Important Friction Formulas PDF

Formulas
Examples
with Units

List of 28
Important Friction Formulas

1) Angle Friction Formulas

1.1) Angle of Repose Formula

Evaluate Formula

Formula

$$\alpha_r = a\tan\left(\frac{F_{lim}}{R_n}\right)$$

Example with Units

$$18.4534° = a\tan\left(\frac{2.15\,\text{N}}{6.4431\,\text{N}}\right)$$

1.2) Coefficient of Friction between Cylinder and Surface of Inclined Plane for Rolling without Slipping Formula

Evaluate Formula

Formula

$$\mu = \frac{\tan\left(\theta_i\right)}{3}$$

Example with Units

$$0.3333 = \frac{\tan\left(45°\right)}{3}$$

1.3) Efficiency of Inclined Plane when Effort Applied Horizontally to Move Body Downward Formula

Evaluate Formula

Formula

$$\eta = \frac{\tan\left(\alpha_i - \Phi\right)}{\tan\left(\alpha_i\right)}$$

Example with Units

$$0.9043 = \frac{\tan\left(23° - 2°\right)}{\tan\left(23°\right)}$$

1.4) Efficiency of Inclined Plane when Effort Applied Horizontally to Move Body Upward Formula

Evaluate Formula

Formula

$$\eta = \frac{\tan\left(\alpha_i\right)}{\tan\left(\alpha_i + \Phi\right)}$$

Example with Units

$$0.9103 = \frac{\tan\left(23°\right)}{\tan\left(23° + 2°\right)}$$

1.5) Efficiency of Inclined Plane when Effort Applied Parallel to Move Body Downward Formula

Evaluate Formula

Formula

$$\eta = \frac{\sin\left(\alpha_i - \Phi\right)}{\sin\left(\alpha_i\right)\cdot\cos\left(\Phi\right)}$$

Example with Units

$$0.9177 = \frac{\sin\left(23° - 2°\right)}{\sin\left(23°\right)\cdot\cos\left(2°\right)}$$

1.6) Efficiency of Inclined Plane when Effort Applied Parallel to Move Body Upward Formula

Evaluate Formula

Formula

$$\eta = \frac{\sin\left(\alpha_i\right) \cdot \cos\left(\Phi\right)}{\sin\left(\alpha_i + \Phi\right)}$$

Example with Units

$$0.924 = \frac{\sin\left(23^\circ\right) \cdot \cos\left(2^\circ\right)}{\sin\left(23^\circ + 2^\circ\right)}$$

1.7) Efficiency of Inclined Plane when Effort Applied to Move Body Downward Formula

Evaluate Formula

Formula

$$\eta = \frac{\cot\left(\alpha_i\right) - \cot\left(\theta_e\right)}{\cot\left(\alpha_i - \Phi\right) - \cot\left(\theta_e\right)}$$

Example with Units

$$0.901 = \frac{\cot\left(23^\circ\right) - \cot\left(85^\circ\right)}{\cot\left(23^\circ - 2^\circ\right) - \cot\left(85^\circ\right)}$$

1.8) Efficiency of Inclined Plane when Effort Applied to Move Body Upward Formula

Evaluate Formula

Formula

$$\eta = \frac{\cot\left(\alpha_i + \Phi\right) - \cot\left(\theta_e\right)}{\cot\left(\alpha_i\right) - \cot\left(\theta_e\right)}$$

Example with Units

$$0.9068 = \frac{\cot\left(23^\circ + 2^\circ\right) - \cot\left(85^\circ\right)}{\cot\left(23^\circ\right) - \cot\left(85^\circ\right)}$$

1.9) Effort Applied Parallel to Inclined Plane to Move Body Downward Considering Friction Formula

Evaluate Formula

Formula

$$P_d = W \cdot \left(\sin\left(\alpha_i\right) - \mu \cdot \cos\left(\alpha_i\right)\right)$$

Example with Units

$$10.0676\,\text{N} = 120\,\text{N} \cdot \left(\sin\left(23^\circ\right) - 0.333333 \cdot \cos\left(23^\circ\right)\right)$$

1.10) Effort Applied Parallel to Inclined Plane to Move Body Upward Considering Friction Formula

Evaluate Formula

Formula

$$P_u = W \cdot \left(\sin\left(\alpha_i\right) + \mu \cdot \cos\left(\alpha_i\right)\right)$$

Example with Units

$$83.7079\,\text{N} = 120\,\text{N} \cdot \left(\sin\left(23^\circ\right) + 0.333333 \cdot \cos\left(23^\circ\right)\right)$$

1.11) Effort Applied Parallel to Inclined Plane to Move Body Upward or Downward Neglecting Friction Formula

Evaluate Formula

Formula

$$P_0 = W \cdot \sin\left(\alpha_i\right)$$

Example with Units

$$46.8877\,\text{N} = 120\,\text{N} \cdot \sin\left(23^\circ\right)$$

1.12) Effort Applied Perpendicular to Inclined Plane to Move Body along Inclination Neglecting Friction Formula

Evaluate Formula

Formula

$$P_0 = W \cdot \tan\left(\alpha_i\right)$$

Example with Units

$$50.937\,\text{N} = 120\,\text{N} \cdot \tan\left(23°\right)$$

1.13) Effort Applied Perpendicular to Inclined Plane to Move Body Downward Considering Friction Formula

Evaluate Formula

Formula

$$P_d = W \cdot \tan\left(\alpha_i - \Phi\right)$$

Example with Units

$$46.0637\,\text{N} = 120\,\text{N} \cdot \tan\left(23° - 2°\right)$$

1.14) Effort Applied Perpendicular to Inclined Plane to Move Body Upward Considering Friction Formula

Evaluate Formula

Formula

$$P_u = W \cdot \tan\left(\alpha_i + \Phi\right)$$

Example with Units

$$55.9569\,\text{N} = 120\,\text{N} \cdot \tan\left(23° + 2°\right)$$

1.15) Effort Applied to Move Body Downward on Inclined Plane Considering Friction Formula

Evaluate Formula

Formula

$$P_d = \frac{W \cdot \sin\left(\alpha_i - \Phi\right)}{\sin\left(\theta_e - \left(\alpha_i - \Phi\right)\right)}$$

Example with Units

$$47.8465\,\text{N} = \frac{120\,\text{N} \cdot \sin\left(23° - 2°\right)}{\sin\left(85° - \left(23° - 2°\right)\right)}$$

1.16) Effort Applied to Move Body Upward on Inclined Plane Considering Friction Formula

Evaluate Formula

Formula

$$P_u = \frac{W \cdot \sin\left(\alpha_i + \Phi\right)}{\sin\left(\theta_e - \left(\alpha_i + \Phi\right)\right)}$$

Example with Units

$$58.5597\,\text{N} = \frac{120\,\text{N} \cdot \sin\left(23° + 2°\right)}{\sin\left(85° - \left(23° + 2°\right)\right)}$$

1.17) Effort Required to Move Body down Plane Neglecting Friction Formula

Evaluate Formula

Formula

$$P_0 = \frac{W \cdot \sin\left(\alpha_i\right)}{\sin\left(\theta_e - \alpha_i\right)}$$

Example with Units

$$53.1036\,\text{N} = \frac{120\,\text{N} \cdot \sin\left(23°\right)}{\sin\left(85° - 23°\right)}$$

1.18) Effort Required to Move Body up Plane Neglecting Friction Formula

Evaluate Formula

Formula

$$P_0 = \frac{W \cdot \sin\left(\alpha_i\right)}{\sin\left(\theta_e - \alpha_i\right)}$$

Example with Units

$$53.1036\,\text{N} = \frac{120\,\text{N} \cdot \sin\left(23°\right)}{\sin\left(85° - 23°\right)}$$

1.19) Frictional Force between Cylinder and Inclined Plane surface for Rolling without Slipping Formula

Evaluate Formula

Formula

$$F_f = \frac{M_c \cdot g \cdot \sin(\theta_i)}{3}$$

Example with Units

$$22.1749\,\text{N} = \frac{9.6\,\text{kg} \cdot 9.8\,\text{m/s}^2 \cdot \sin(45°)}{3}$$

1.20) Limiting Angle of Friction Formula

Evaluate Formula

Formula

$$\Phi = a\tan\left(\frac{F_{lf}}{R_n}\right)$$

Example with Units

$$2° = a\tan\left(\frac{0.225\,\text{N}}{6.4431\,\text{N}}\right)$$

1.21) Minimum Force Required to Slide Body on Rough Horizontal Plane Formula

Evaluate Formula

Formula

$$P_{min} = W \cdot \sin(\theta_e)$$

Example with Units

$$119.5434\,\text{N} = 120\,\text{N} \cdot \sin(85°)$$

2) Laws of Friction Formulas

2.1) Coefficient of Friction Formula

Evaluate Formula

Formula

$$\mu = \frac{F_{lim}}{R_n}$$

Example with Units

$$0.3337 = \frac{2.15\,\text{N}}{6.4431\,\text{N}}$$

2.2) Coefficient of Friction using Forces Formula

Evaluate Formula

Formula

$$\mu = \frac{F_c \cdot \tan(\theta_f) + P_t}{F_c - P_t \cdot \tan(\theta_f)}$$

Example with Units

$$0.6006 = \frac{1200\,\text{N} \cdot \tan(29.793805347°) + 25\,\text{N}}{1200\,\text{N} - 25\,\text{N} \cdot \tan(29.793805347°)}$$

2.3) Total Torque Required to Overcome Friction in Rotating Screw Formula

Evaluate Formula

Formula

$$T = W \cdot \tan(\psi + \Phi) \cdot \frac{d_m}{2} + \mu_c \cdot W \cdot R_c$$

Example with Units

$$52.3556\,\text{N*m} = 120\,\text{N} \cdot \tan(25.00° + 2°) \cdot \frac{1.7\,\text{m}}{2} + 0.16 \cdot 120\,\text{N} \cdot 0.02\,\text{m}$$

3) Screw Friction Formulas

3.1) Angle of inclination of thread Formula

Evaluate Formula

Formula

$$\theta_t = a\tan\left(\frac{P_s}{\pi \cdot d_m}\right)$$

Example with Units

$$66.8651° = a\tan\left(\frac{12.5\,\text{m}}{3.1416 \cdot 1.7\,\text{m}}\right)$$

3.2) Pitch of screw Formula

Evaluate Formula

Formula

$$P_s = \frac{L}{n}$$

Example with Units

$$12.5333\,\text{m} = \frac{188\,\text{m}}{15}$$

3.3) Slope of thread Formula

Evaluate Formula

Formula

$$\alpha = \frac{P_s}{\pi \cdot d_m}$$

Example with Units

$$2.3405 = \frac{12.5\,\text{m}}{3.1416 \cdot 1.7\,\text{m}}$$

3.4) Slope of thread in multi-threaded screw Formula

Evaluate Formula

Formula

$$\alpha_m = \frac{n \cdot P_s}{\pi \cdot d_m}$$

Example with Units

$$35.1077 = \frac{15 \cdot 12.5\,\text{m}}{3.1416 \cdot 1.7\,\text{m}}$$

Variables used in list of Friction Formulas above

- d_m Mean Diameter of Screw *(Meter)*
- F_c Centripetal Force *(Newton)*
- F_f Force of Friction *(Newton)*
- F_{lf} Limit Force *(Newton)*
- F_{lim} Limiting Force *(Newton)*
- g Acceleration Due to Gravity *(Meter per Square Second)*
- L Lead of Screw *(Meter)*
- M_c Mass of Cylinder *(Kilogram)*
- n Number of Threads
- P_0 Effort Required to Move Neglecting Friction *(Newton)*
- P_d Effort to Move Downwards Considering Friction *(Newton)*
- P_{min} Minimum Effort *(Newton)*
- P_s Pitch *(Meter)*
- P_t Tangential Force *(Newton)*
- P_u Effort to Move Upwards Considering Friction *(Newton)*
- R_c Mean Radius of Collar *(Meter)*
- R_n Normal Reaction *(Newton)*
- T Total Torque *(Newton Meter)*
- W Weight of Body *(Newton)*
- α Slope of Thread
- α_i Angle of Inclination of Plane to Horizontal *(Degree)*
- α_m Slope of Multiple Threads
- α_r Angle of Repose *(Degree)*
- η Efficiency of Inclined Plane
- θ_e Angle of Effort *(Degree)*
- θ_f Angle of Friction *(Degree)*
- θ_i Angle of Inclination *(Degree)*
- θ_t Thread Angle *(Degree)*

Constants, Functions, Measurements used in list of Friction Formulas above

- constant(s): **pi**, 3.14159265358979323846264338327950288 *Archimedes' constant*
- Functions: **atan**, atan(Number) *Inverse tan is used to calculate the angle by applying the tangent ratio of the angle, which is the opposite side divided by the adjacent side of the right triangle.*
- Functions: **cos**, cos(Angle) *Cosine of an angle is the ratio of the side adjacent to the angle to the hypotenuse of the triangle.*
- Functions: **cot**, cot(Angle) *Cotangent is a trigonometric function that is defined as the ratio of the adjacent side to the opposite side in a right triangle.*
- Functions: **sin**, sin(Angle) *Sine is a trigonometric function that describes the ratio of the length of the opposite side of a right triangle to the length of the hypotenuse.*
- 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: **Weight** in Kilogram (kg) *Weight Unit Conversion*
- Measurement: **Acceleration** in Meter per Square Second (m/s²) *Acceleration 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*

- μ Coefficient of Friction
- μ_c Coefficient of Friction For Collar
- Φ Limiting Angle of Friction *(Degree)*
- ψ Helix Angle *(Degree)*

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