Work Done



$$fx \quad P = \frac{W}{M_a}$$

[Open Calculator !\[\]\(e3275251d0893157c3584e20c81dc3ba\_img.jpg\)](#)

$$ex \quad 200N = \frac{1000N}{5}$$



### 3) Frictional Effort Lost

$$fx \quad F_e = P - \frac{W}{V_i}$$

[Open Calculator !\[\]\(cbe80b694ebd74fcfe136a095b608235\_img.jpg\)](#)

$$ex \quad 33.33333N = 200N - \frac{1000N}{6}$$

### 4) Ideal Effort given Load and Velocity Ratio

$$fx \quad P_o = \frac{W}{V_i}$$

[Open Calculator !\[\]\(3e2231b1ad3ca8da8658228c00dd08e0\_img.jpg\)](#)

$$ex \quad 166.6667N = \frac{1000N}{6}$$

### 5) Ideal Load given Velocity Ratio and Effort

$$fx \quad W_i = V_i \cdot P$$

[Open Calculator !\[\]\(0d5ec72f61334709c3fc9450209b754f\_img.jpg\)](#)

$$ex \quad 1200N = 6 \cdot 200N$$

### 6) Load Lifted given Effort and Mechanical Advantage

$$fx \quad W = M_a \cdot P$$

[Open Calculator !\[\]\(b64b40baaee5acddc1eab8538ba84754\_img.jpg\)](#)

$$ex \quad 1000N = 5 \cdot 200N$$



## 7) Mechanical Advantage given Load and Effort

$$\text{fx } M_a = \frac{W}{P}$$

[Open Calculator !\[\]\(e78f798d4ea5c530c9db49e7d26e6b95\_img.jpg\)](#)

$$\text{ex } 5 = \frac{1000\text{N}}{200\text{N}}$$

## 8) Useful Work Output of Machine

$$\text{fx } W_1 = W \cdot D_1$$

[Open Calculator !\[\]\(05be7c7a8995decd503647c99211f7c2\_img.jpg\)](#)

$$\text{ex } 3750\text{J} = 1000\text{N} \cdot 3.75\text{m}$$

## 9) Velocity Ratio given Distance Moved due to Effort and Distance Moved due to Load

$$\text{fx } V_i = \frac{D_e}{D_l}$$

[Open Calculator !\[\]\(fe3aebe81acea8d45108cd2768939da7\_img.jpg\)](#)

$$\text{ex } 6.4 = \frac{24\text{m}}{3.75\text{m}}$$

## 10) Work Done by Effort

$$\text{fx } W_1 = W \cdot D_1$$

[Open Calculator !\[\]\(899d8b7697d64725bf017d3296cfcf1b\_img.jpg\)](#)

$$\text{ex } 3750\text{J} = 1000\text{N} \cdot 3.75\text{m}$$



## Pulley Block

### 11) Efficiency of Geared Pulley Block

$$\text{fx } \eta = \frac{M_a}{V_i}$$

[Open Calculator !\[\]\(74d4806277d7e73349d8e8c0897931e9\_img.jpg\)](#)

$$\text{ex } 0.833333 = \frac{5}{6}$$

### 12) Efficiency of Weston's Differential Pulley Block

$$\text{fx } \eta = \frac{M_a}{V_i}$$

[Open Calculator !\[\]\(8bba887393ca45b761e5cb49e755e762\_img.jpg\)](#)

$$\text{ex } 0.833333 = \frac{5}{6}$$

### 13) Efficiency of Worm Geared Pulley Block

$$\text{fx } \eta = \frac{M_a}{V_i}$$

[Open Calculator !\[\]\(0fb13ad0bfa3d86868cdd3883e5665b3\_img.jpg\)](#)

$$\text{ex } 0.833333 = \frac{5}{6}$$

### 14) Net Shortening of Chain in Weston's Differential Pulley Block

$$\text{fx } L_c = \pi \cdot (d_l - d_s)$$

[Open Calculator !\[\]\(e50091943b385fe16d3277389202856f\_img.jpg\)](#)

$$\text{ex } 0.062832\text{m} = \pi \cdot (0.06\text{m} - .04\text{m})$$




15) Net Shortening of String in Worm Gear Pulley Block 

$$\text{fx } L_s = \frac{2 \cdot \pi \cdot R}{T_w}$$

[Open Calculator !\[\]\(d3fb9f94af8b26d1c844efa9a98805b0\_img.jpg\)](#)

$$\text{ex } 0.274889\text{m} = \frac{2 \cdot \pi \cdot 1.4\text{m}}{32}$$

16) Velocity Ratio in Weston's Differential Pulley Block 

$$\text{fx } V_i = \frac{2 \cdot d_1}{d_1 - d_s}$$

[Open Calculator !\[\]\(e1d6102fe77919492c04879c8450f1f5\_img.jpg\)](#)


$$\text{ex } 6 = \frac{2 \cdot 0.06\text{m}}{0.06\text{m} - .04\text{m}}$$

17) Velocity Ratio in Weston's Differential Pulley given Number of Teeth 

$$\text{fx } V_i = 2 \cdot \frac{T_1}{T_1 - T_2}$$

[Open Calculator !\[\]\(ab4e2b3fc7e7887b7a72f548aa6f5e60\_img.jpg\)](#)

$$\text{ex } 6.133333 = 2 \cdot \frac{46}{46 - 31}$$

18) Velocity Ratio in Weston's Differential Pulley given Radius of Pulleys 

$$\text{fx } V_i = 2 \cdot \frac{r_1}{r_1 - r_2}$$

[Open Calculator !\[\]\(5abce1a84a655b073239ab33e1199487\_img.jpg\)](#)

$$\text{ex } 6.545455 = 2 \cdot \frac{9\text{m}}{9\text{m} - 6.25\text{m}}$$



## 19) Velocity Ratio of Worm Geared Pulley Block

$$\text{fx } V_i = \frac{d_w \cdot T_w}{R}$$

[Open Calculator !\[\]\(9dfdaff1d86ba3c1f8353b4d1b61b8c5\_img.jpg\)](#)

$$\text{ex } 6.857143 = \frac{0.3\text{m} \cdot 32}{1.4\text{m}}$$

## Screw Jack

### 20) Efficiency of Differential Screw Jack

$$\text{fx } \eta = \frac{M_a}{V_i}$$

[Open Calculator !\[\]\(3cb60d42b10e53f9522bb0b392c1c4cd\_img.jpg\)](#)

$$\text{ex } 0.833333 = \frac{5}{6}$$

### 21) Efficiency of Screw Jack

$$\text{fx } \eta = \frac{\tan(\psi)}{\tan(\psi + \theta)} \cdot 100$$

[Open Calculator !\[\]\(0d7ca0919e6c47bbd874bfa0189fe22e\_img.jpg\)](#)

$$\text{ex } 0.839817 = \frac{\tan(12.9^\circ)}{\tan(12.9^\circ + 75^\circ)} \cdot 100$$



## 22) Efficiency of Worm Geared Screw Jack

$$\text{fx } \eta = \frac{M_a}{V_i}$$

[Open Calculator !\[\]\(6605b201d6f14d9b3bcb8ab5f274d107\_img.jpg\)](#)

$$\text{ex } 0.833333 = \frac{5}{6}$$

## 23) Torque Required while Load is Ascending in Screw Jack

$$\text{fx } T_{\text{asc}} = \frac{d_m}{2} \cdot W \cdot \tan(\theta + \Phi)$$

[Open Calculator !\[\]\(e8fb589d58dad1692debababa5e928b6\_img.jpg\)](#)

$$\text{ex } 2748.452\text{N}\cdot\text{m} = \frac{0.24\text{m}}{2} \cdot 1000\text{N} \cdot \tan(75^\circ + 12.5^\circ)$$

## 24) Torque Required while Load is Descending in Screw Jack

$$\text{fx } T_{\text{des}} = \frac{d_m}{2} \cdot W \cdot \tan(\theta - \Phi)$$

[Open Calculator !\[\]\(4688aadfd656ded00cd6bdfae55089a9\_img.jpg\)](#)

$$\text{ex } 230.5179\text{N}\cdot\text{m} = \frac{0.24\text{m}}{2} \cdot 1000\text{N} \cdot \tan(75^\circ - 12.5^\circ)$$

## 25) Velocity Ratio of Differential Screw Jack

$$\text{fx } V_i = \frac{2 \cdot \pi \cdot l}{p_a - p_b}$$

[Open Calculator !\[\]\(4146d17f71dced09c6ad789cacceaa6d\_img.jpg\)](#)

$$\text{ex } 6.283185 = \frac{2 \cdot \pi \cdot 12\text{m}}{34\text{m} - 22\text{m}}$$





26) Velocity Ratio of Simple Screw Jack 

$$\text{fx } V_i = \frac{2 \cdot \pi \cdot l}{P_s}$$

Open Calculator 


$$\text{ex } 5.385587 = \frac{2 \cdot \pi \cdot 12\text{m}}{14\text{m}}$$

27) Velocity Ratio of Worm Geared Screw Jack 

$$\text{fx } V_i = \frac{2 \cdot \pi \cdot R_w \cdot T_s}{P_s}$$

Open Calculator 

$$\text{ex } 6.485145 = \frac{2 \cdot \pi \cdot 0.85\text{m} \cdot 17}{14\text{m}}$$

28) Velocity Ratio of Worm Geared Screw Jack with Double Threaded 

$$\text{fx } V_i = \frac{2 \cdot \pi \cdot R_w \cdot T_w}{2 \cdot P_s}$$

Open Calculator 

$$\text{ex } 6.103666 = \frac{2 \cdot \pi \cdot 0.85\text{m} \cdot 32}{2 \cdot 14\text{m}}$$

29) Velocity Ratio of Worm Geared Screw Jack with Multiple Threads 

$$\text{fx } V_i = \frac{2 \cdot \pi \cdot R_w \cdot T_w}{n \cdot P_s}$$

Open Calculator 

$$\text{ex } 6.103666 = \frac{2 \cdot \pi \cdot 0.85\text{m} \cdot 32}{2 \cdot 14\text{m}}$$



## Worm Wheel

### 30) Efficiency of Worm and Worm Wheel

$$\text{fx } \eta = \frac{M_a}{V_i}$$

[Open Calculator !\[\]\(339a16584d5da0f0a3ca4e9ec17bf6a1\_img.jpg\)](#)

$$\text{ex } 0.833333 = \frac{5}{6}$$

### 31) Velocity Ratio of Worm and Worm Wheel

$$\text{fx } V_i = \frac{D_m \cdot T_w}{2 \cdot R_d}$$

[Open Calculator !\[\]\(6059a5aa8b4ca7bb793408023d6c6e42\_img.jpg\)](#)

$$\text{ex } 6.857143 = \frac{0.15\text{m} \cdot 32}{2 \cdot 0.35\text{m}}$$

### 32) Velocity Ratio of Worm and Worm Wheel, if Worm has Multiple Threads

$$\text{fx } V_i = \frac{d_w \cdot T_w}{2 \cdot n \cdot R_d}$$

[Open Calculator !\[\]\(e3275251d0893157c3584e20c81dc3ba\_img.jpg\)](#)

$$\text{ex } 6.857143 = \frac{0.3\text{m} \cdot 32}{2 \cdot 2 \cdot 0.35\text{m}}$$



### 33) Velocity Ratio of Worm and Worm Wheel, if Worm is Double Threaded



$$\text{fx } V_i = \frac{d_w \cdot T_w}{4 \cdot R_d}$$

[Open Calculator](#)

$$\text{ex } 6.857143 = \frac{0.3\text{m} \cdot 32}{4 \cdot 0.35\text{m}}$$



## Variables Used






- $D_e$  Distance Moved Due to Effort (Meter)
- $d_l$  Diameter of Larger Pulley (Meter)
- $D_l$  Distance Moved Due to Load (Meter)
- $d_m$  Mean Diameter of Screw (Meter)
- $D_m$  Minimum Diameter of Effort Wheel (Meter)
- $d_s$  Diameter of Smaller Pulley (Meter)
- $d_w$  Diameter of Effort Wheel (Meter)
- $F_e$  Frictional Effort Lost (Newton)
- $l$  Length of Lever Arm (Meter)
- $L_c$  Net Shortening of Chain (Meter)
- $L_s$  Net Shortening of String (Meter)
- $M_a$  Mechanical Advantage
- $n$  Number of Threads
- $P$  Effort (Newton)
- $p_a$  Pitch of Screw A (Meter)
- $p_b$  Pitch of Screw B (Meter)
- $P_o$  Ideal Effort (Newton)
- $P_s$  Pitch (Meter)
- $R$  Radius of Pulley (Meter)
- $r_1$  Radius of Larger Pulley (Meter)
- $r_2$  Radius of Smaller Pulley (Meter)



- $R_d$  Radius of Load Drum (Meter)
- $R_w$  Radius of Effort Wheel (Meter)
- $T_1$  Number of Teeth of Larger Pulley
- $T_2$  Number of Teeth of Smaller Pulley
- $T_{asc}$  Torque Required While Load is Ascending (Newton Meter)
- $T_{des}$  Torque Required While Load is Descending (Newton Meter)
- $T_s$  Number of Teeth in Screw Shaft
- $T_w$  Number of Teeth on Worm Wheel
- $V_i$  Velocity Ratio
- $W$  Load (Newton)
- $W_i$  Ideal Load (Newton)
- $W_1$  Work Done (Joule)
- $\eta$  Efficiency
- $\theta$  Angle of Friction (Degree)
- $\Phi$  Limiting Angle of Friction (Degree)
- $\psi$  Helix Angle (Degree)



## Constants, Functions, Measurements used

- **Constant:** **pi**, 3.14159265358979323846264338327950288  
*Archimedes' constant*
- **Function:** **tan**,  $\tan(\text{Angle})$   
*The tangent of an angle is a trigonometric ratio of the length of the side opposite an angle to the length of the side adjacent to an angle in a right triangle.*
- **Measurement:** **Length** in Meter (m)  
*Length Unit Conversion* 
- **Measurement:** **Energy** in Joule (J)  
*Energy Unit Conversion* 
- **Measurement:** **Force** in Newton (N)  
*Force Unit Conversion* 
- **Measurement:** **Angle** in Degree ( $^{\circ}$ )  
*Angle Unit Conversion* 
- **Measurement:** **Torque** in Newton Meter ( $\text{N}\cdot\text{m}$ )  
*Torque Unit Conversion* 



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