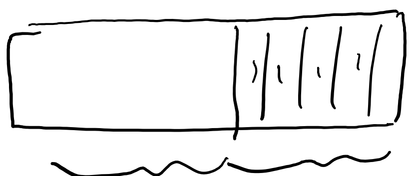
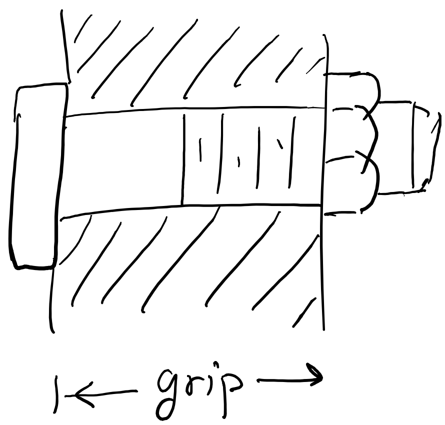
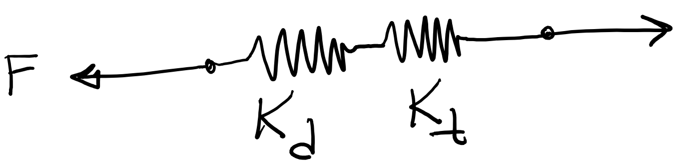
Jan 5^{th}, 2022

Calculating the spring constant of a bolt in a clamping application



Shank	Thread
l_d	l_t
A_d	A_t
E	E

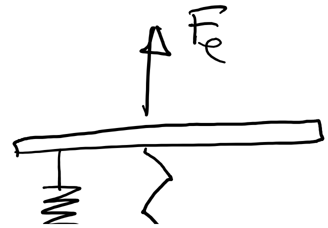


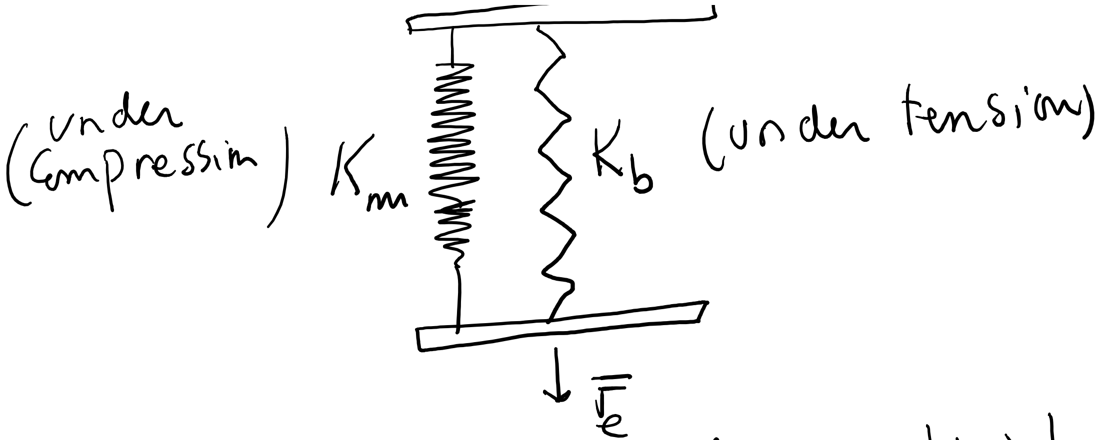


$$\frac{1}{K_b} = \frac{1}{K_d} + \frac{1}{K_t}$$

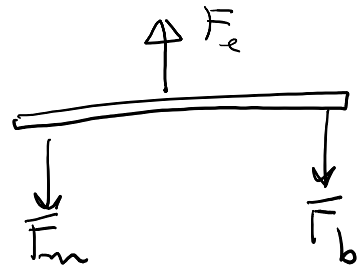
K_b = bolt spring constant

Bolt and clamped material behave like two parallel springs





Q: How does an external load divide between the two springs K_m and K_d



$$F_e = F_m + F_b \quad (\mathrm{I})$$

Also

$$\begin{aligned} F_m &= K_m \Delta \\ F_b &= K_b \Delta \end{aligned} \Rightarrow \frac{F_m}{F_b} = \frac{K_m}{K_b} \quad (\mathrm{II})$$

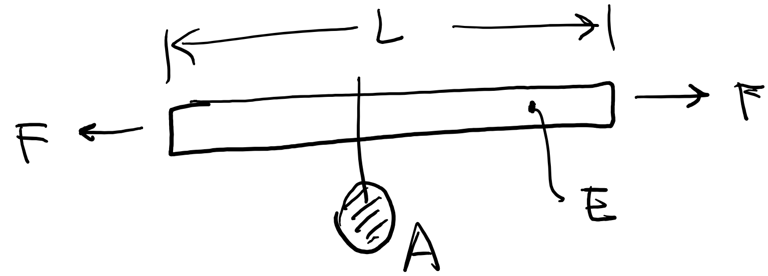
Sub. (II) into (I)

$$F_b = \frac{K_b}{K_m + K_b} F \quad \leftarrow$$

$$F_m = \frac{K_m}{K_m + K_b} F \quad \leftarrow$$

Q: Calculate the spring constant of a bar (A, L, E) in tension

$$K = \frac{AE}{L}$$



example

$A = 1 \; in^2$

$L = 10 \; in$

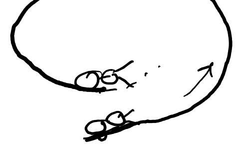
$E = 30 * 10^6 \; psi$

$$K = \frac{1\,(30 * 10^{6})}{10} = 3 e 10^{6} \; lbs/in$$

or $K = 3 \; Mlbs/in$

Power Screws

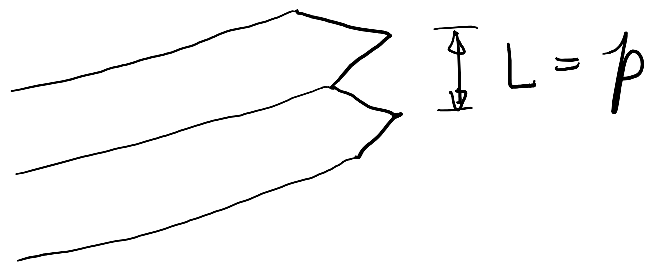
Q: if an ant moves up on a thread of a bolt for a complete turn (360 degrees), how far would the ant move along the bolt axis



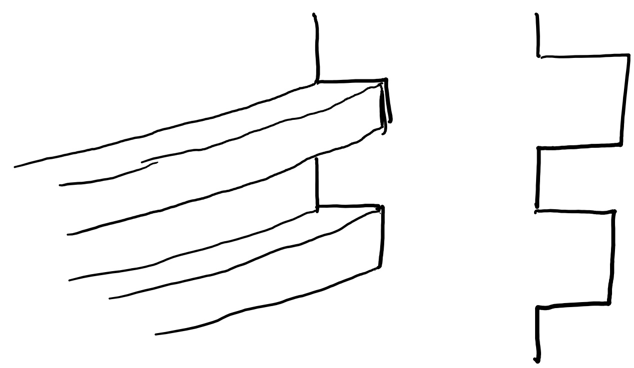
Answer: the distance is called

The thread "Lead" : L

For a bolt (fastener) the lead is the same as pitch

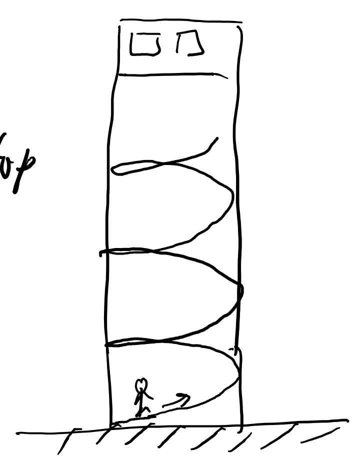


Power Screws usually have a Square thread Profile



Q: Consider a tower

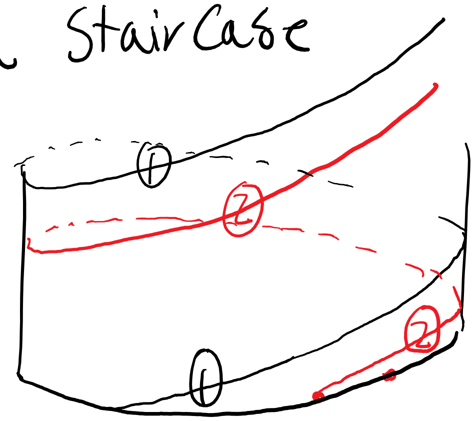
- There is a single narrow spiral staircase going to the top
- We want to increase the capacity so more people can go up (by a factor of 2 or 3)



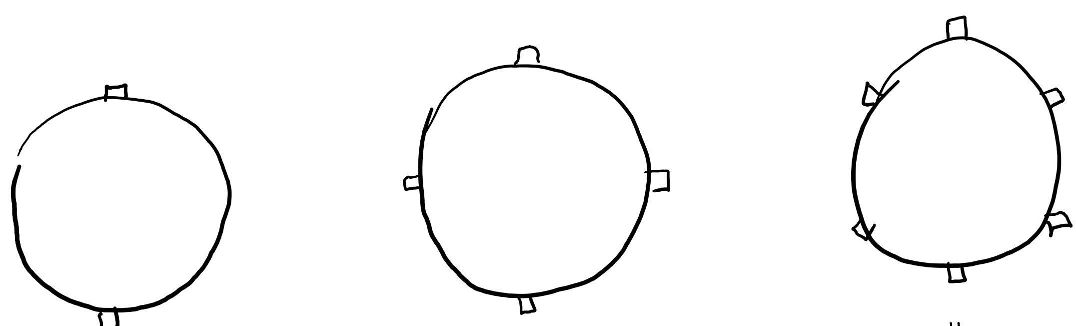
How Can this be done?

- Elevator X not option
- increase Path width X not option
- lower the lead angle
- Adding another Staircase

multiple stair case solution

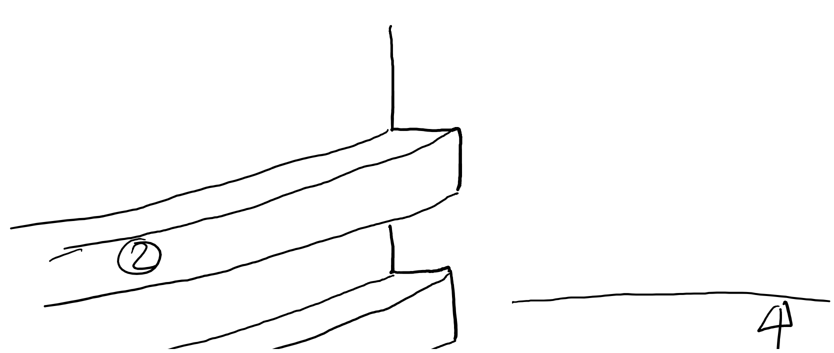


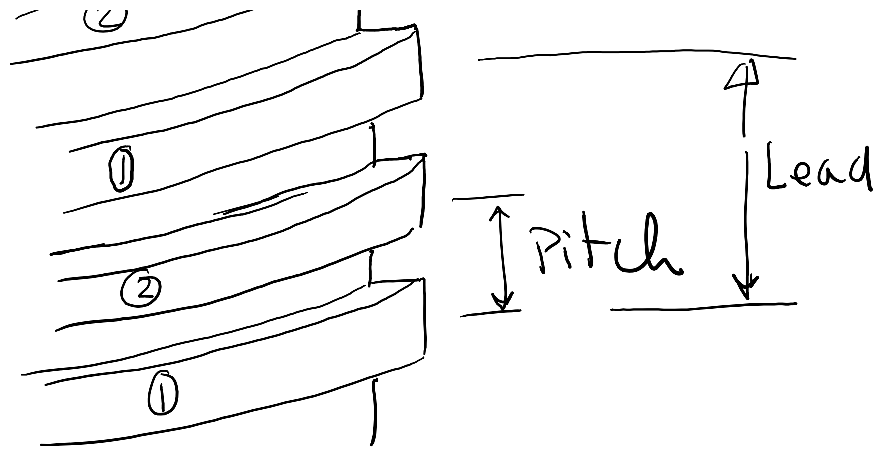
For Power Screws



Double thread 4-thread 6-thread

For a double-thread Screw





$L = \underbrace{N_w}_{\text{The number of thread}} P$

Double thread $N_w = 2$

Q: if the pitch of a double-thread Power screw is $p = 0.2$, what is the Lead

$L = 2(0.2) = 0.4''$

Q: how much the power screw advances (in a stationary nut) with one rotation

Answer: $L = 0.4''$

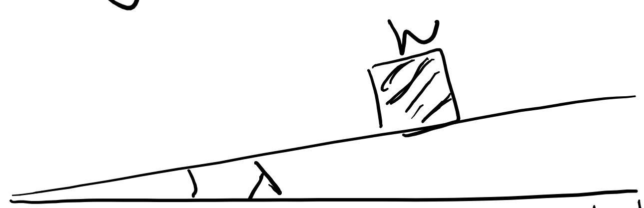
Compared to a single thread.

a double-thread power screw:

- Moves the load twice as fast (T)
- will have the same lead angle (F)

$$\tan\lambda = \frac{L}{\pi d}$$

- will be more efficient (T)
- will be more likely to be self-locking (F)



Condition for not sliding down

$$f > \tan\lambda$$

Question: what torque is necessary to overcome thread friction and raise a load in a square profile power screw if

Load $\equiv F \equiv$ [lbs]

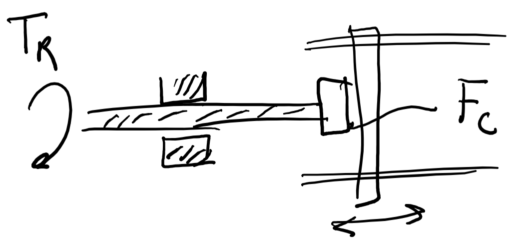
$d_m \equiv$ mean diameter of power screw [in]

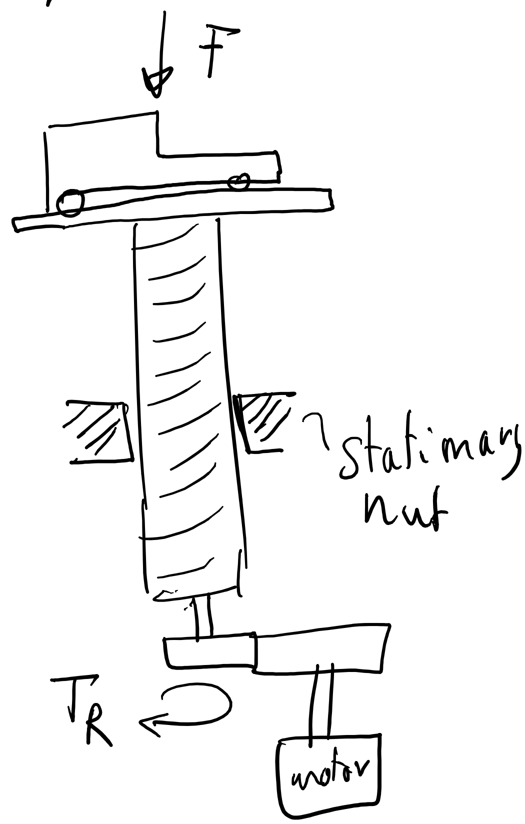
$f \equiv$ thread friction [-]

$L \equiv$ thread lead [in]

$T_R \equiv$ Torque to raise [in-lb]

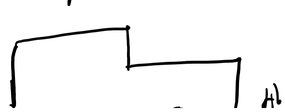
$$T_R = \frac{F d_m}{2} \left(\frac{L + \pi f d_m}{\pi d_m - f L} \right) \quad \text{EQ (8-1)}$$

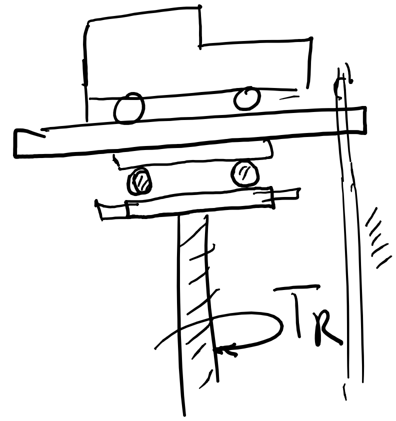




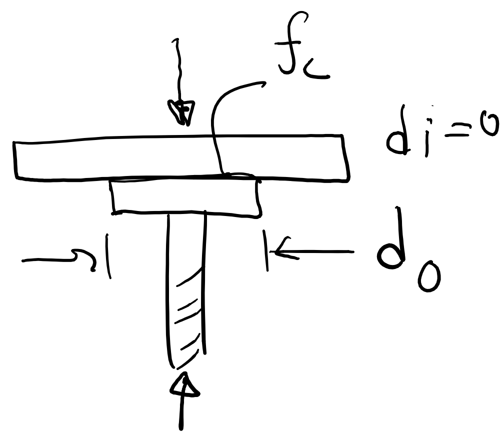
Q: what torque is needed to overcome bearing friction (to prevent the load from rotating with the power screw)

if roller or ball bearing $T_c \approx 0$



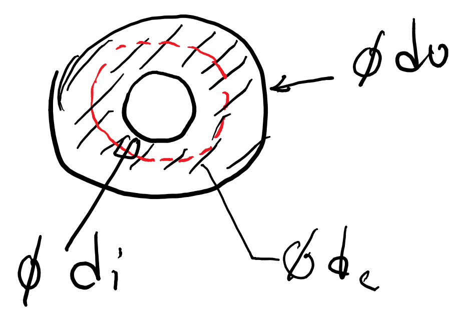


if Plain bearing



$$T_c = \frac{F f_c d_c}{2}$$

$$d_c = \frac{d_i + d_o}{2}$$



$F \equiv [\text{lbs}]$

$f_c \equiv -$

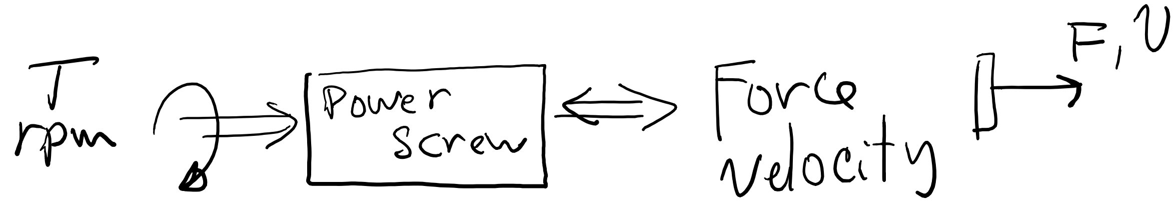
$d_c \equiv [\text{in}] \equiv$ Average diameter

$T_c \equiv [\text{lb-in}] \equiv$ Collar Torque

Q: What is the relationship between Torque (T), rpm (n) and Power in hp? (Look up from internet)

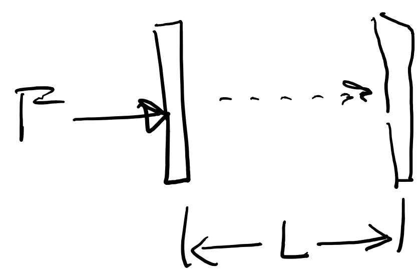
$$hp = \frac{Tn}{5252} \quad \begin{Bmatrix} T = \text{ft-lb} \\ n = \text{rpm} \end{Bmatrix}$$

or $$hp = \frac{Tn}{63000} \quad \begin{Bmatrix} T = \text{in-lb} \\ n = \text{rpm} \end{Bmatrix}$$



Q: if a power screw pushes a load F a distance of L what is the output energy (work)

$$\underbrace{E_{out}}_{\text{in-lb}} = \underbrace{F}_{\text{lbs}}\underbrace{L}_{\text{in}}$$



Q: if L is the power screw lead ... many turns is needed to advance the load by a distance L

one turn

Q: if a shaft is being turned with a torque of T_R and the shaft turns once, how much energy or work is needed

$$\underbrace{E_{in}}_{in-lb} = \underbrace{T_R}_{in-lb} \underbrace{\theta}_{radians}$$

one turn $\equiv 2\pi$ radians

$$E_{in} = 2\pi T_R$$

Q: what is the formula for efficiency

$$\eta = \frac{\text{Energy out in one turn}}{\text{Energy in in one turn}}$$

$$\eta = \frac{FL}{2\pi \ldots}$$ efficiency

$2\pi V_R$

$F =$ lbs

$L =$ in

$T_R =$ in-lb

Q: what is the minimum thread friction f necessary to make the power screw self-locking

T_L = Torque to lower the load

if $T_L \geq 0$ the Power screw is self-locking

$$T_L = \frac{F d_m}{2} \left(\frac{\pi f d_m - L}{\pi d_m + f L} \right)$$

Setting $T_L \geq 0$

$$\Rightarrow \pi f d_m - L \geq 0$$

$$f \geq \frac{L}{\ }$$

πd_m

Remember $\tan\lambda = \dfrac{L}{\pi d_m}$

$\Rightarrow \quad f \geq \tan\lambda$

$\lambda \equiv$ lead angle