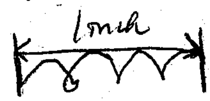
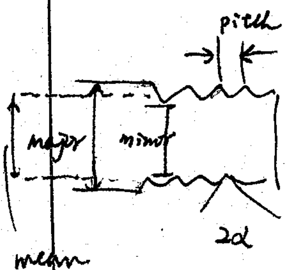
· mechanical fasteners

basic, important components

for example: an airplane may have several millions rivets, bolts and screws, these should be carefully designed with safty factors



Threaded fasteners

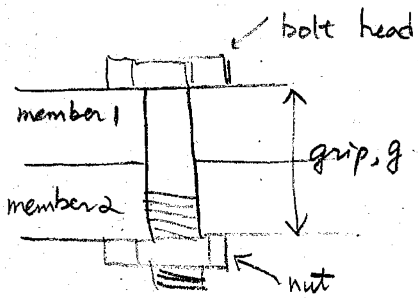


· see 8.1 for standard size and nomenclature

- pitch p (inch), $\frac{1}{p}$ = number of thread per inch
- lead ℓ = axial advance per revolution $\ell = np$
- thread angle 2α
- major & minor diameter, mean diameter
- tensile stress area

$n = \begin{cases} 1, & \text{single threaded screw} \\ 2, & \text{double threaded screw} \end{cases}$

later: Analysis of bolted joint



F_i = "preload" produced by tightening nut

$\frac{5}{8}'' - 18$ UNRF

- $\frac{5}{8}''$ ← nominal major diameter
- 18 ← number of threads per inch $\frac{1}{p}$
- UNRF ← thread series

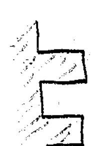
M12 × 1.75

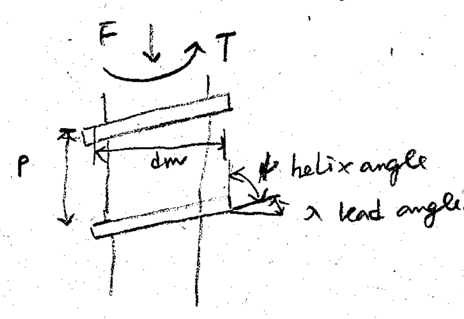
- M ← mm
- 12 ← nominal major diameter
- 1.75 ← pitch

- UN → unified thread standard
- UNR → must use root radius → reduce stress concentration ↓ improved fatigue strength
- UNRF → fine
- (C) coarse

· power screw

raising a load F — square thread

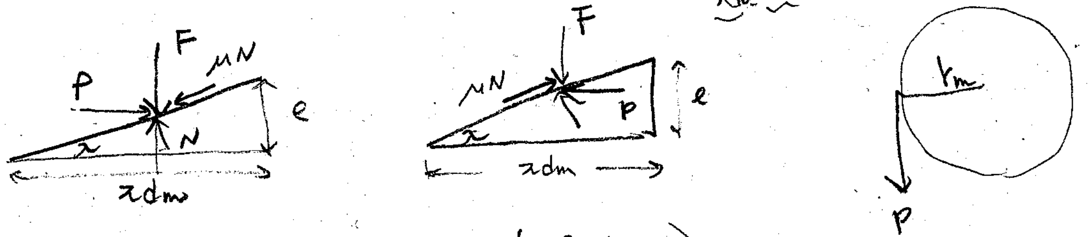




T: Torque required to raise the load?

extend one cycle (This represent the whole system)

$\because \frac{F}{\pi N}$ $\frac{P}{\pi N}$ $\rightarrow$



raise

lower

$$\begin{cases} \Sigma F_H = 0 = P - N\sin\lambda - \mu N\cos\lambda = 0 \\ \Sigma F_V = 0 = F + \mu N\sin\lambda - N\cos\lambda = 0 \end{cases}$$

we are not interested in N

eliminate it

$$\rightarrow \quad P = \frac{F(\sin\lambda + \mu\cos\lambda)}{\cos\lambda - \mu\sin\lambda} \qquad \text{raise}$$

Same way for lower

$$\rightarrow \quad P = \frac{F(\mu\cos\lambda - \sin\lambda)}{\cos\lambda + \mu\sin\lambda} \qquad \text{lower}$$

check the book formula (■) is not correct ✓

also we have $\tan\lambda = \frac{e}{\pi d_m}$

$$\begin{cases} P = \dfrac{F\left[\left(\frac{e}{\pi d_m}\right) + \mu\right]}{1 - \frac{\mu e}{\pi d_m}} & \text{raise} \\ P = \quad & \text{lower} \end{cases}$$

$$\text{Torque} = P \cdot \frac{d_m}{2}$$

$$= \frac{F d_m}{2}\left[\frac{e + \pi\mu d_m}{\pi d_m - \mu e}\right] \qquad \text{raise}$$

same way $\text{Torque} = \frac{F d_m}{2}\left(\frac{\pi\mu d_m - e}{\pi d_m + \mu e}\right)$ lower

if Torque lower $< 0 \rightarrow$ lower automatically

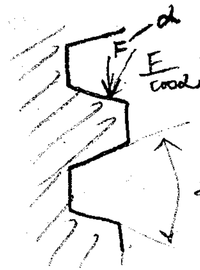
$> 0 \rightarrow$ self-locking

for self locking $\Longrightarrow \pi d_m \mu > e$

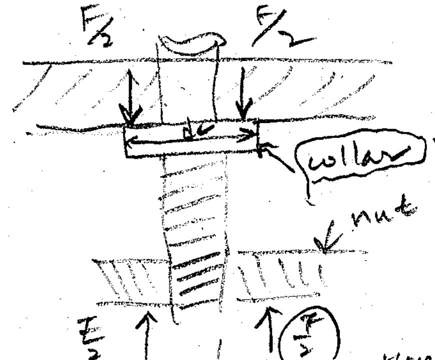
$$\Longrightarrow \mu > \frac{e}{\pi d_m} = \tan\lambda$$

friction coefficient — thread lead angle.

- non-square thread



→ equivalent to increase the frictional force by $\frac{1}{\cos\alpha}$



same derivation

$$T_{raise} = \frac{F d_m}{2}\left(\frac{l + \pi \mu d_m \sec\alpha}{\pi d_m - \mu l \sec\alpha}\right) + \frac{F \mu_c d_c}{2}$$

μ_c: collar coefficient of friction

d_c: collar diameter

(neglect the lead angle effect) since it is small in most cases.

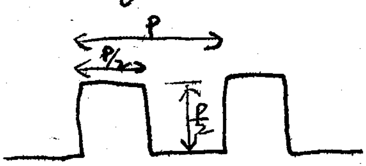
yes · efficiency of gear

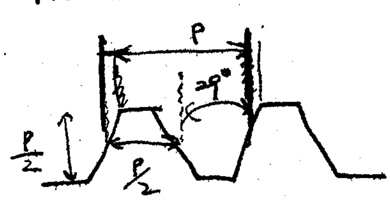
if $\mu = 0$ (no friction)

$$\rightarrow T_0 = \frac{Fl}{2\pi}$$

$$e = \frac{T_0}{T} = \frac{Fl}{2\pi T}$$

square & ACME thread





read Fig. 8-3

Table 8-3 (preferred pitches)

- example for power screw

problems 8-5, 8-6

load = 5000 lb

ACME TREADS $p = \frac{1}{2}'' =$ lead l ($= np$, ($n=1$ here)), Diamete $= 3''$, $\mu = 0.05$

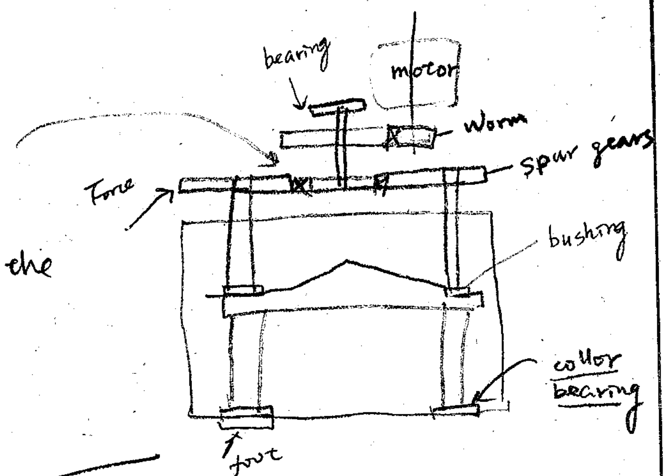
motor 1720 rpm

$\mu_c = 0.06$

$d_c = 5''$

gear efficiency $e = 95\%$

Speed ratio $= 75:1$ (gears)



$\Rightarrow$ horse power rating of the motor ?

Sol:

motor 1720 rpm

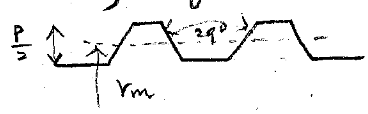
Speed ration 75 : 1

~~1 rev $\rightarrow \frac{1}{2}''$~~

~~$\rightarrow \frac{1720}{75}$ rev/min $\rightarrow 22.9 \cdot \frac{1}{2}$ in/min~~

Full load 5000 lb $\rightarrow$ each screw 2500 lb

ACME thread, Fig 8.3 — preferred pitch, $p = \frac{1}{2}'' \rightarrow d = ?$



raise

$$T_{raise} = \frac{F d_m}{2}\left(\frac{l + \pi \mu d_m \sec\alpha}{\pi d_m - \mu l \sec\alpha}\right) + \frac{F \mu_c d_c}{2}$$

($F = 2500$, $\mu = 0.05$, $\mu_c = 0.06$, $d_c = 5$)

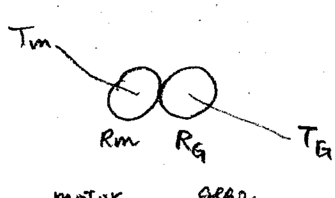
$r_m =$

$d_m = d - \frac{P}{2} = 3 - \frac{\frac{1}{2}}{2} = 2.75''$

$2\alpha = 29° \rightarrow \sec\alpha = 1.033$

$$T_G = \frac{2500 \cdot 2.75}{2}\left(\frac{\frac{1}{2} + \pi \cdot (0.05)\, 2.75 \cdot 1.033}{\pi(2.75) - (0.05)\frac{1}{2}(1.033)}\right) + \frac{2500 \cdot 0.06 \cdot 5}{2}$$

$= 753$ lb-in (377.6 + 375)



distance is the same

$Speed_m \cdot R_m = Speed_G \cdot R_G$

$$\Rightarrow \frac{Speed_m}{Speed_G} = 75 = \frac{R_G}{R_m}$$