

Limiting angle of friction

every body

It may be defined as the angle which the resultant reaction R makes with the normal reaction R_N.

$$\tan \phi = \frac{F}{R_N} = \frac{(R_N \sin \theta) \cos \theta - W \sin \theta}{(R_N \cos \theta) \sin \theta + W \cos \theta} = 7$$

so that it does not move

Angle of Repose

(x - \phi) \sin \theta

if the angle of inclination \alpha of the plane to the horizontal is such that the body begins to slide down the plane, then the angle α is called angle of repose.

does not move

$$W \sin \alpha = F = \frac{W R_N \cos \alpha}{\text{does not move}} = W \cos \alpha$$

$$\tan \alpha = \frac{W \cos \alpha}{W \sin \alpha} = \tan \phi$$

$$\alpha = \phi \quad \frac{(\phi + \lambda) \sin \theta}{[(\phi + \lambda) - \theta] \cos \theta} = 7$$

$$[(\phi + \lambda) - \theta] \cos \theta$$

Efficiency

The efficiency of an inclined plane, when a body slides up the plane, is defined as the ratio of force required to move the body without consideration (and) with consideration of friction of force.

not present

The efficiency of an inclined plane, when a body slides down the plane is defined as the ratio of forces required to move the body with and without consideration of forces.

$$e = \frac{W}{W - b \sin \theta}$$

$$b \sin \theta + W =$$

$$W - b \sin \theta$$

Inclined plane

Motion up the plane

In a position diagram with forces shown, it is evident that:

$$F = \frac{W \sin(\alpha + \phi)}{\sin[\theta - (\alpha + \phi)]} = \text{proff}$$

Motion down the plane

$$\text{at stand} F = \frac{W \sin(\phi - \alpha)}{\sin[\theta + (\phi - \alpha)]}$$

ability of angle θ to move with respect to ϕ .

so easier to express by θ as a function of ϕ and α .

Screw Threads

Square Threads

if the w.t is to be lifted

$$F = \frac{W \sin(\alpha + \phi)}{\sin[\theta - (\alpha + \phi)]}$$

$$F = \frac{W \sin(\alpha + \phi)}{\cos(\alpha + \phi)}$$

$$\text{friction factor} = \tan \alpha \tan \phi$$

$$= \frac{1 - \tan \alpha \tan \phi}{1 + \tan \alpha \tan \phi}$$

$$= W \frac{4\pi d \cdot u}{1 - 4\pi d \cdot u}$$

$$= W \frac{1 + 4\pi d}{\pi d - 4u}$$

Let f = force applied at the end of the bar of length L

$$fL = Frc \quad \frac{\text{bottom } + W}{\frac{W}{2}} = A.M.$$

$$f = \frac{Frc}{L} = \frac{Wrc}{L} \tan(\alpha + \phi) \text{ go snoteb}$$

$$\frac{W}{2} =$$

if the w.t is to be lowered

$$F = \frac{W \sin(\phi - \alpha) + W}{\sin[\alpha + (\phi - \alpha)]} \text{ not } \frac{W}{2}$$

$$(\phi + \alpha) + \alpha = \frac{\pi}{2}$$

$$= W \tan(\phi - \alpha)$$

other pticular

$$f = \frac{Wrc}{L} \tan(\phi - \alpha) \text{ go snoteb}$$

vert/broad pd between snoteb

Screw efficiency

W.D in lifting the load/rev

$$\eta_{\text{screw}} = \frac{\text{W.D by the applied force/rev}}{\text{W.D in lifting the load/rev}}$$

$$= \frac{W \cdot L}{F \cdot \pi d} \quad \frac{1}{2 \pi d} =$$

$$= \frac{W}{F} \cdot \frac{L}{\pi d}$$

$$= \frac{\tan \alpha}{\tan(\alpha + \phi)}$$

$$(\eta_{\text{screw}})_{\max} = \frac{1 - \sin \phi}{1 + \sin \phi}$$

$$\text{when } \alpha = 45^\circ - \frac{\phi}{2}$$

Mechanical Advantage bridge error = 7 for

$$M.A. = \frac{W + \text{lifted}}{\text{force applied} \times \text{not lift}} = \frac{W}{\frac{W}{L} \tan(\alpha + \phi) \cos \theta} = \frac{L}{\tan(\alpha + \phi)} = 7$$

(not lift = 1)

$$= \frac{W}{\frac{W}{L} \tan(\alpha + \phi) \cos \theta}$$

$$= \frac{L}{\tan(\alpha + \phi)}$$

Velocity ratio $(\alpha + \phi) \text{ not lift} =$

$$V.R. = \frac{\text{distance moved by force/rev}}{\text{distance moved by load/rev}} = 7$$

(not lift = 1)

$$= \frac{\frac{2\pi L}{\text{rev}}}{\frac{L}{\tan \alpha}} = \frac{2\pi}{\tan \alpha} = 7$$

(not lift = 1)

$$= \frac{\frac{L}{\text{rev}} \frac{d}{2}}{\frac{\pi d}{2}} = \frac{L}{\pi \text{rev}} = 7$$

(not lift = 1)

$$= \frac{L}{r \tan \alpha} = \frac{L}{r \tan \alpha} = 7$$

(not lift = 1)

$$\frac{1}{6\pi} \frac{W}{7} = 7$$

(not lift = 1)

$$\frac{W}{(7\phi + 7)} = 7$$

(not lift = 1)

$$\frac{\phi \cos \theta - 1}{\phi \cos \theta + 1} = 7$$

(not lift = 1)

$$\frac{\phi}{\cos \theta} - \frac{1}{\cos \theta} = 7$$

(not lift = 1)

Overhauling of Screw and Self Locking of Screw

~~Cutting force of threads over the load~~

$$F = W \tan(\phi - \alpha) \quad T + \frac{F}{s} = T$$

$$T = W \tan(\phi - \alpha) \frac{\pi d}{2} + \frac{b}{s} \neq T$$

If $\phi < \alpha$, then the torque required to lower the load will be negative i.e. the load will start moving downward without the application of any torque. Such a condition is known as overhauling of screw. It is due to the fact that $\tan(\phi - \alpha)$ is negative.

If $\phi > \alpha$, the torque required to lower the load will be +ve i.e. an effort is required to lower the load. Such a screw is known as self locking of screw.

Screw Jack

Torque required to lift the body by a screw jack
effort applied at the circumference of the screw to lift the load

$$F = W \tan(\alpha + \phi)$$

Torque required to overcome friction b/w the screw and nut

$$T_1 = F \times \frac{d}{2} = W \tan(\alpha + \phi) \frac{d}{2}$$

Torque required to overcome friction at collar

$$T_2 = \mu_1 W \left(\frac{R_1 + R_2}{2} \right) = \mu_1 WR$$

μ_1 = coefficient of friction of collar

Cause 2 to prevent the bus from moving forward

Total force required to overcome friction?

$$T = T_1 + T_2 \quad (\lambda - \phi) \text{ not } W = 7$$

$$T = R \frac{d}{2} + \mu_1 W (R - \phi) \text{ not } W = T$$

point of lever arm about eff. net, $\lambda > \phi$ so
given that effort is applied at the end of a lever of length d the total force required to overcome friction must be equal to the force applied at the end of the lever

eff. net $T = R \frac{d}{2} + f \lambda$, $\lambda < \phi$ so
leverage of lever $\mu_1 W R$ force to o.s. lift and now total force to prevent the bus from moving as every other is lift $\frac{d_0 + d_e}{2} = \frac{d_0 - \frac{\mu_1 W R}{\lambda}}{2} = \frac{d_0 + \frac{\phi}{\lambda}}{2}$ lift force

Net force of bus about center of lever support

eff. net of bus about center of lever support is equal to bridge force $(\phi + \lambda) \text{ not } W = 7$ bus

bus with front and rear of lever support has

$$\frac{1}{2} (\phi + \lambda) \text{ not } W = \frac{1}{2} * 7 = 7$$

net force about center of lever support

$$\text{bridge} = \left(\frac{\phi + \lambda}{2} \right) W = 7$$

note to third approximation $\frac{1}{2} \phi W = 7$

1. Flat pivot Bearing

W = load transmitted over bearing surface

R = radius of bearing surface

P = intensity of pressure per unit area of bearing surface b/w rubbing surface

μ = coefficient of friction

1. Considering uniform pressure

When the pressure is uniformly distributed over the bearing area, then

$$P = \frac{W}{\pi R^2}$$

consider a ring of radius r and thickness dr of the bearing area

$$\text{Area of bearing surface } A = 2\pi r dr$$

Load transmitted to ring

$$SW = P * A = P * 2\pi r dr$$

Fractional resistance to sliding on the ring acting tangentially at radius r

$$F_r = \mu SW = \mu P * 2\pi r dr$$

$$F_r = 2\pi \mu P r dr$$

Fractional torque on the ring

$$T = F_r * r = 2\pi \mu P r dr * r$$

$$T = 2\pi \mu P r^2 dr$$

Total frictional torque,

$$T = \int_0^R 2\pi r \mu w r^2 dr$$

per unit length = $\frac{2}{3} \mu W R$

per unit length force varying from zero at center to $\mu W R$ at outer edge

When the shaft rotates at w rad/s

then power lost in friction

$$P = T * w$$

considering uniform wear

$$Pr = C$$

shaft load transmitted to ring

$$S_{int} = P * 2\pi r dr$$

$$S_{int} = \frac{C}{r} * 2\pi r dr$$

$$= 2\pi C dr$$

Total load transmitted to bearing

$$W = \int_0^R S_{int} dr = A * q = W$$

$$W = \int_0^R 2\pi C dr$$

$$C = W / 2\pi R$$

Frictional torque acting on the ring

$$T_r = 2\pi C \mu r^2 dr$$

$$T_r = 2\pi C \mu r dr$$

Total frictional torque on the bearing

$$T = \int_0^R 2\pi C \mu r dr$$

$$T = \frac{1}{2} \mu W R$$

conical pivot bearing

p_n = intensity of pressure normal to the cone

α = semi-angle of cone no. of contact points

μ = coefficient of friction b/w shaft and bearing

R = radius of the shaft

$$\sin \alpha = dr/dl$$

area of the ring

$$A = 2\pi r c dl$$

$$A = 2\pi r c dr \cosec \alpha$$

1. Consider uniform pressure

Normal load acting on the rings

$$S_{W_n} = \text{Normal pressure} * \text{area}$$

$$= p_n * 2\pi r c dr \cosec \alpha$$

Vertical load acting on the ring

S_{W_v} = vertical component of S_{W_n}

$$= S_{W_n} \sin \alpha$$

$$= p_n 2\pi r c dr \cosec \alpha \sin \alpha$$

$$= p_n 2\pi r c dr$$