Important Lifting Machines Formulas PDF

Formulas
Examples
with Units

List of 33
Important Lifting Machines Formulas

1) Machine Design Characteristics Formulas

1.1) Efficiency of Machine given Mechanical Advantage and Velocity Ratio Formula

Evaluate Formula

Formula

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

Example

$$0.8333 = \frac{5}{6}$$

1.2) Effort Required by Machine to Overcome Resistance to Get Work Done Formula

Evaluate Formula

Formula

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

Example with Units

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

1.3) Frictional Effort Lost Formula

Evaluate Formula

Formula

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

Example with Units

$$33.3333\,\text{N} = 200\,\text{N} - \frac{1000\,\text{N}}{6}$$

1.4) Ideal Effort given Load and Velocity Ratio Formula

Evaluate Formula

Formula

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

Example with Units

$$166.6667\,\text{N} = \frac{1000\,\text{N}}{6}$$

1.5) Ideal Load given Velocity Ratio and Effort Formula

Evaluate Formula

Formula

$$W_i = V_i \cdot P$$

Example with Units

$$1200\,\text{N} = 6 \cdot 200\,\text{N}$$

1.6) Load Lifted given Effort and Mechanical Advantage Formula

Evaluate Formula

Formula

$$W = M_a \cdot P$$

Example with Units

$$1000\,\text{N} = 5 \cdot 200\,\text{N}$$

1.7) Mechanical Advantage given Load and Effort Formula

Evaluate Formula

Formula

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

Example with Units

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

1.8) Useful Work Output of Machine Formula

Evaluate Formula

Formula

$$W_l = W \cdot D_l$$

Example with Units

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

1.9) Velocity Ratio given Distance Moved due to Effort and Distance Moved due to Load Formula

Evaluate Formula

Formula

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

Example with Units

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

1.10) Work Done by Effort Formula

Evaluate Formula

Formula

$$W_l = W \cdot D_l$$

Example with Units

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

2) Pulley Block Formulas

2.1) Efficiency of Geared Pulley Block Formula

Evaluate Formula

Formula

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

Example

$$0.8333 = \frac{5}{6}$$

2.2) Efficiency of Weston's Differential Pulley Block Formula

Evaluate Formula

Formula

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

Example

$$0.8333 = \frac{5}{6}$$

2.3) Efficiency of Worm Geared Pulley Block Formula

Evaluate Formula

Formula

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

Example

$$0.8333 = \frac{5}{6}$$

2.4) Net Shortening of Chain in Weston's Differential Pulley Block Formula

Evaluate Formula

Formula

$$L_c = \pi \cdot \left(d_l - d_s \right)$$

Example with Units

$$0.0628\,\text{m} = 3.1416 \cdot \left(0.06\,\text{m} - .04\,\text{m} \right)$$

2.5) Net Shortening of String in Worm Gear Pulley Block Formula

Evaluate Formula

Formula

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

Example with Units

$$0.2749\,\text{m} = \frac{2 \cdot 3.1416 \cdot 1.4\,\text{m}}{32}$$

2.6) Velocity Ratio in Weston's Differential Pulley Block Formula

Evaluate Formula

Formula

$$V_i = \frac{2 \cdot d_l}{d_l - d_s}$$

Example with Units

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

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

Evaluate Formula

Formula

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

Example

$$6.1333 = 2 \cdot \frac{46}{46 - 31}$$

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

Evaluate Formula

Formula

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

Example with Units

$$6.5455 = 2 \cdot \frac{9\,\text{m}}{9\,\text{m} - 6.25\,\text{m}}$$

2.9) Velocity Ratio of Worm Geared Pulley Block Formula

Evaluate Formula

Formula

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

Example with Units

$$6.8571 = \frac{0.3\,\text{m} \cdot 32}{1.4\,\text{m}}$$

3) Screw Jack Formulas

3.1) Efficiency of Differential Screw Jack Formula

Evaluate Formula

Formula

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

Example

$$0.8333 = \frac{5}{6}$$

3.2) Efficiency of Screw Jack Formula

Evaluate Formula

Formula

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

Example with Units

$$0.8398 = \frac{\tan(12.9^\circ)}{\tan(12.9^\circ + 75^\circ)} \cdot 100$$

3.3) Efficiency of Worm Geared Screw Jack Formula

Evaluate Formula

Formula

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

Example

$$0.8333 = \frac{5}{6}$$

3.4) Torque Required while Load is Ascending in Screw Jack Formula

Evaluate Formula

Formula

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

Example with Units

$$2748.4519\,\text{N*m} = \frac{0.24\,\text{m}}{2} \cdot 1000\,\text{N} \cdot \tan(75^\circ + 12.5^\circ)$$

3.5) Torque Required while Load is Descending in Screw Jack Formula

Evaluate Formula

Formula

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

Example with Units

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

3.6) Velocity Ratio of Differential Screw Jack Formula

Evaluate Formula

Formula

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

Example with Units

$$6.2832 = \frac{2 \cdot 3.1416 \cdot 12\,\text{m}}{34\,\text{m} - 22\,\text{m}}$$

3.7) Velocity Ratio of Simple Screw Jack Formula

Evaluate Formula

Formula

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

Example with Units

$$5.3856 = \frac{2 \cdot 3.1416 \cdot 12\,\text{m}}{14\,\text{m}}$$

3.8) Velocity Ratio of Worm Geared Screw Jack Formula

Evaluate Formula

Formula

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

Example with Units

$$6.4851 = \frac{2 \cdot 3.1416 \cdot 0.85\,\text{m} \cdot 17}{14\,\text{m}}$$

3.9) Velocity Ratio of Worm Geared Screw Jack with Double Threaded Formula

Evaluate Formula

Formula

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

Example with Units

$$6.1037 = \frac{2 \cdot 3.1416 \cdot 0.85\,\text{m} \cdot 32}{2 \cdot 14\,\text{m}}$$

3.10) Velocity Ratio of Worm Geared Screw Jack with Multiple Threads Formula

Evaluate Formula

Formula

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

Example with Units

$$6.1037 = \frac{2 \cdot 3.1416 \cdot 0.85\,\text{m} \cdot 32}{2 \cdot 14\,\text{m}}$$

4) Worm Wheel Formulas

4.1) Efficiency of Worm and Worm Wheel Formula

Evaluate Formula

Formula

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

Example

$$0.8333 = \frac{5}{6}$$

4.2) Velocity Ratio of Worm and Worm Wheel Formula

Evaluate Formula

Formula

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

Example with Units

$$6.8571 = \frac{0.15\,\text{m} \cdot 32}{2 \cdot 0.35\,\text{m}}$$

4.3) Velocity Ratio of Worm and Worm Wheel, if Worm has Multiple Threads Formula

Evaluate Formula

Formula

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

Example with Units

$$6.8571 = \frac{0.3\,\text{m} \cdot 32}{2 \cdot 2 \cdot 0.35\,\text{m}}$$

4.4) Velocity Ratio of Worm and Worm Wheel, if Worm is Double Threaded Formula

Evaluate Formula

Formula

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

Example with Units

$$6.8571 = \frac{0.3\,\text{m} \cdot 32}{4 \cdot 0.35\,\text{m}}$$

Variables used in list of Lifting Machines Formulas above

- 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

Constants, Functions, Measurements used in list of Lifting Machines Formulas above

- constant(s): **pi**, 3.14159265358979323846264338327950288 *Archimedes' constant*
- Functions: **tan**, tan(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 (°) *Angle Unit Conversion*
- Measurement: **Torque** in Newton Meter (N*m) *Torque Unit Conversion*

- V_i Velocity Ratio
- **W** Load *(Newton)*
- W_i Ideal Load *(Newton)*
- W_l Work Done *(Joule)*
- **η** Efficiency
- **θ** Angle of Friction *(Degree)*
- **Φ** Limiting Angle of Friction *(Degree)*
- **ψ** Helix Angle *(Degree)*

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