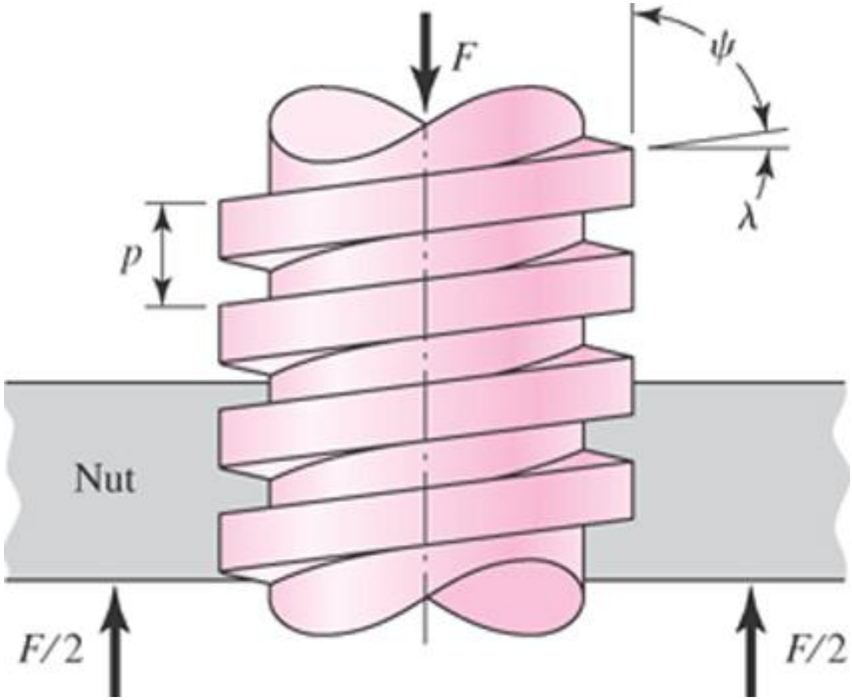
MECH 325
Power Screw Analysis



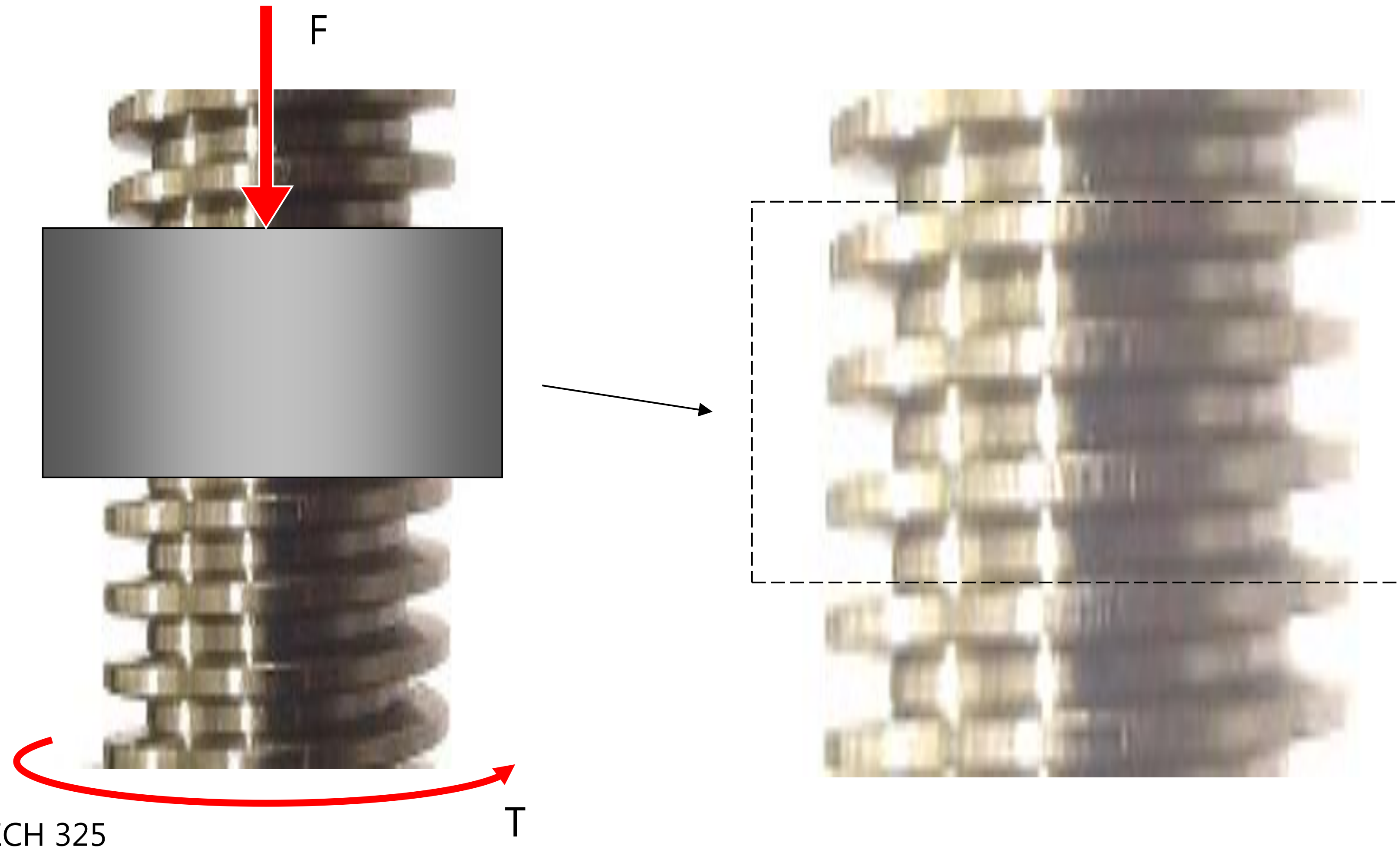
Objectives

By the end of today's class, you should be able to:

- Calculate torque for various power screw applications
- Describe the characteristic of self-locking and determine conditions necessary for self-locking
- Describe and quantify the effect of the thread type and nut on raising and lowering torque
- Analyze power screw thread stress

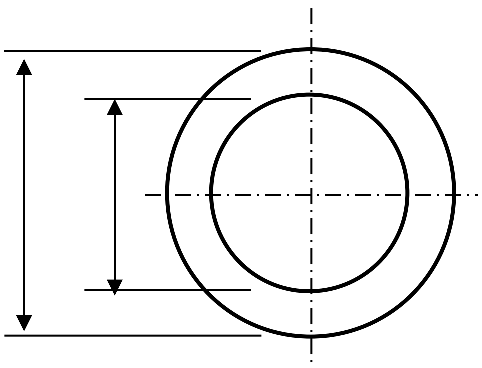
Stresses

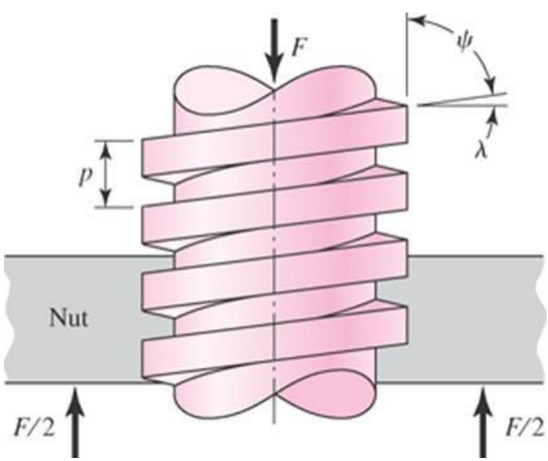
- Sketch the stress distribution present on the screw threads for an axial load F on the nut and a torque T on the screw



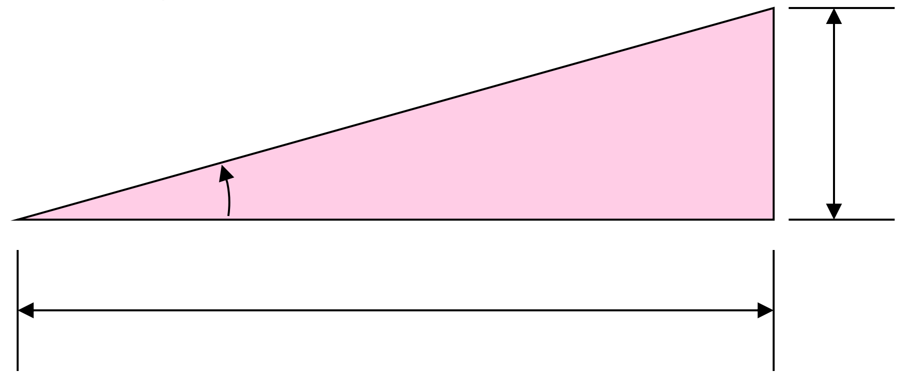
Origin of Power Screw Torque

- Complete the diagrams (represent stresses and torques as point forces on the unrolled incline planes)

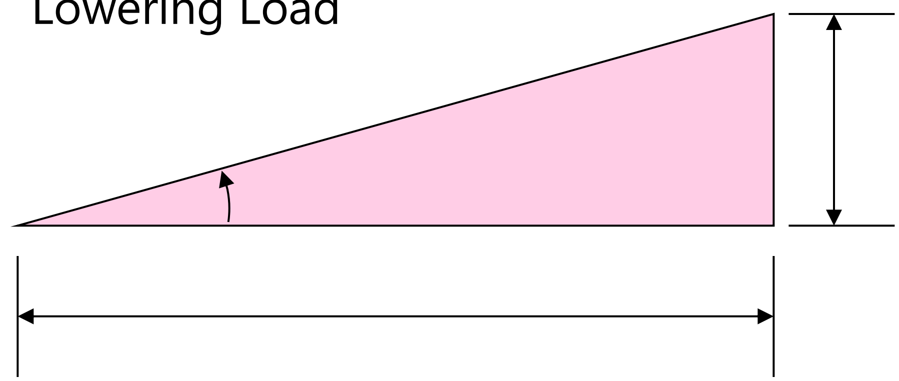




Raising Load



Lowering Load



Torque Relationships

- Express the driving forces in terms of other known variables:

- With some simple geometry, and noting that the driving force (P_R or P_L) is actually a torque (T_R or T_L) acting at a distance, we get the two characteristic torque equations

$$T_R = \frac{Fd_m}{2}\left(\frac{\pi f d_m + l}{\pi d_m - fl}\right) \qquad T_L = \frac{Fd_m}{2}\left(\frac{\pi f d_m - l}{\pi d_m + fl}\right)$$

Conditions for Self Locking

- Starting with the lowering torque equation:

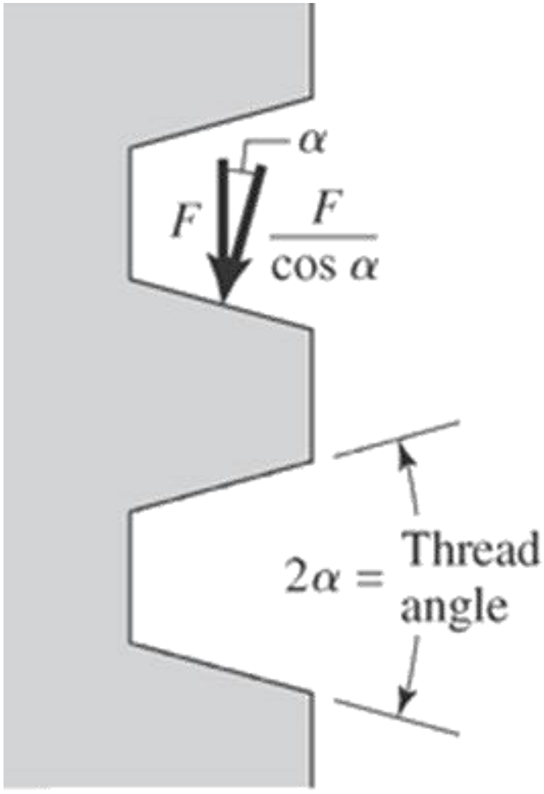
$$T_L = \frac{Fd_m}{2}\left(\frac{\pi f d_m - l}{\pi d_m + fl}\right)$$

- Self-locking occurs when:

- Efficiency, *e*, is the ratio of raising torque without friction to with friction:

Effect of Thread Angle

- Change when ACME threads used:



$$T_R = \frac{Fd_m}{2}\left(\frac{\pi f d_m \sec\alpha + l}{\pi d_m - fl\sec\alpha}\right)$$

$$T_L = \frac{Fd_m}{2}\left(\frac{\pi f d_m \sec\alpha - l}{\pi d_m + fl\sec\alpha}\right)$$

Friction Coefficients

Screw-Nut friction coefficient, f

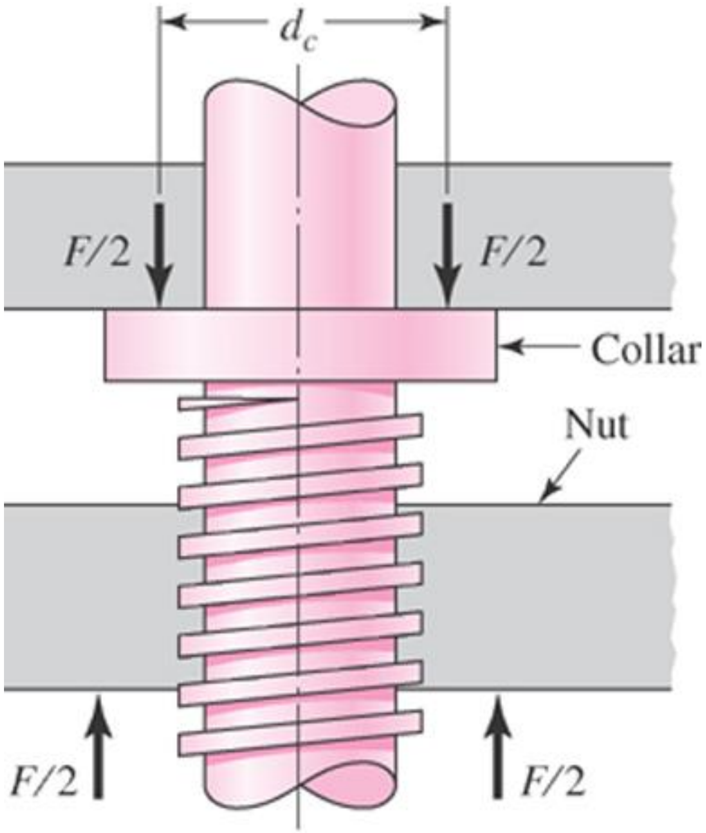
Screw Material	Nut Material Steel	Bronze	Brass	Cast Iron
Steel, dry	0.15–0.25	0.15–0.23	0.15–0.19	0.15–0.25
Steel, machine oil	0.11–0.17	0.10–0.16	0.10–0.15	0.11–0.17
Bronze	0.08–0.12	0.04–0.06	—	0.06–0.09

Thrust collar friction coefficient, f_c

Combination	Running	Starting
Soft steel on cast iron	0.12	0.17
Hard steel on cast iron	0.09	0.15
Soft steel on bronze	0.08	0.10
Hard steel on bronze	0.06	0.08

Collar Friction Torque

- A thrust collar is needed to carry axial loads
- Creates additional frictional torque:



Thread Stress

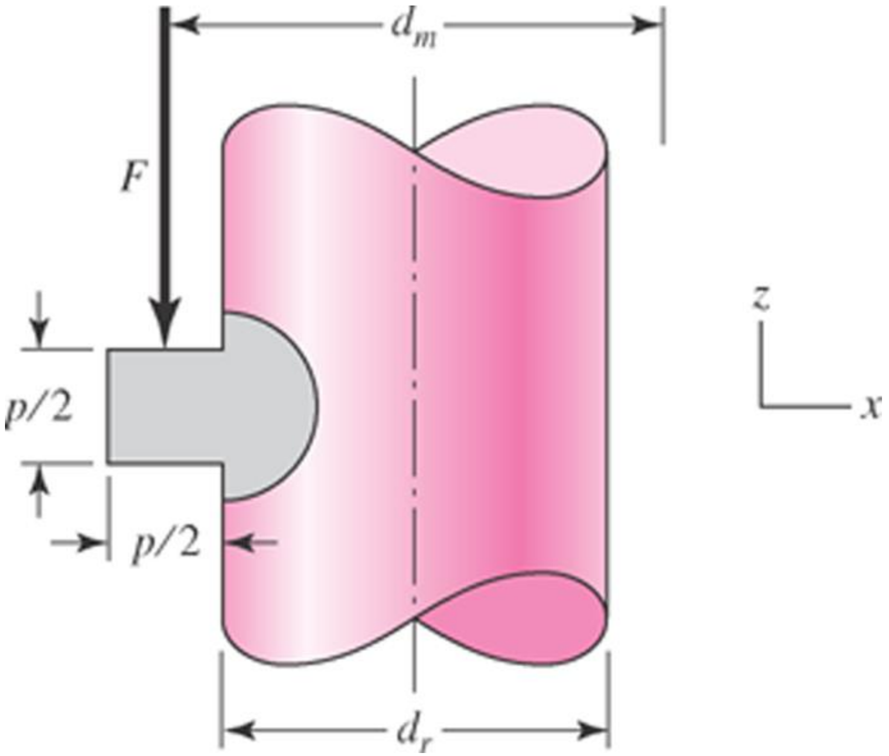
- Thread stress arises from:

- Resulting equations:

$$\sigma_x = \frac{6F}{\pi d_r n_t p}$$

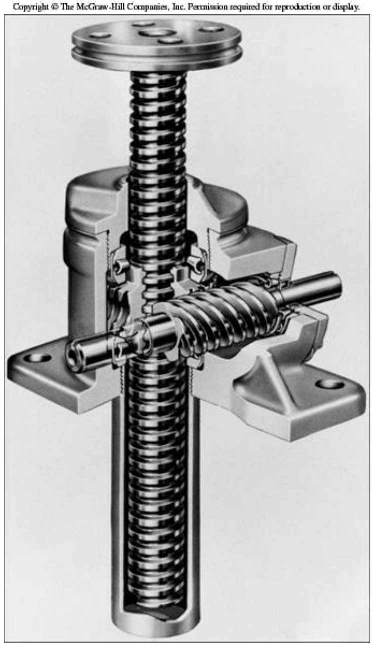
$$\sigma_z = -\frac{4F}{\pi d_r^{\,2}}$$

$$\tau_{yz} = \frac{16T}{\pi d_r^{\,3}}$$

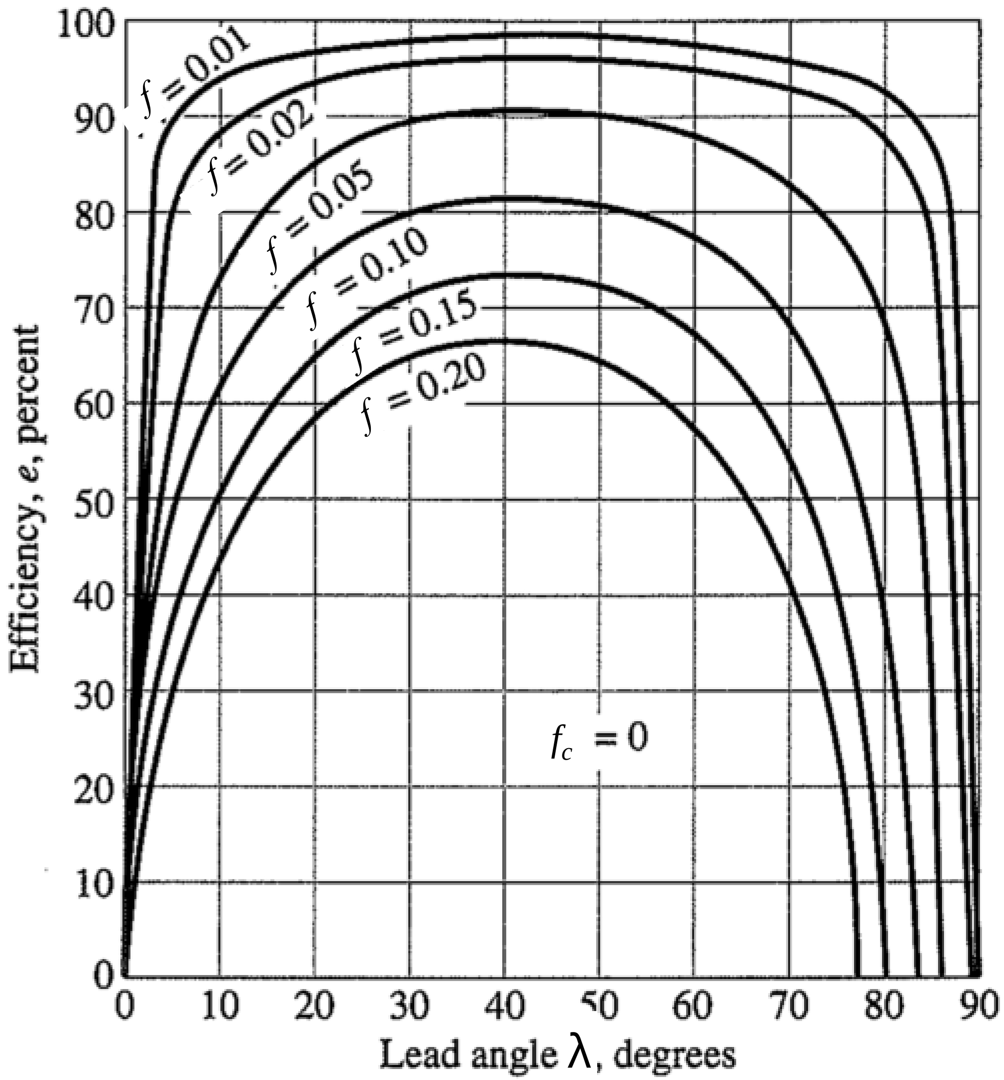


Engaged Threads

- Power screw in compression raising an axial load:
  - How does the screw deform?
  - How does the nut deform?
- All threads not equally engaged
  - 1st engaged thread carries ~38% of load
  - 2nd engaged thread carries ~25% of load
  - 3rd engaged thread carries ~18% of load
  - … 7th engaged thread carries ~0% of load

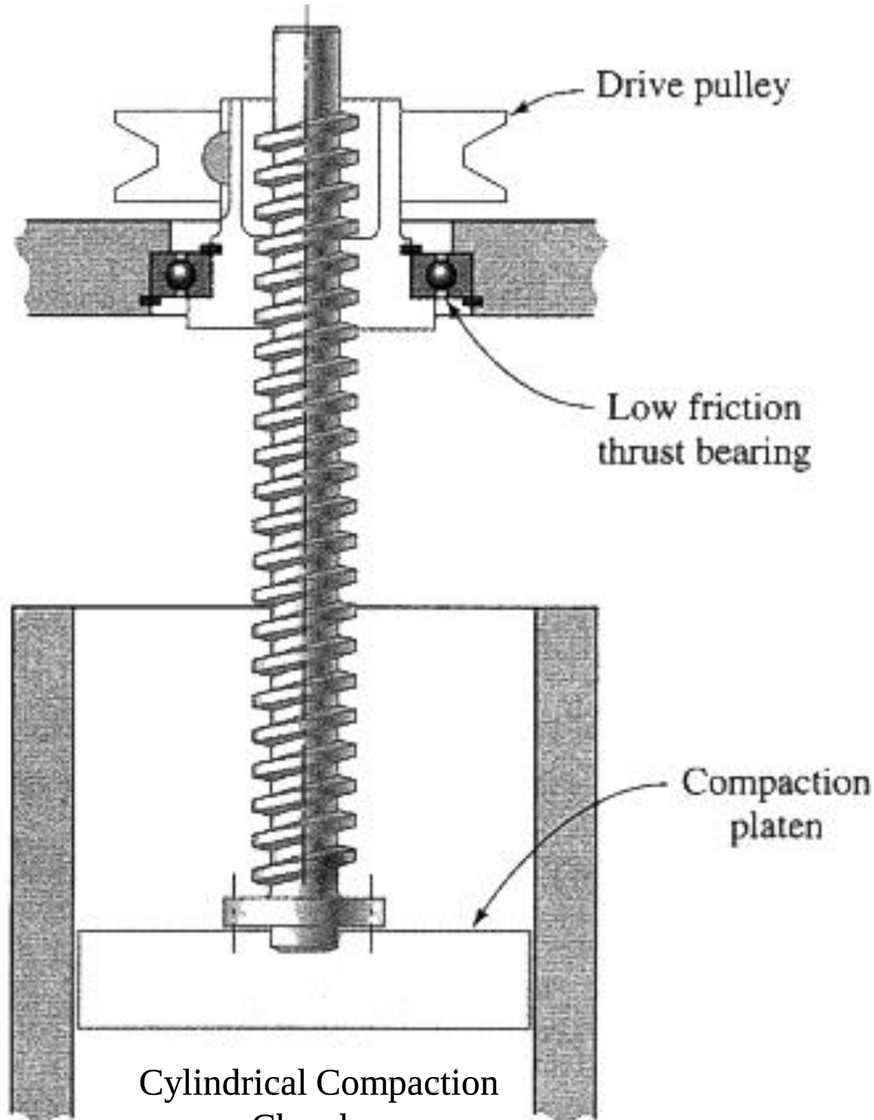


Power Screw Efficiency



Design Examples

- For the designs that follow, will they work as intended?
  - If no, how should the design be changed?
  - If yes, could the design be further improved?



Cylindrical Compaction Chamber

Design Examples