EICoM
ELECTRICAL COMPUTER MECHATRONICS

تقدم لجنة

ملخص لمادة:

تصميم ميكانيكي

جزيل الشكر للطالب:

حمزة اسماعيل

* Mechanical Engineering Design :-

* Ch1 :- Concept of stress :-

* Stresses :-

1. Normal stress → Tension stress. / → Compression stress.
2. Shearing and Bearing stress.
3. Torsion stress.
4. Bending stress.
5. Buckling stress X

* Normal stress (Axial stress) :-

$$\boxed{\sigma = \frac{P}{A}}$$

P → Axial force.

A → cross section area.

σ → Positive ⇒ Tension force

σ → Negative ⇒ Compression force

$\sigma = \frac{N}{m^2} = Pa.$

$$\boxed{\begin{array}{ll} K = 1000 & M = 10^6 \\ G = 10^9. & \end{array}}$$

* Shearing stress :- . القطع stress

shearing stress ⇒ . الخاص بالبراغي stress ال.

1) Single shear ⇒ One Cutting area.

$$\boxed{\tau = \frac{P}{A} = \frac{F}{A}}$$

→ force

→ cross section area of screw للبرغي

2) Double shear ⇒ Two Cutting area.

$$\boxed{\tau = \frac{P}{A} = \frac{F/2}{A} = \frac{F}{2A}.}$$

* Bearing stress :- (shearing stress) مرتبط بال stress

$$\boxed{\sigma_b = \frac{P}{A} = \frac{F}{td}}$$

t → thickness

d → diameter.

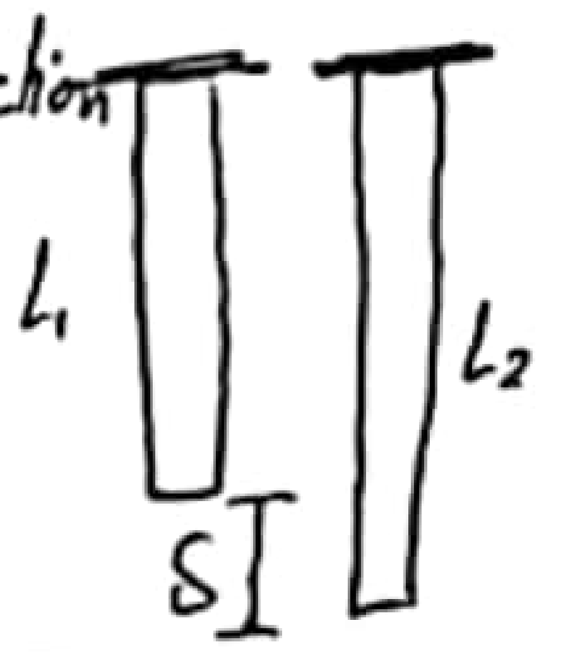
* Ch2 :- Stress and strain (Axial loading)

$$\boxed{\varepsilon = \frac{\delta}{L_1}} = \frac{L_2 - L_1}{L_1}$$

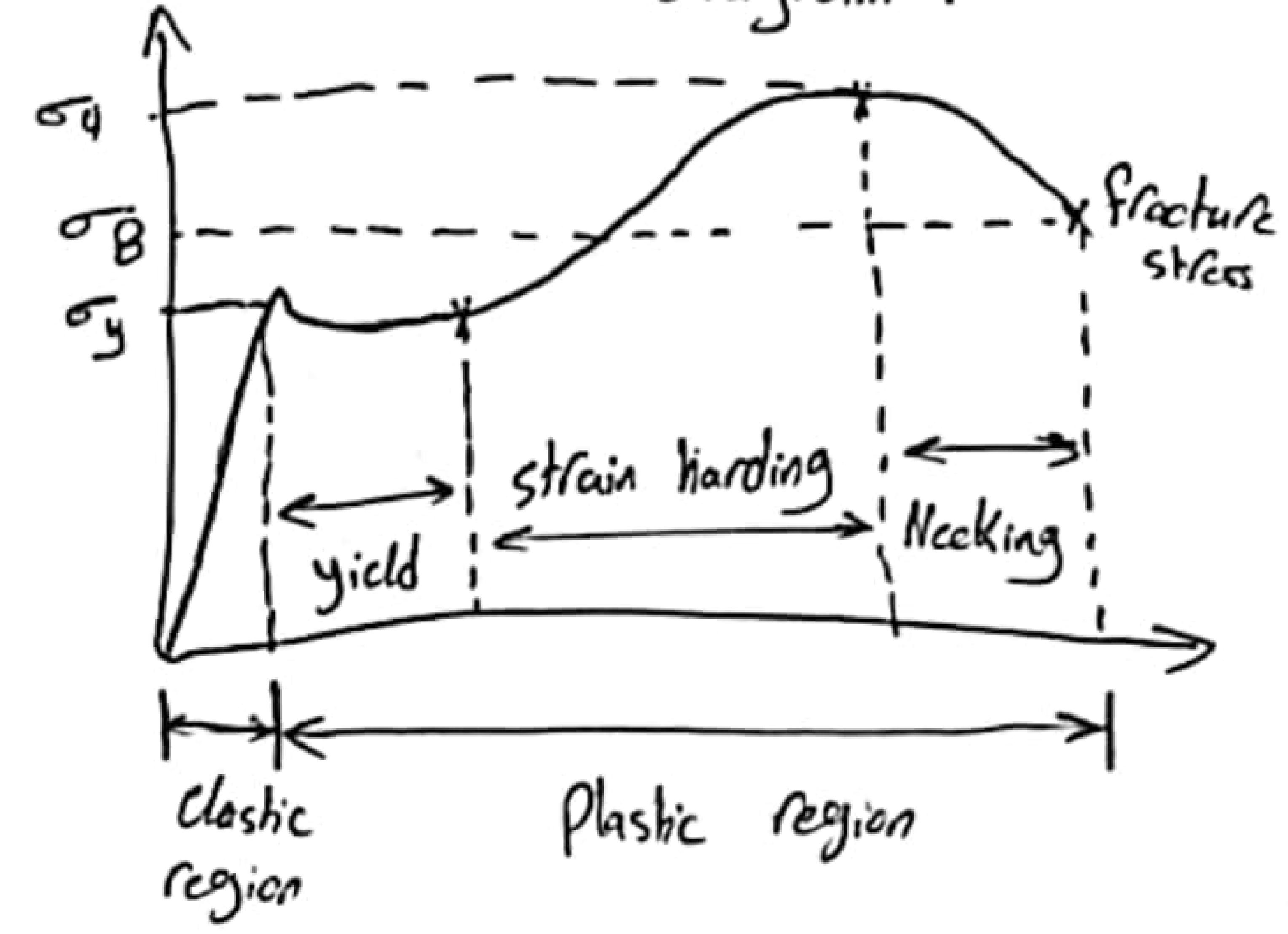
$L_2 - L_1$ → deflection

L_1 → length.

ε → strain (مطاوعة المادة).



* Stress and strain Diagram :-



σ_y → yield stress.

σ_u → Ultimate stress.

σ_B → Breaking stress.

* Hooke's law :- modulus of elasticity :-

$$\boxed{\sigma = E\varepsilon}$$

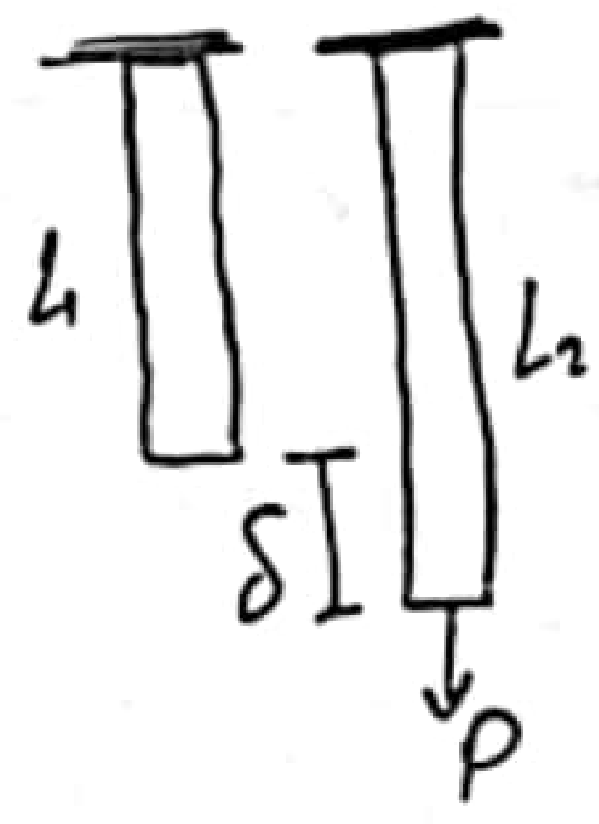
E → modulus of elasticity.
elastic.

* Deformations of members :-

$\sigma = \frac{P}{A}$, $\varepsilon = \frac{\delta}{L}$

$\sigma = E\varepsilon$

$\frac{P}{A} = E\frac{\delta}{L} \Rightarrow \boxed{\delta = \frac{PL}{AE}}$



* Deformations of members :-

for more than one Cylinder.

$$\boxed{\delta = \sum_i \frac{PL}{AE}}$$

δ → total deformation

P → tension ⇒ ⊕ elongation

P → Comprision ⇒ ⊖ elongation

→ more than one force (P).

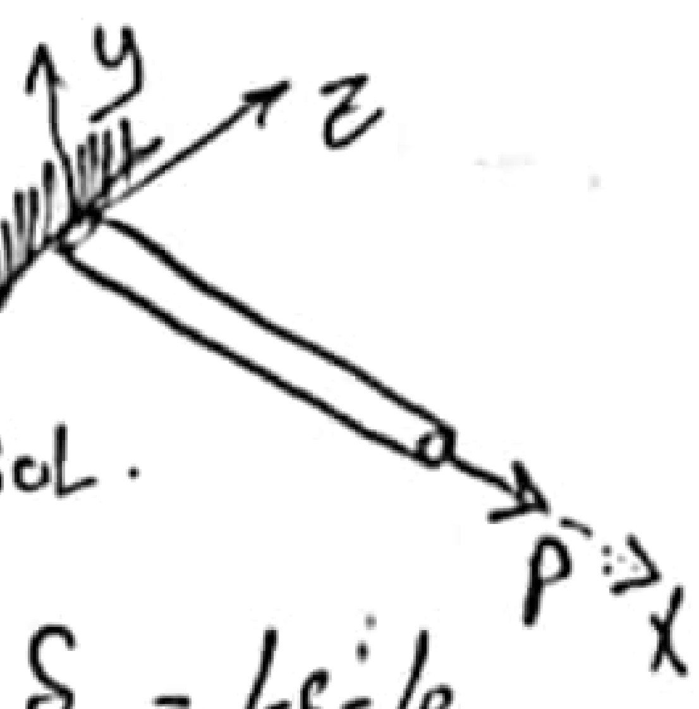
→ more than one length (L).

→ more than one Area (A).

* Mechanical Engineering Design :-

* Ch 2 : stress and strain :-

* Poisson's ratio (ν) :-



$$\nu = -\frac{\text{Lateral strain}}{\text{axial strain}} = -\frac{\varepsilon_{lat}}{\varepsilon_{axial}}.$$

$$\varepsilon_{lat} = \frac{\Delta d}{d} = \frac{d_f - d_o}{d_o} \quad , \quad \varepsilon_{axial} = \frac{\delta}{L} = \frac{L_f - L_o}{L_o}.$$

$$\sigma = E\varepsilon. \quad , \quad \nu = -\frac{\varepsilon_y}{\varepsilon_x}.$$

$$\boxed{\varepsilon_x = \frac{\sigma}{E}.} \qquad \boxed{\varepsilon_y = -\nu\varepsilon_x}$$

↳ axial strain. ↳ ~~axial~~lateral strain.

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* Allowable stress :-

$$\text{allowable stress} = \frac{\text{ultimate stress}}{\text{factor of safety}}.$$

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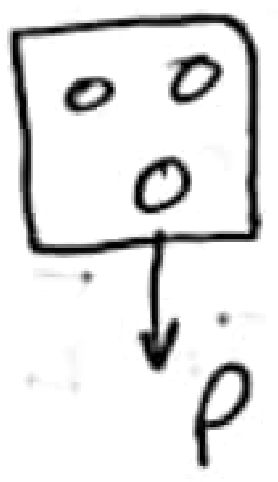
* shear stress with more than one bolt :-

$$\tau = \frac{P}{NA}$$

N → number of bolt.

A → Area of bolt.



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* Torsion stress :-

$$\boxed{\tau = \frac{Tr}{J}}$$

$$\boxed{J = \frac{\pi}{2} r^4 = \frac{\pi}{32} d^4}$$

$$\boxed{J = \frac{\pi}{2}(R^4 - r^4)}$$

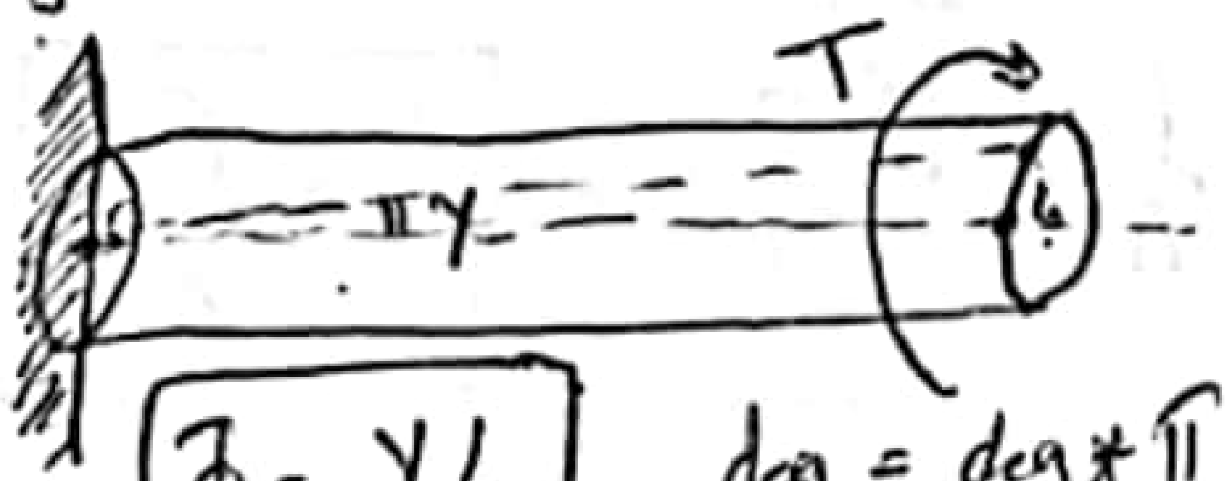
$$\boxed{\gamma = \frac{r\Phi}{L}\,(\text{rad})}$$

τ → shear stress.

T → Torqe

r → radius of shaft

J → moment of Inertia.



$$\boxed{\Phi = \frac{\gamma L}{r}.}$$

(rad)

$$\text{deg} = \text{deg} * \frac{\pi}{180}$$

γ → shear strain (rad) r → radius of shaft

Φ → twist angle (rad) L → lenght of shaft.

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* Hook's law for shear loading states :-

$$\tau = G\gamma.$$

G → Modulus of rigidity

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* Hook's law for shear loading states :-

$$\tau = G\gamma.$$

$$\frac{Tr}{J} = G\frac{r\Phi}{L}$$

$$\Rightarrow \boxed{T = \frac{GJ\Phi}{L}} \quad , \quad \boxed{T = \frac{G\gamma J}{r.}}$$

$$\Rightarrow \boxed{\Phi = \frac{TL}{GJ}} \qquad \boxed{\Phi = \frac{TL}{Gr.}}$$

$$\tau_{max} = G\gamma_{max}.$$

$$\boxed{\frac{\tau_{max}}{\tau_{min}} = \frac{r_{max}}{r_{min}.}}$$

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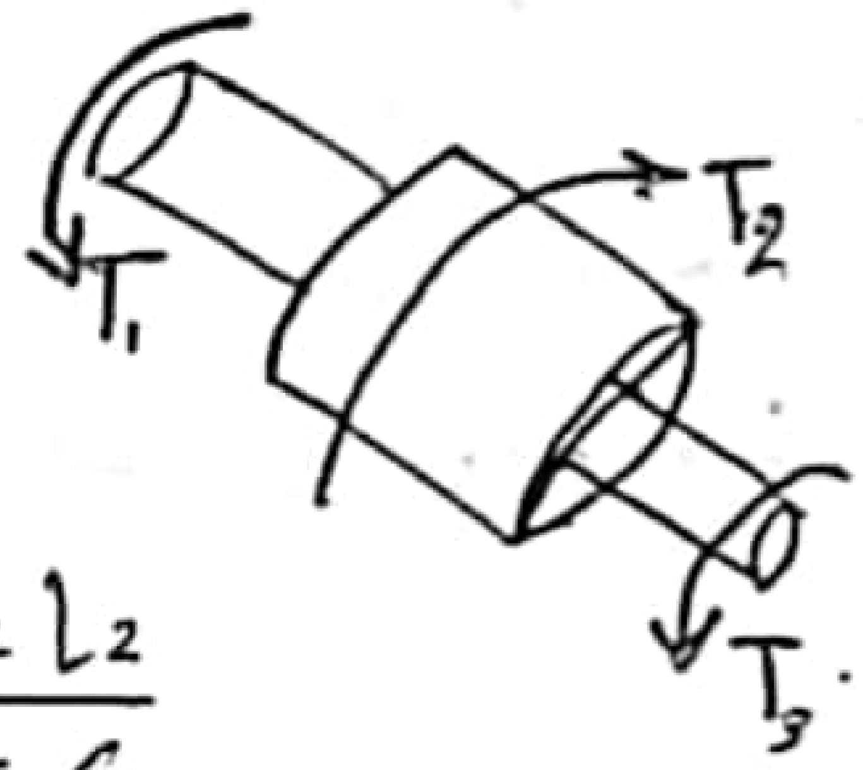
* Angle of Twist for complex shaft.

$$\Phi = \sum_{i=0}^{i=i} \frac{T_i L_i}{J_i G_i}$$



$$\Phi = \frac{T_1 L_1}{J_1 G_1} \oplus \frac{T_3 L_3}{J_3 G_3} \ominus \frac{T_2 L_2}{J_2 G_2}.$$

انتبه للاشارات .

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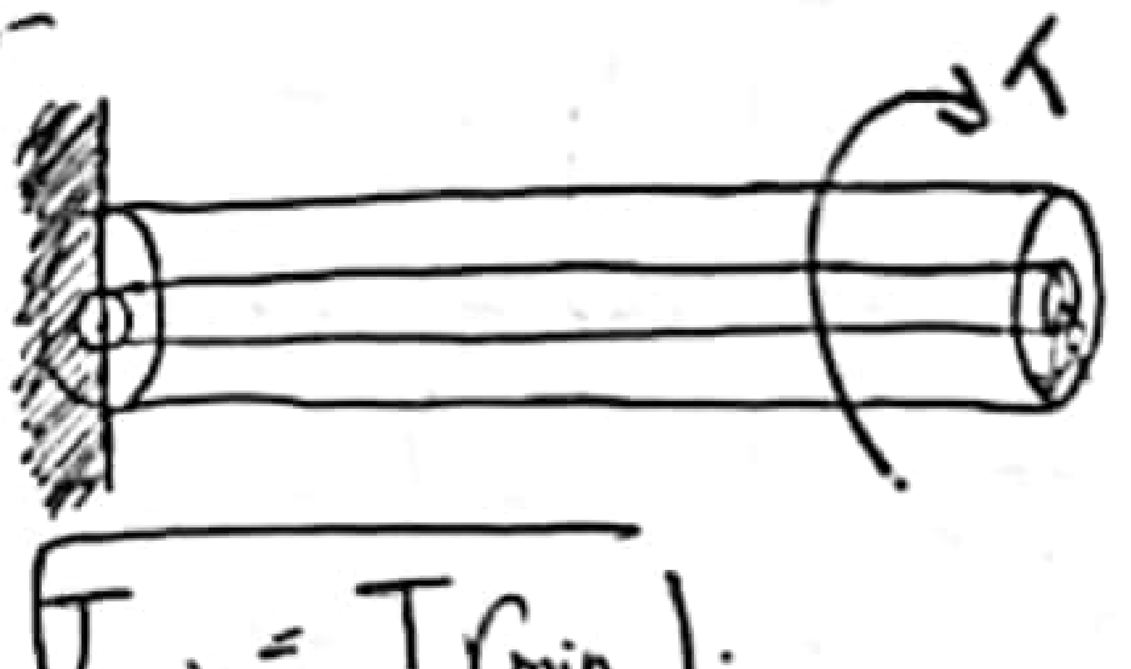
* Shear stress :-

$$\tau = \frac{Tr}{J}.$$



$$J = \frac{\pi}{2}(R^4 - r^4).$$

$$\boxed{\tau_{max} = \frac{TR_{max}}{J}} \quad , \quad \boxed{\tau_{min} = \frac{Tr_{min}}{J}}$$

$$\frac{\tau_{max}}{\tau_{min}} = \frac{R_{max}}{r_{min}}.$$

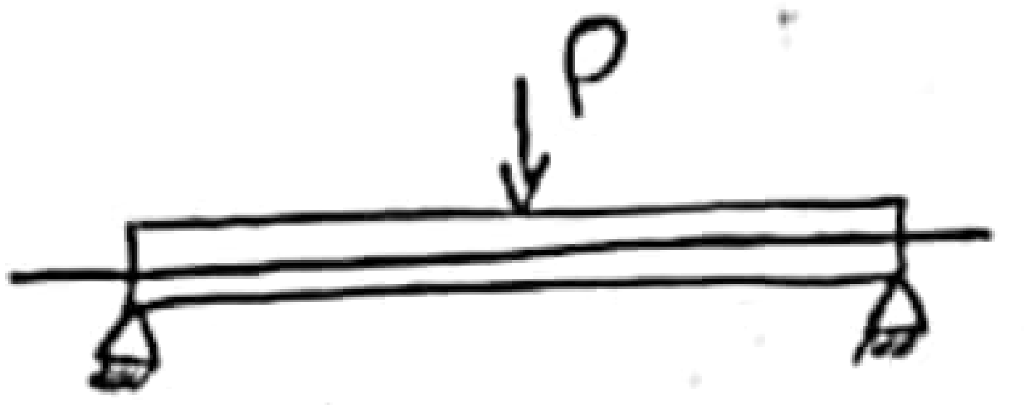
$$\boxed{\tau_{max} = G\gamma_{max}}$$

$$\boxed{\tau_{min} = G\gamma_{min}}$$

* Mechanical Engineering Design :-

* Ch3 :- Pure Bending :-

* Pure Bending :-



maximum stress (σ)

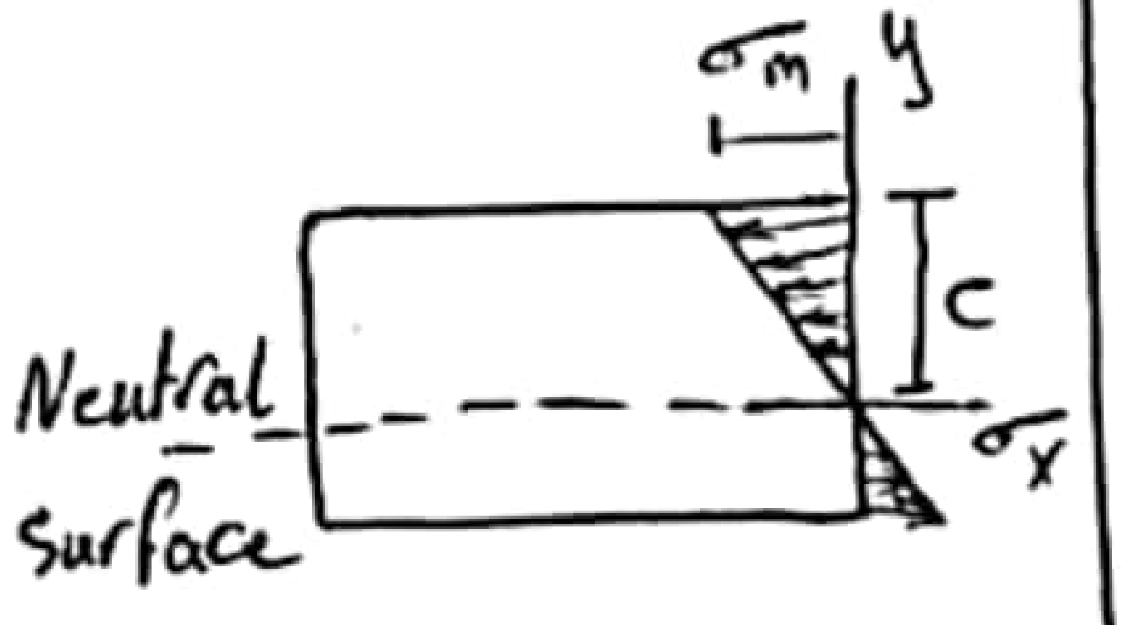
$$\boxed{\sigma = \frac{M}{S}}$$

M → moment

S → Section modulus

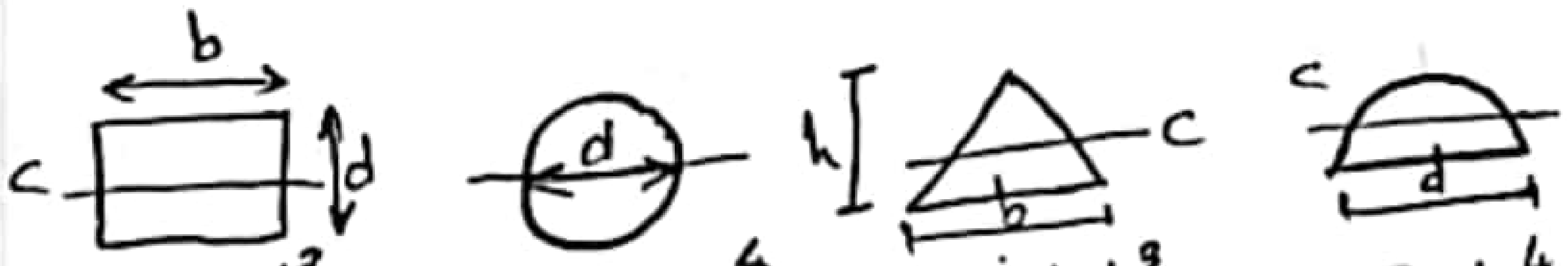
$\boxed{S = \frac{I}{c}}$ → moment of inertia, → Centroid.

$$\boxed{\sigma = \frac{Mc}{I}}$$



$$\boxed{\sigma_m = \frac{M}{S}}$$

$$\boxed{\sigma_x = \frac{y}{c}\sigma_m}$$



$I = \frac{bd^3}{12}$ $\quad I = \frac{\pi}{4}\left(\frac{d}{2}\right)^4$ $\quad I = \frac{bh^3}{36}$ $\quad I = \frac{\pi}{8}\left(\frac{d}{2}\right)^4$

$c = \frac{d}{2}$ $\quad c = \frac{d}{2}$ $\quad c = \frac{2h}{3}$ $\quad c = \frac{d}{2} - \frac{2d}{3\pi}$

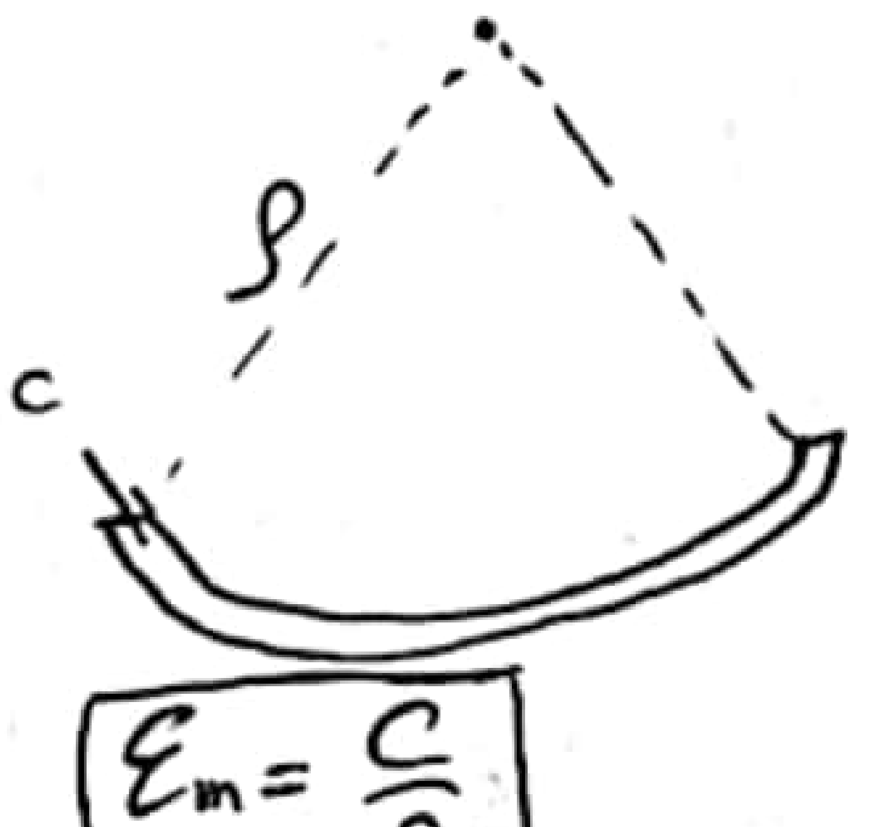
* Stresses and deformations in the Elastic :-

$$\boxed{\sigma_x = E\,\varepsilon_x}$$

$$\boxed{\sigma_m = E\,\varepsilon_m.}$$

$$\boxed{\sigma_x = \frac{y}{c}\sigma_m}$$

$$\boxed{\varepsilon_x = \frac{y}{c}\varepsilon_m}$$



$$\boxed{\varepsilon_m = \frac{c}{\rho}}$$

$$\boxed{\varepsilon_x = \frac{y}{\rho}}$$

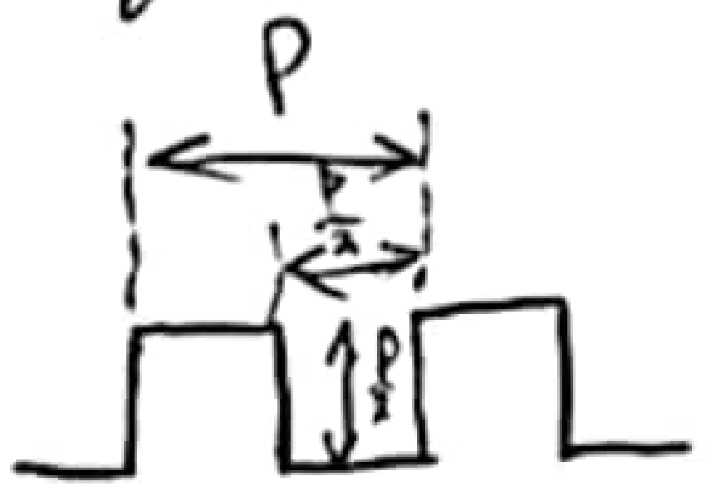
* Screws and Fasteners :-

- Pitch : distance between adjacent (اسنان متتالية)
- Major diameter (dm) :- the largest diameter
- Minor diameter : the smallest diameter
- Pitch diameter :- diameter between the major and the minor diameter

* Screws and Fasteners :-

- The lead (L) :- distance the nut moves parallel to the screw axis.
- The lead and pitch.
  - → single thread → L = p.
  - → double - thread → L = 2p.
  - → triple - thread → L = 3p.

* Square and Acme Thread



width = $\frac{p}{2}$

depth = $\frac{p}{2}$

width = $\frac{p}{2}$

depth = $\frac{p}{2}$

* Raising and lowering force :-

$$P_R = \frac{F(\sin\lambda + f\cos\lambda)}{\cos\lambda - f\sin\lambda.}$$

$$P_R = \frac{F[(L/\pi d_m) + f]}{1 - (fL/\pi d_m)}$$

$$P_L = \frac{F(f\cos\lambda - \sin\lambda)}{\cos\lambda + f\sin\lambda.}$$

$$P_L = \frac{F[f - (L/\pi d_m)]}{1 + (fL/\pi d_m)}$$

P_R → Raising force

d_m → Pitch diameter - L = lead.

f → coefficient of friction.

P_L → lowering force

F → force, load

$\tan\lambda = \frac{L}{\pi d_m}$.

λ → lead angle

* Mechanical Engineering Design:-

* Ch4:- Screws and Fasteners:-

* Raising and lowering Torques:-

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

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

* Power screw efficiency:-

$$T_R \big|_{f=0} = T_o = \frac{F L}{2\pi}$$

$$e = \frac{T_o}{T_R} - \frac{F L}{2\pi\, T_R}.$$

* Adding Collar Torque:-

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

, $d_c \rightarrow$ Collar diameter

$f_c \rightarrow$ Coefficient of collar friction.

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

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

* Threaded fasteners:-

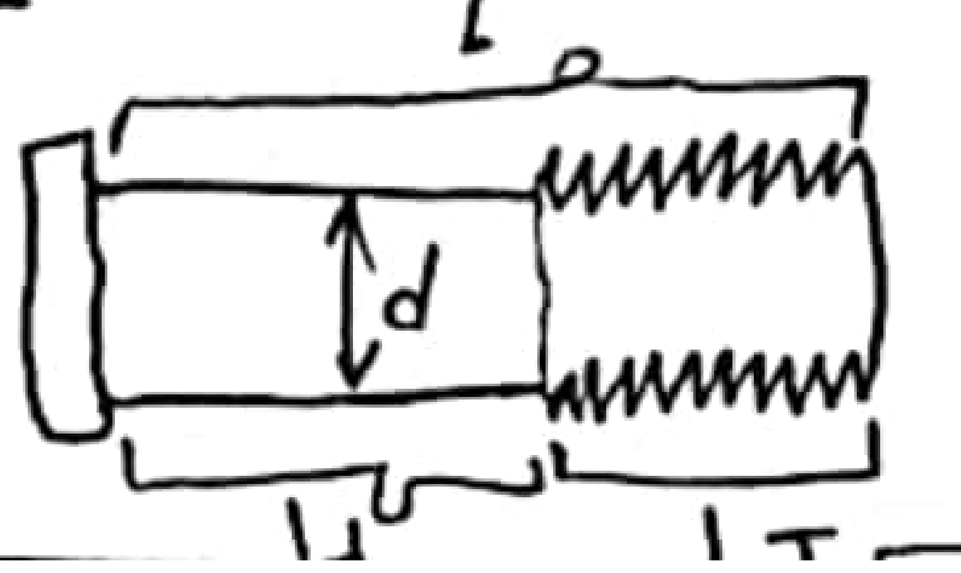
- standard bolt Length:-

thread length of inch-series bolts.

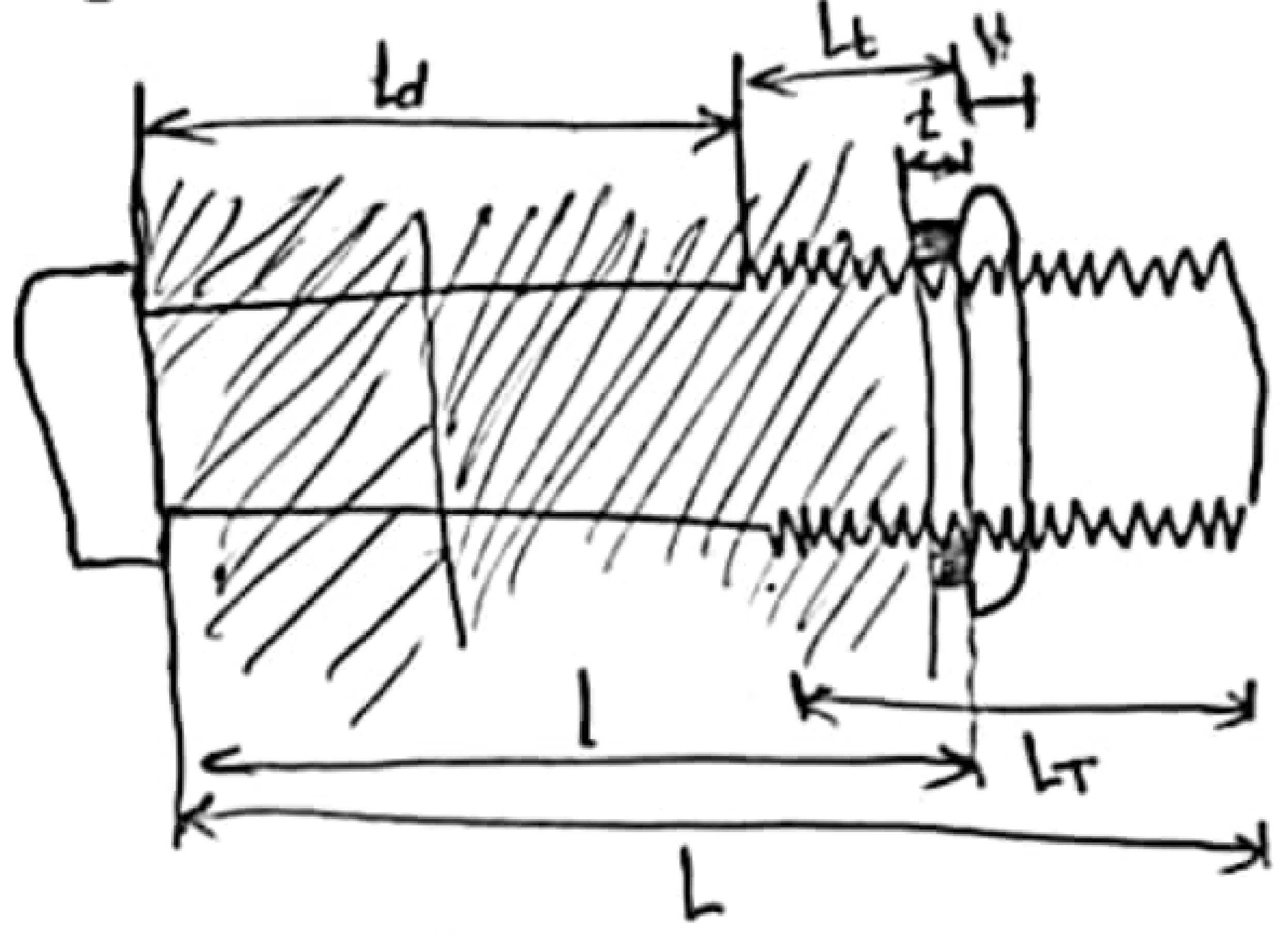
$$L_T = \begin{cases} 2d + \frac{1}{4}\text{ in} & L \leq 6\text{ in} \\ 2d + \frac{1}{2}\text{ in} & L > 6\text{ in} \end{cases}$$

thread length of metric bolts.

$$L_T = \begin{cases} 2d + 6 & L \leq 125\text{ mm} \\ 2d + 12 & L \leq 200\text{ mm} \\ 2d + 25 & L > 200\text{ mm} \end{cases}$$



* Joints and Fastener Terminology:-



L= nominal length total length (الطول الكلي)

L_T = Threaded length of bolt الطول المسنن

L_d = Unthreaded length of bolt الطول الغير مسنن

$\boxed{L_d = L - L_T}$ ⟶ نجده من القوانين السابقة

t: Washer thickness

H: Nut Height.

l = Thickness of all material squeezed between face of bolt and face of nut

l_t = Threaded portion of bolt inside the squeezed material

$\boxed{l_t = l - L_d} \leftarrow L_d = L - L_T.$

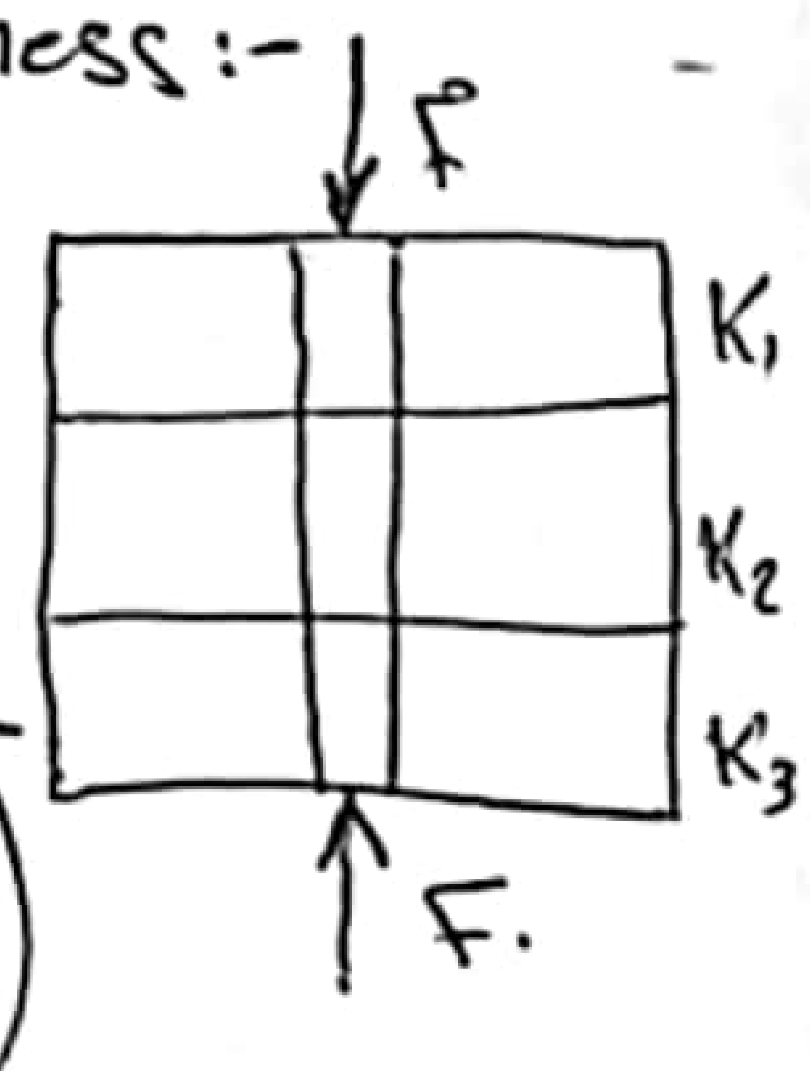
* Bolt stiffness (K_b):-

$$K_t = \frac{A_t E}{l_t} \qquad K_d = \frac{A_d E}{l_d} \qquad K_b = \frac{K_d K_t}{K_d + K_t}.$$

$$\Rightarrow \boxed{K_b = \frac{A_d A_t E}{A_d l_t + A_t l_d}} \Rightarrow \text{Bolt stiffness}$$

* Joints - Member stiffness:-

$$\frac{1}{K_m} = \frac{1}{K_1} + \frac{1}{K_2} + \frac{1}{K_3} \dots$$



$$K = \frac{0.5774\pi E d}{\ln\left(\frac{(1.155t + D - d)(D + d)}{(1.155t + D + d)(D - d)}\right)}$$

d → diameter of the bolt.

D → Smallest diameter in Frustum.