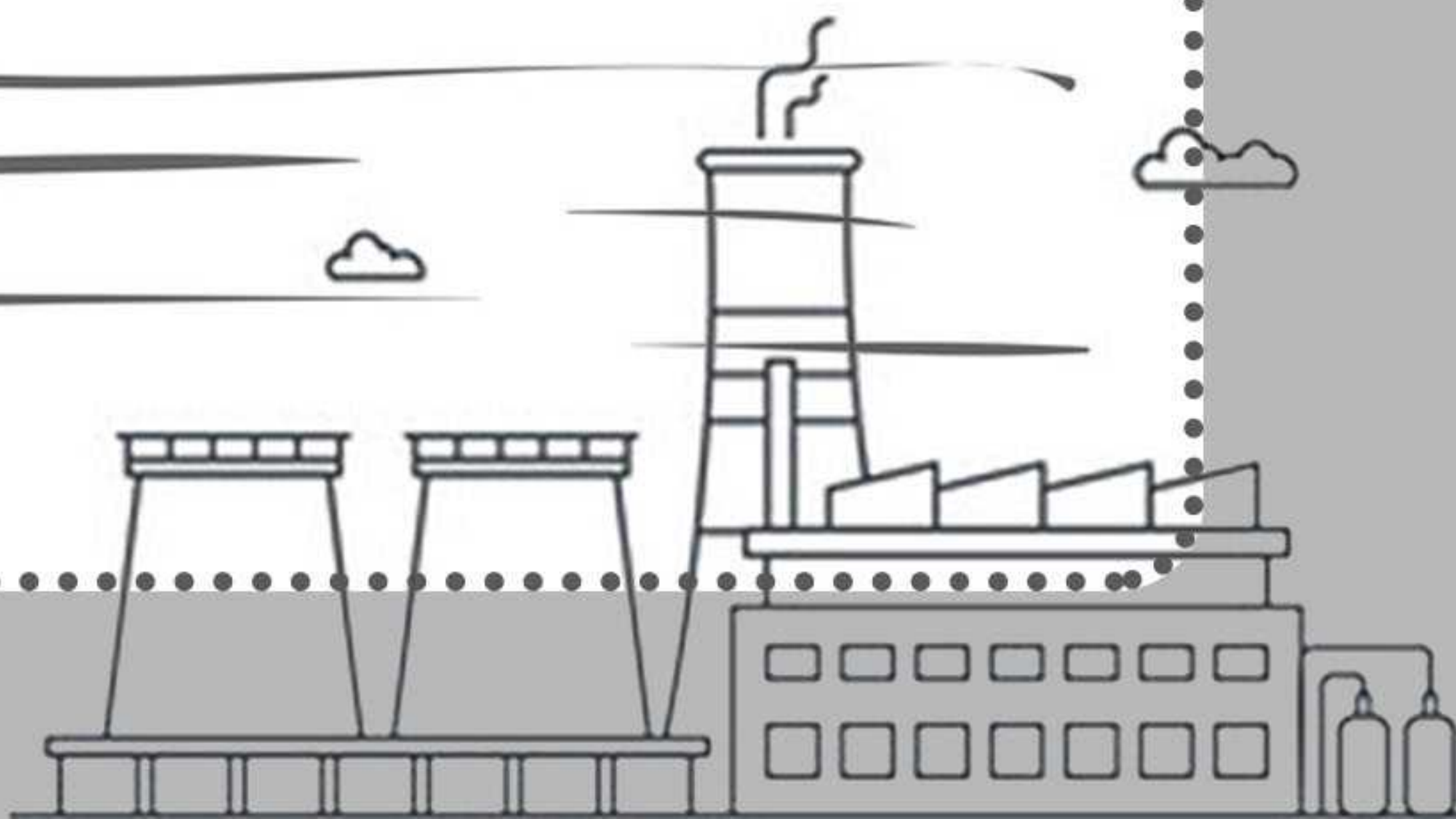


WEEKLY NOTEBOOK

Design

second semester
2021



Lecture 1

Friday, 26 February 2021

7:15 PM

Engineering design:- is a systematic process by which solutions to the needs of humankind are obtained.

فيها لازم نتبع خطوات معينة ولازم نطلع منها حلول اصل هذا بمقدور هدف للإنسانية.

* Engineering design process:-

1) Define the problem: **إيضاح صيغة المشكلة**

بعد التعريف ويكون واضح التعريف

2) Identify constraints on your solution
(time, money, material, ---)

محددات محدودة لل design بتعلق مثال:-
معدك فصيلته لحل المشكلة.

3) Brainstorming:- multiple solutions for the problem

لازم نطلع حل ولازم يكون أكثر من حل واحد.

4) Select the best solution

الحل الأفضل يكون أقرب لل constraints

يعني إني بحققه إن constraints يكون best solution

* هو ضروري يكون أحسن واحد من ال multiple solutions
بسه هو يكون أفضل واحد بالنسبة لل constraints.

5) prototype your solution:-

نموذج أولي ممكن يكون 3D printing

6) Test and evaluate your prototype

* ممكن بعد إن testing لل prototype يكون فيه failure يرجع تعريفي إن solution وتعمل prototype جديد وتعمل Test

7) * العملية من Test and evaluate your prototype إلى

Select the best solution

Iterate to improve your prototype.

(Iteration)

8) Communicate your solution.

الإعلان عنه.

* Some Categories of Engineering design.

1) industrial design.

a) product design:-

b) manufacturing design:-

يقول design ل process كامل
نصنع منها product يعني هو خط إنتاج بك خطوات design
عبارته عن Science

Product design:- empathic بتشوف متطلبات

الناس شو يحتاج
عبارته عن CAD

2) Machine element design:- CAD و Science

يعني في النهاية لازم نطلع عيني prototype

3) Materials design:-

الواحد بقدر ال Structure

لصق يطلع properties معينة

* What is Empathic design:-

user - centered design approach that pays attention to the user's feelings toward a product.

Empathic design caters to real user needs.

* Graphic design:-

uses visual compositions to solve problems and communicate ideas through typography, imagery, color and form. (CAD)

* Power transmission System:- Gears, Bearings

Shafts, Seals.

* Veld factor of safety

Factor of safety (n)

$n = \frac{\text{Property}}{\text{max applied stress}} = \frac{\sigma_{\text{yield}}}{\sigma_{\text{working}}}$ from table

التي فيه

factor of safety (n) should be more than 1

$n > 1$

failure
1.2-4

صحي نضمنه انو ما يكون في

غالبًا يكون ما بينه

كل ما تزيد n ربح قدير Cost.

* لازم نحدد ال n and Reliability

* Factor of safety Method:-

* إذا حددنا بيه رقم n يعني

The deterministic

* إذا حددنا رقم ال n وحددنا ال reliability يعني

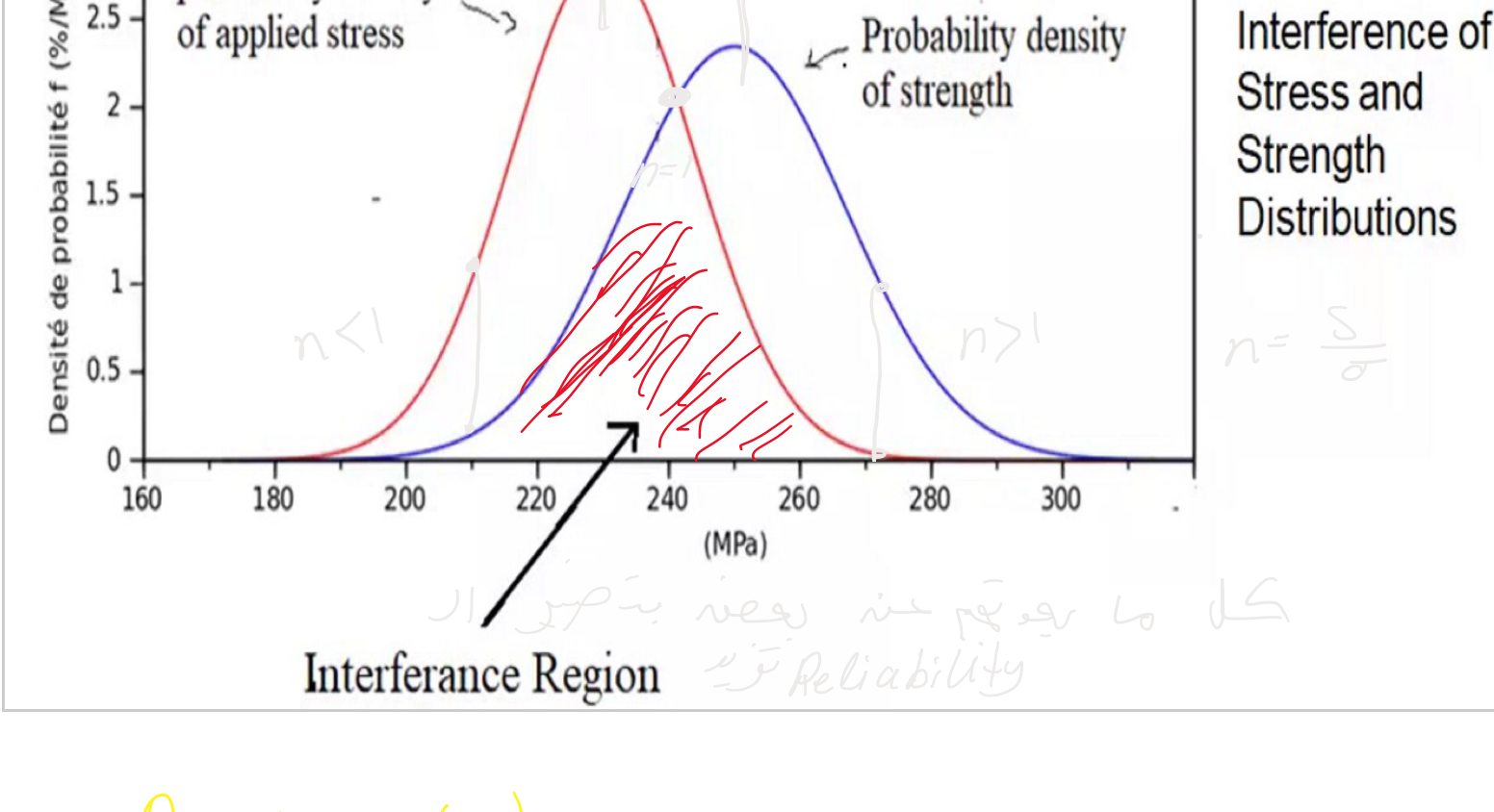
The Stochastic or reliability approach.

* Stress - Strength Analysis is tool used in

reliability engineering.

Stress $\rightarrow$ applied $\sigma \rightarrow (M_{\sigma}, \sigma_{\sigma})$

Strength $\rightarrow$ property $S \rightarrow (M_s, \sigma_s)$



$$R = 1 - P(Z)$$

average $\rightarrow$ average

$$Z = \frac{M_s - M_{\sigma}}{\sqrt{\sigma_s^2 + \sigma_{\sigma}^2}}$$

tables

Lecture 2

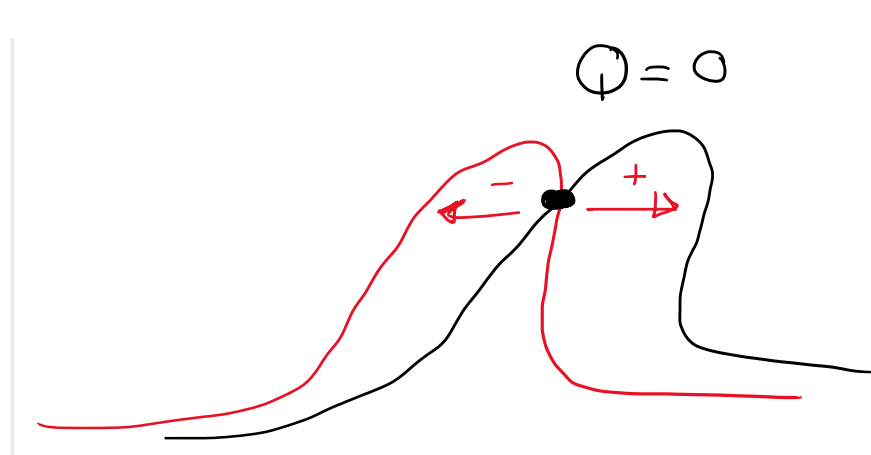
Saturday, 27 February 2021

5:13 PM

Working stress FOS یعنی انوار element
 Stress ای اینت بیسڈ حتمو عی ار
 ار ار material لازم بیكونه اقل منه ار yield
 $\sigma < \sigma_y$
 وصی یعنی صفا امکی لازم FOS بیكونه ایچو منه
 واه

$$\sigma_y = n \sigma$$

عنه نقطه التقاطع $Q=0$



$$\text{Margin } Q = S - \sigma \quad (\mu_Q, \sigma_Q)$$

$$Z_0 = \frac{Q - \mu_Q}{\sigma_Q} \quad \text{at } Q=0$$

$$Z_0 = - \frac{\mu_Q}{\sigma_Q}$$

$$\mu_Q = \mu_S - \mu_\sigma$$

$$\sigma_Q = \sqrt{\sigma_S^2 + \sigma_\sigma^2}$$

Ex:- Suppose that the stress on a component is 2500 psi and its strength is 4000 psi ,
 the stress and strength were normally distributed about the means of 2500 psi and 4000 psi with standard deviations of 500 psi and 400 psi , respectively ,
 calculate the probabilistic factor of safety ?

$$\mu_\sigma = 2500 \quad , \quad \mu_S = 4000$$

$$\sigma_\sigma = 500 \quad \sigma_S = 400$$

$$n = S / \sigma = 4000 / 2500 = 1.6$$

$$Z = \frac{-4000 - 2500}{\sqrt{500^2 + 400^2}} = -2.34$$

$$P(-2.34) = 0.0096$$

$$R = 1 - P(Z) = 1 - 0.0096 = 0.9904$$

* كلما بعدنا ار Two Means (Strength و Working load) عنه
 بكونه بتصير ار probability تقبل لانوار
 interference region بتقل

Ex:- Consider a structural member ($\mu_S = 40, 6$)
 Subjected to a static load that develops a stress
 σ ($\mu_\sigma = 30, 8$) Find the reliability of member ?

$$n = S / \sigma = 40 / 30 = 1.33$$

$$Z_0 = \frac{\mu_Q}{\sigma_Q} = - \frac{40 - 30}{\sqrt{6^2 + 8^2}} = -1$$

$$P(-1) = 0.1587 \quad (\text{Failure})$$

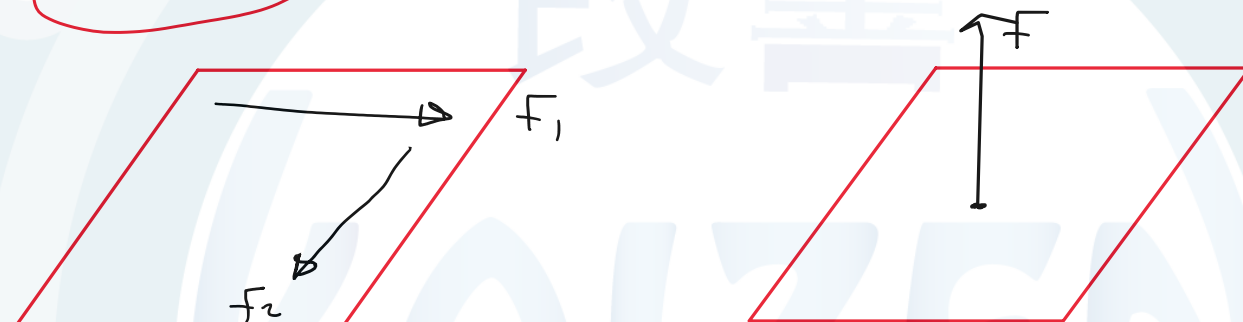
$$R = 1 - P(-1) = 1 - 0.1587 = 0.8413$$

Principal stresses = Max. stress (developed in the element).

$$\sigma = \frac{F}{A}$$

normal stress

إذا كانه ار Force بنفسه الاتجاه ار normal



$$\tau = \frac{F_1}{A}$$

Shear stress

* عی ای سطح عی Maximum
 Three Stress Components

* Stress has units: N/m^2 or lb/in

$$\epsilon = \frac{\Delta L}{L_0}$$

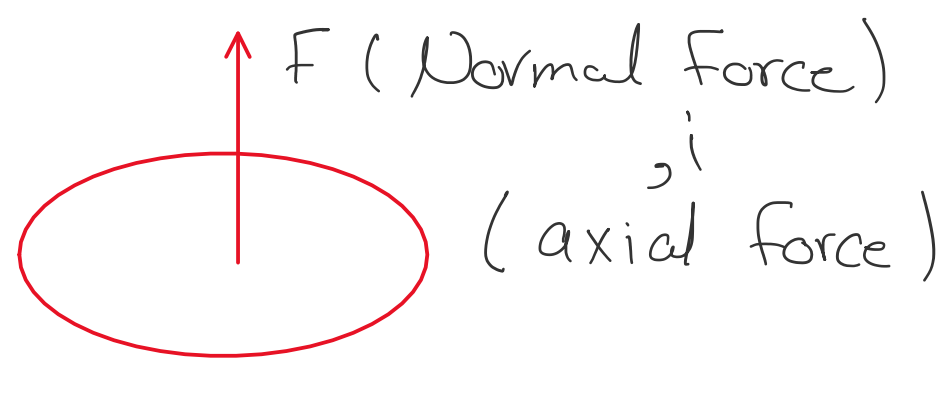
Strain

$$\vec{T} = \vec{r} \times \vec{F}$$

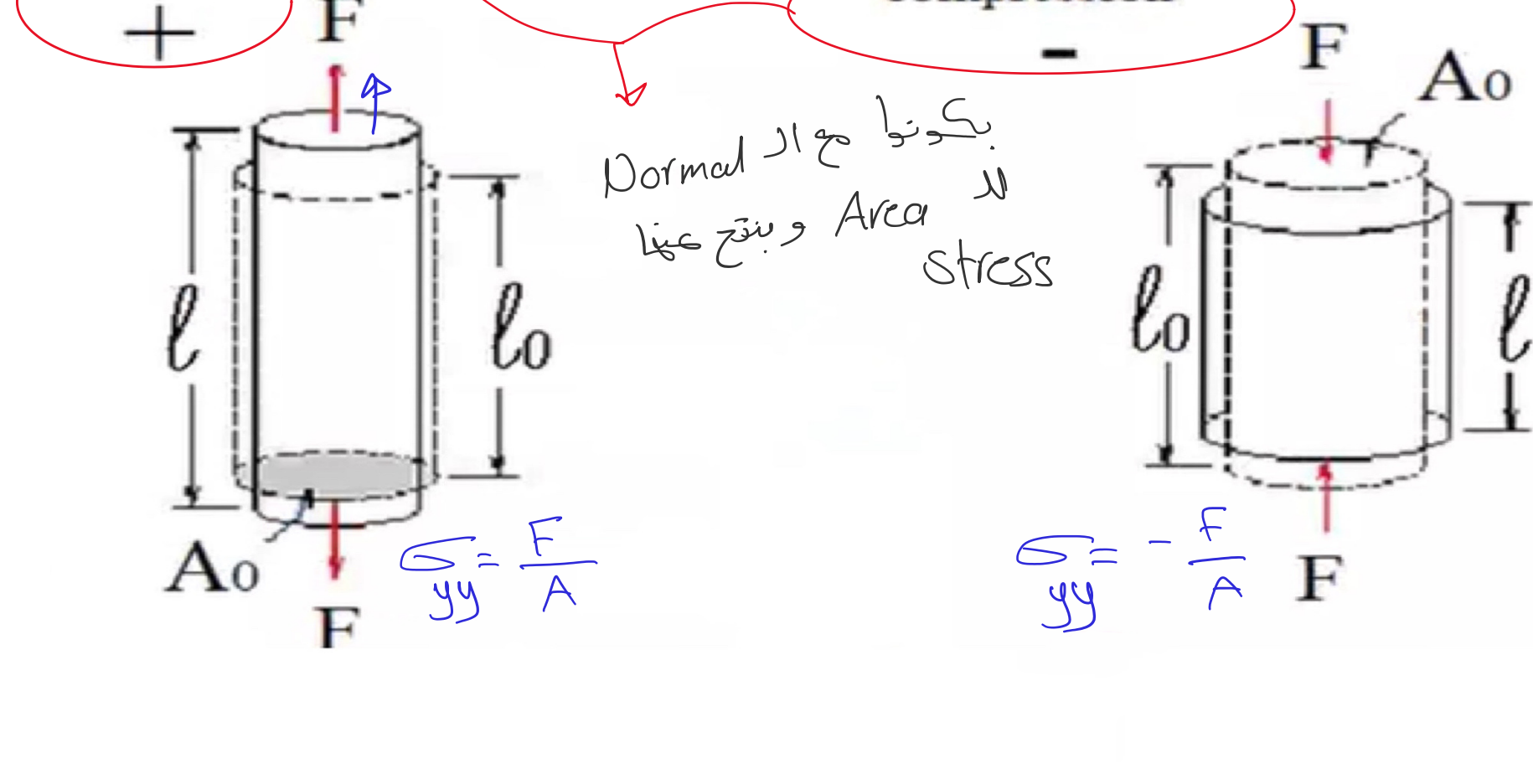
$$|T| = |r| |F| \sin \theta$$

Lecture 3

Friday, 5 March 2021 9:56 PM

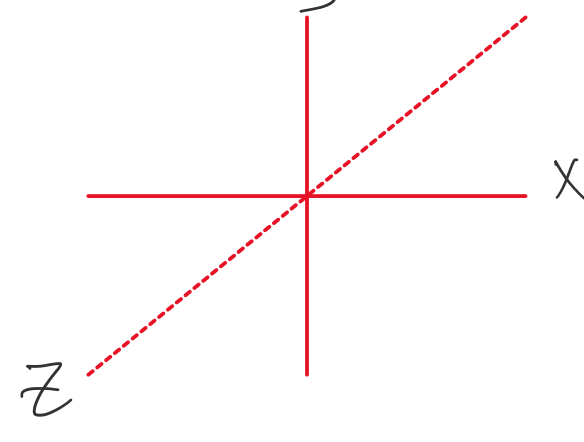


(+) Tension (Force) : Force
(-) Compression (Force)

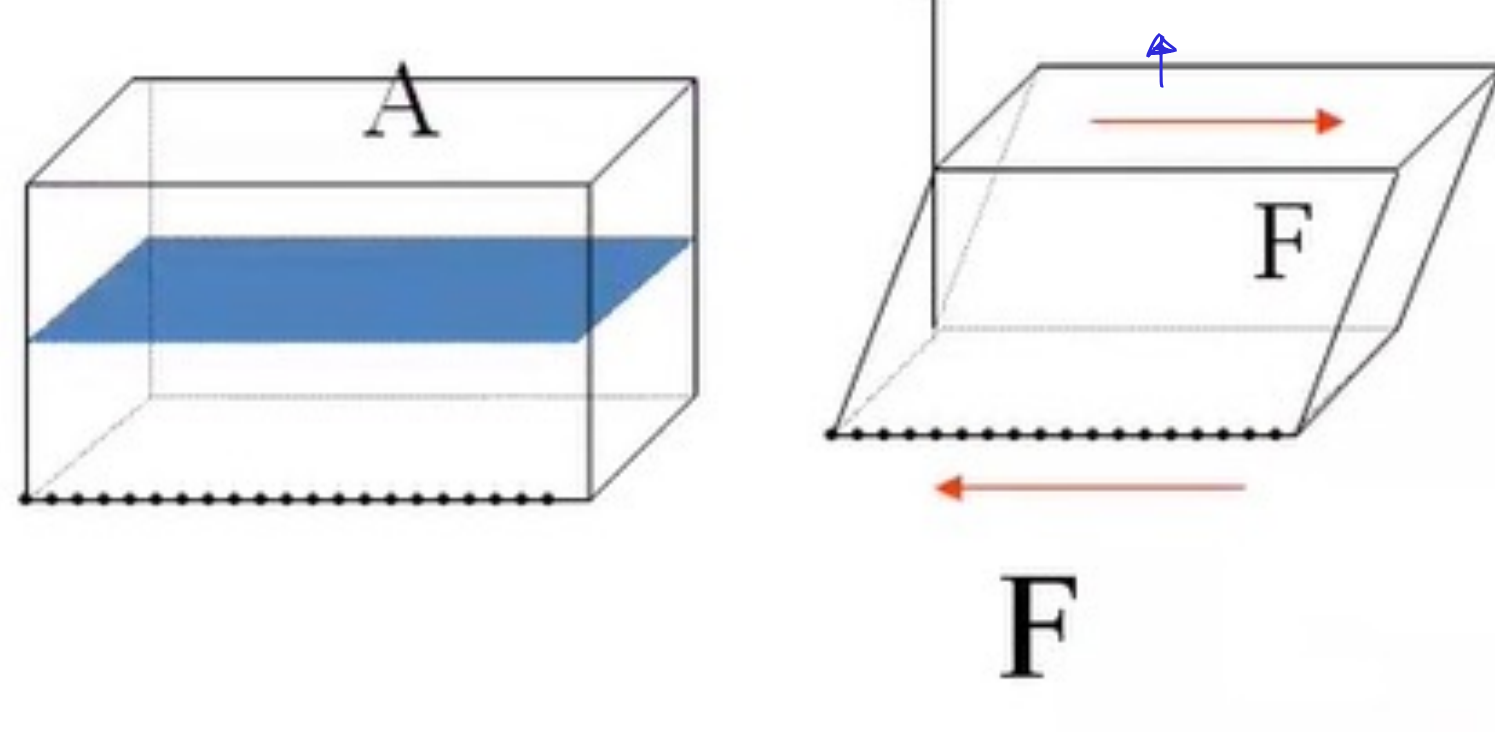
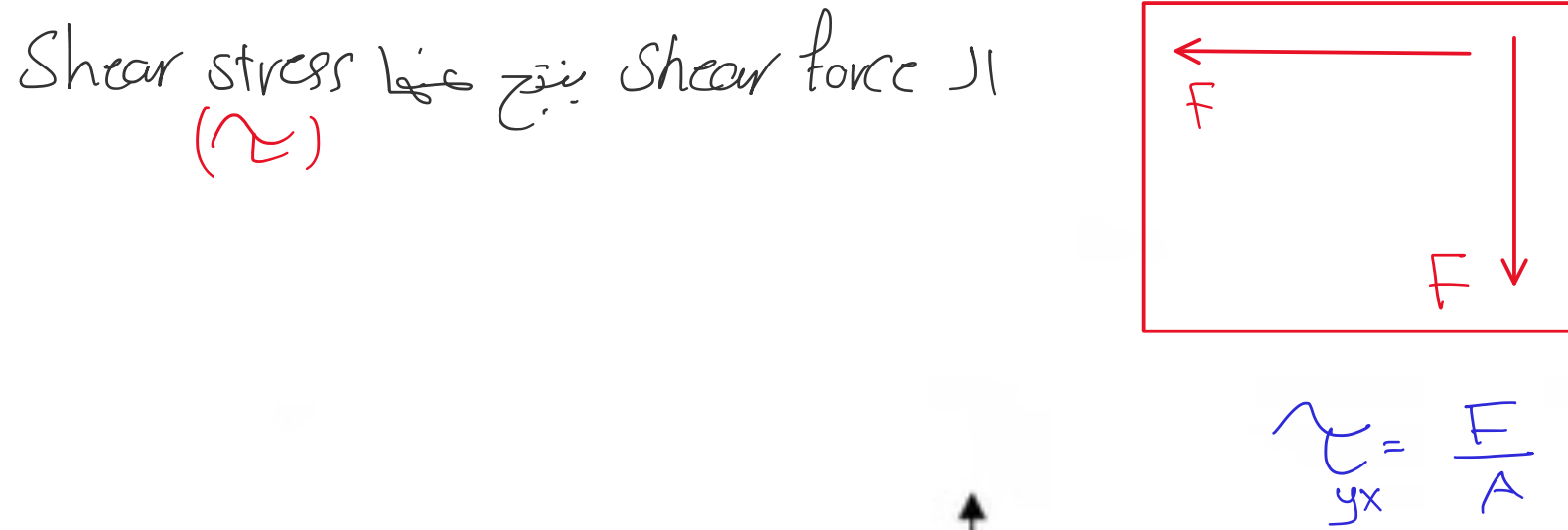


True Stress : True area
Engineering Stress : original area

* Stress has subscript (direction) and direction (area)



Force : Normal stress (direction) and area (direction)



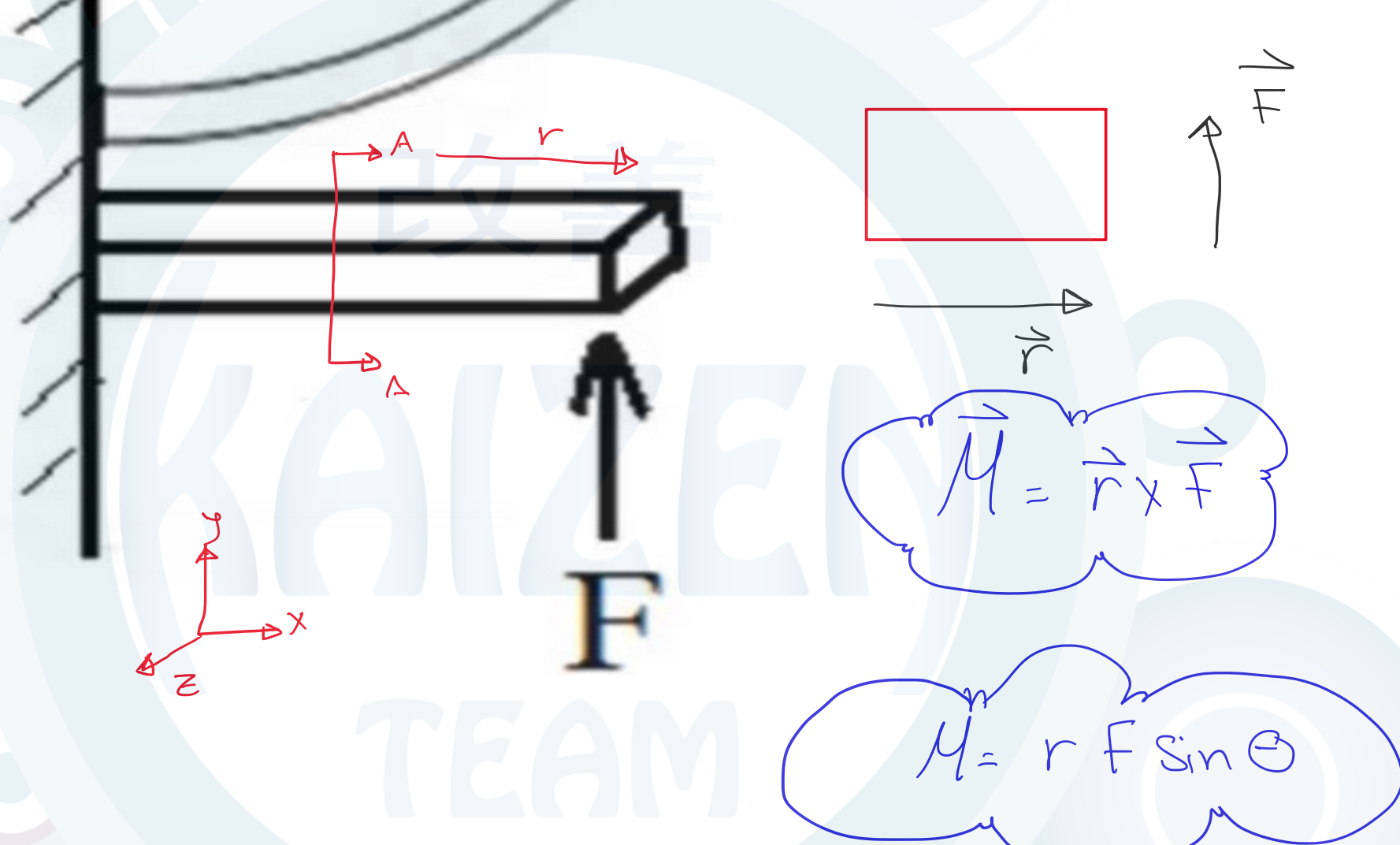
* Normal Force : Subscript (direction) and direction (area)

* Shear Stress Sign : (direction)

- 1) C.W (+)
- 2) C.C.W (-)

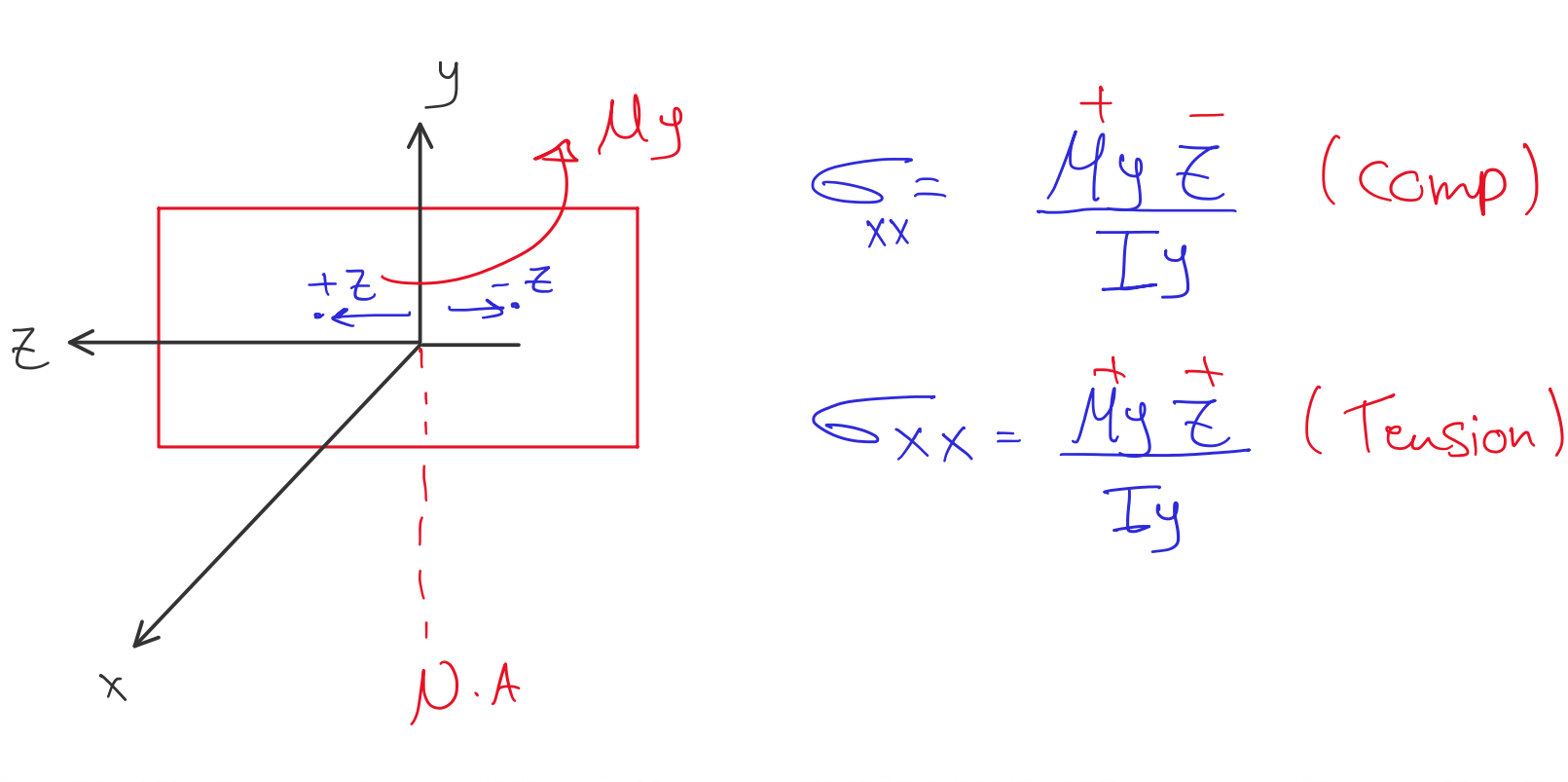
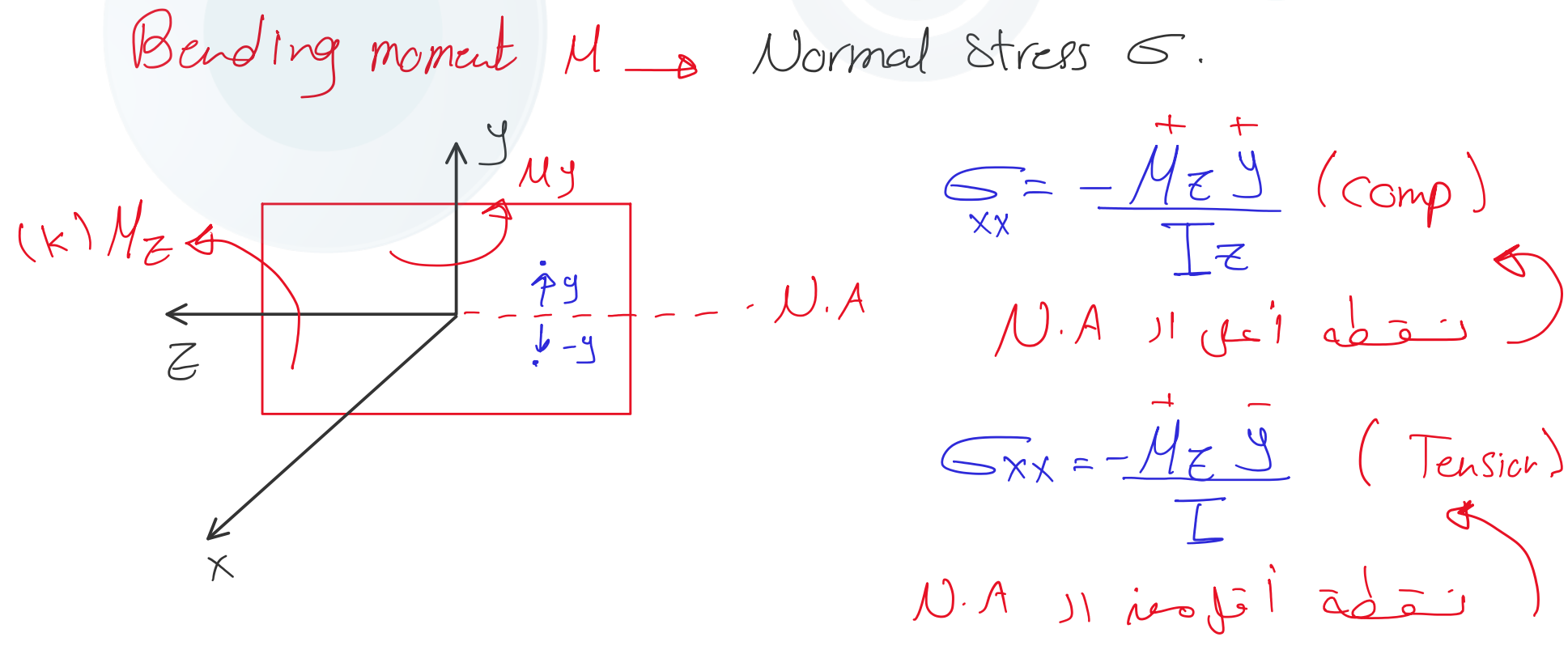
Stress has units:-

- 1) N/m² = Pa
- 2) lb/in² = psi

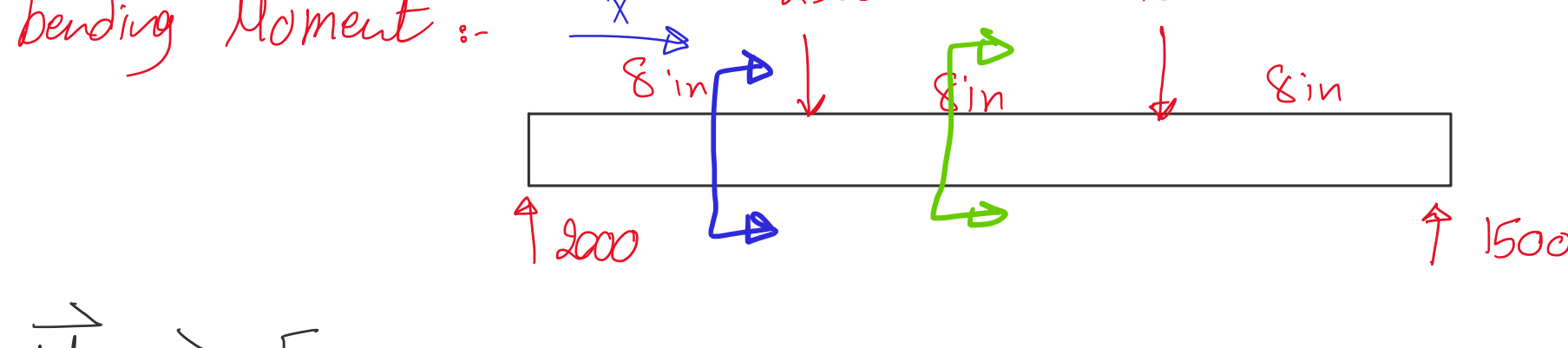
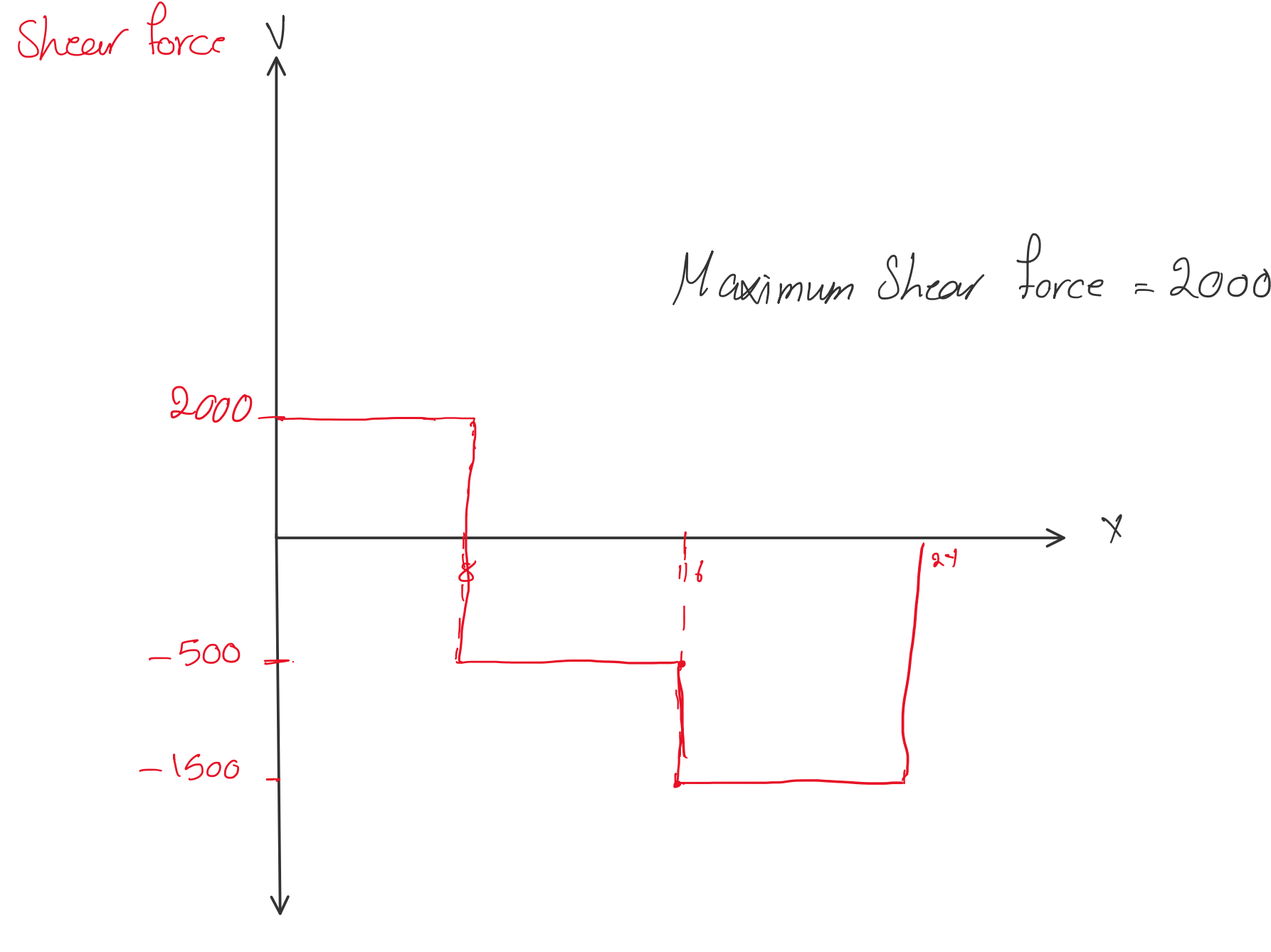
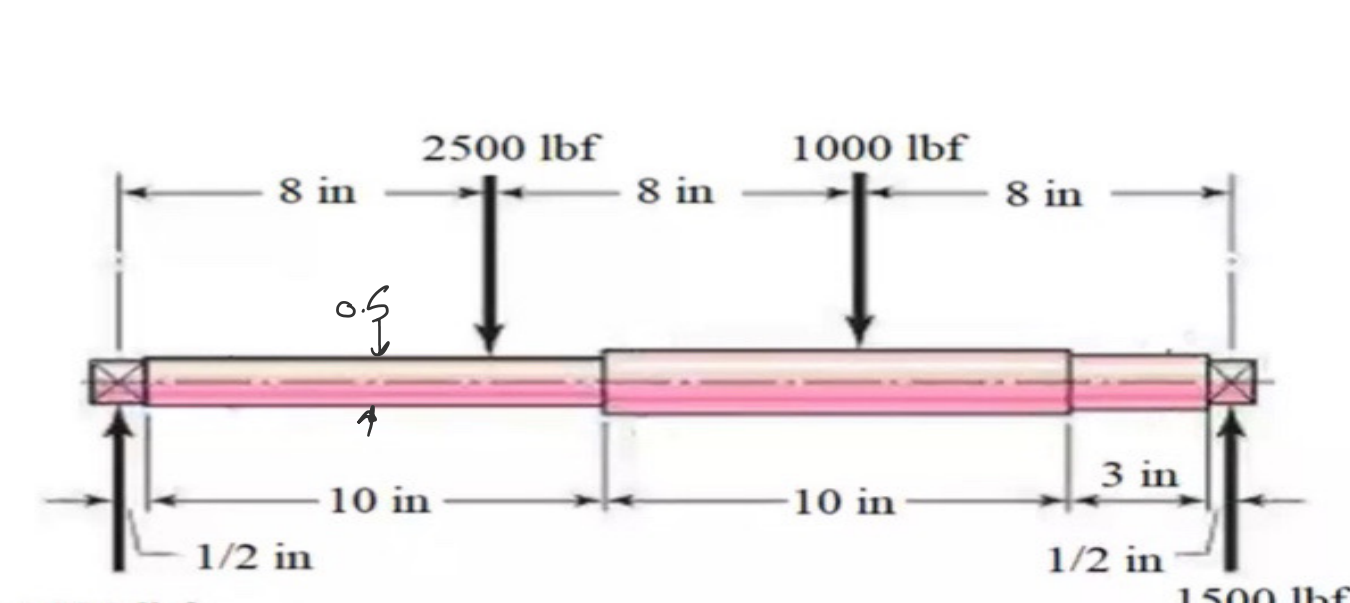


Shearing force V → Shearing stress tau

Bending moment M → Normal stress sigma



Ex: The shaft shown is machined from a AISI 1040 CD steel . Draw the shear force and bending-moment diagrams . What is the maximum shear force V. What is the maximum shear stress developed in the shaft



$$\vec{M} = \vec{r} \times \vec{F}$$

$$= x * 2000 \text{ (Linear)} = 8 * 2000 = 16000$$

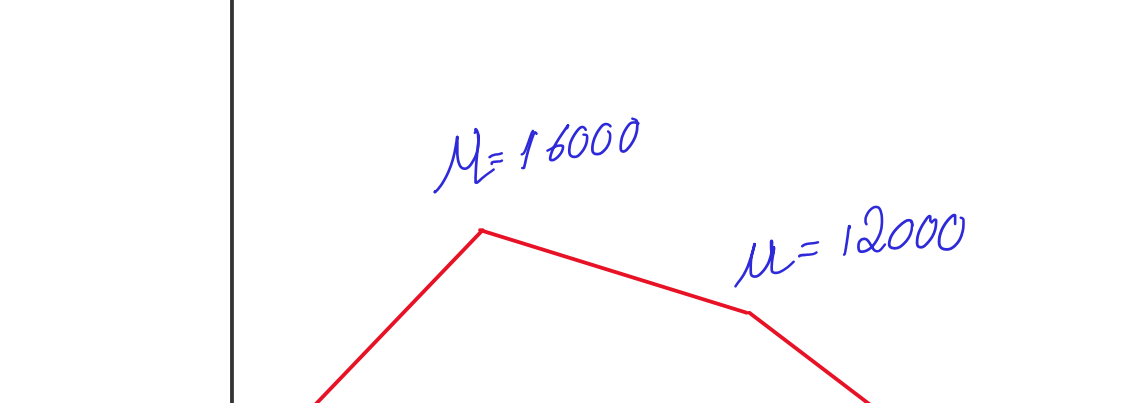
$$\vec{M} = \vec{r} \times \vec{F}$$

$$2000x - 2500(x - 8)$$

$$= 2000x - 2500x + 2500 * 8$$

$$= 2000 * 16 - 2500 * 16 + 2500 * 8$$

$$= 12000$$



$$\tau_{xy} = \frac{V}{A_{avg}} = \frac{2000}{\pi * 0.5^2 / 4} =$$

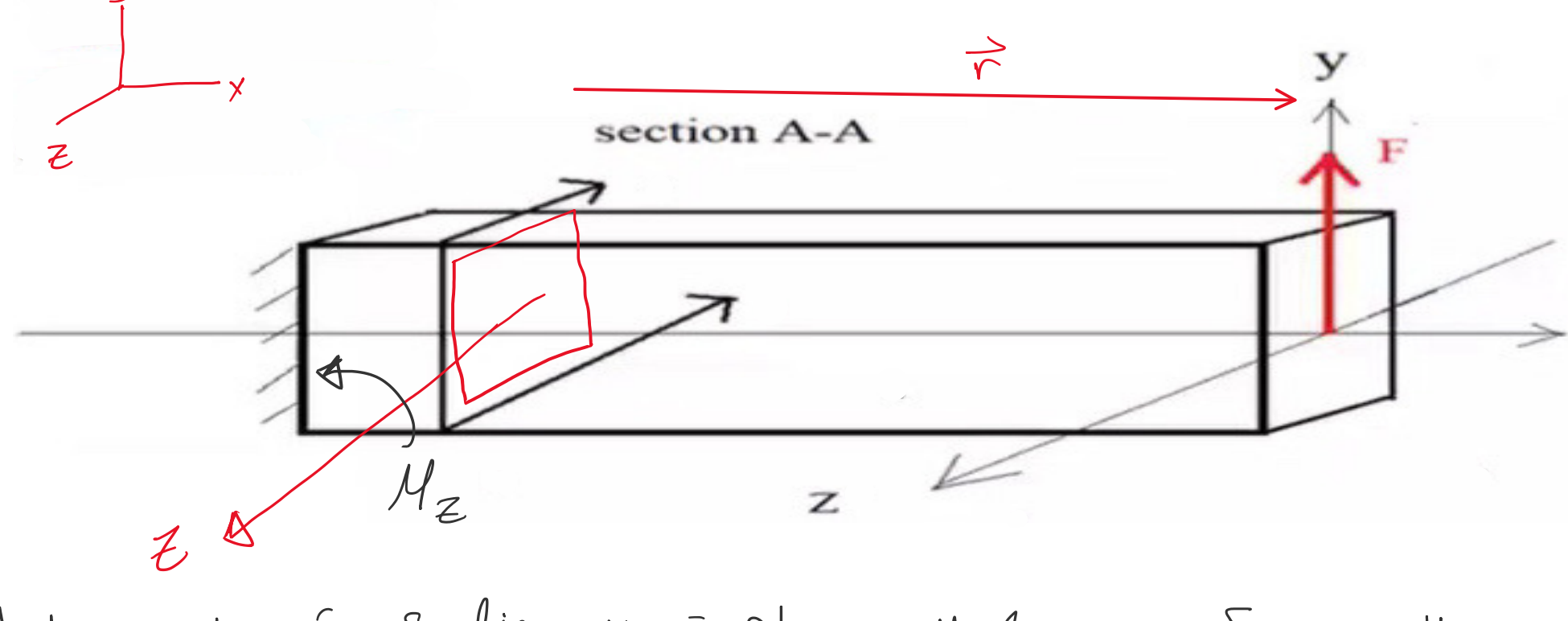
Lecture4

Tuesday, 9 March 2021

7:53 PM

* Notes:-

- Normal force $\xrightarrow{\text{بنتج عليها}}$ Normal stress.
- Shear force $\longrightarrow$ Shear stress.
- Bending Moment $\longrightarrow$ Normal stress.
- Torsion $\longrightarrow$ Shear stress.

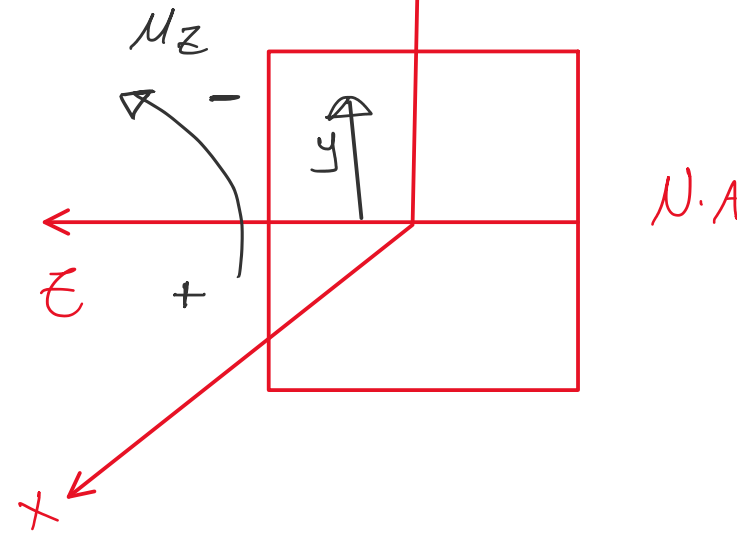


ال Force $\xrightarrow{\text{بنتج عليها}}$ Normal stress. $\xrightarrow{\text{بنتج عليها}}$ Shear stress. $\xrightarrow{\text{بنتج عليها}}$ Normal stress. $\xrightarrow{\text{بنتج عليها}}$ Shear stress.

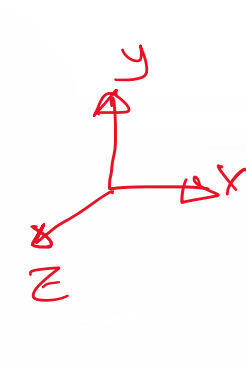
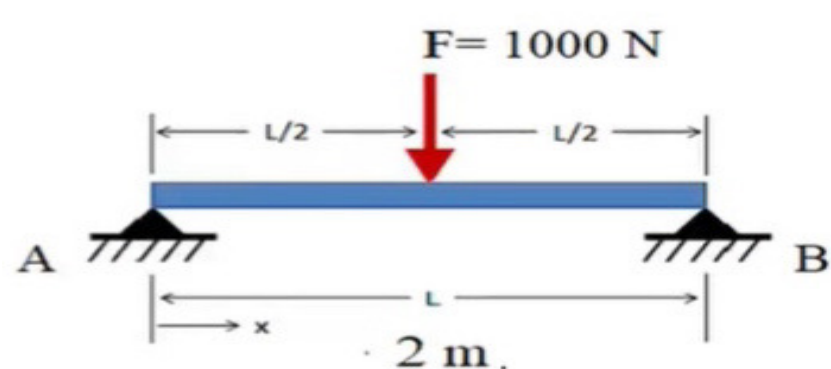
$$M = \vec{r} \times \vec{F}$$

$$\vec{i} \times \vec{j} = \vec{k}$$

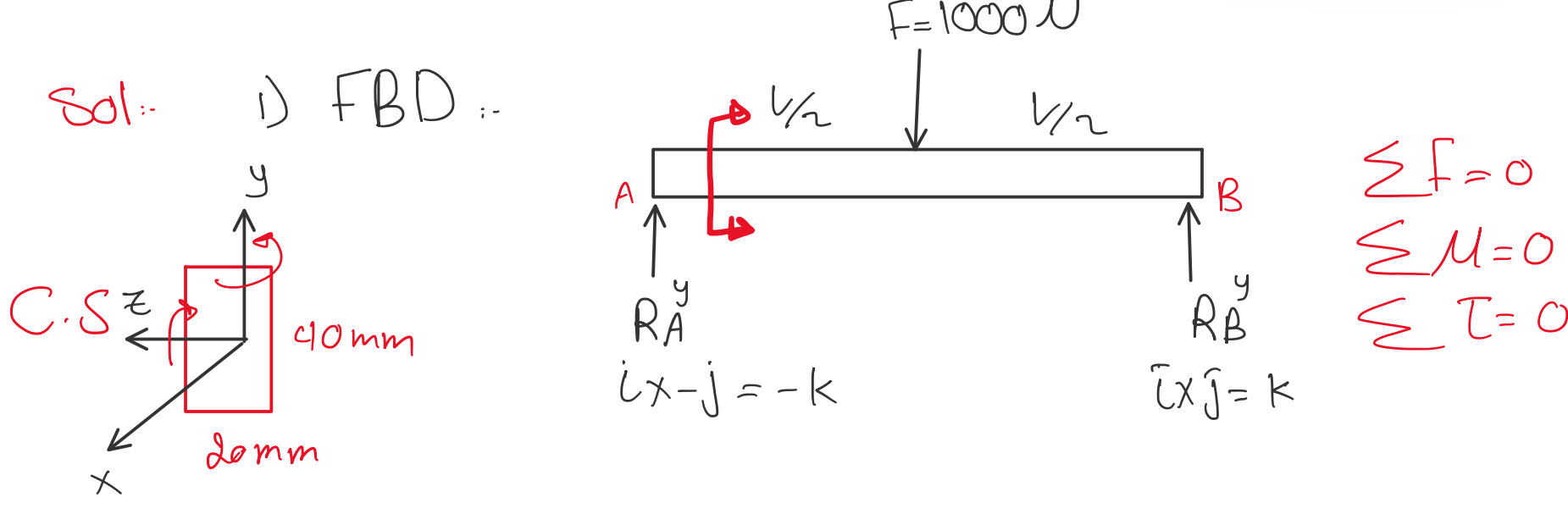
$$\sigma_{xx} = -\frac{M_z y}{I_z}$$



Ex: A simply supported 2 m. beam with a load of 1000 N. acting downward at the center of the beam. The beam used is a rectangular 20 mm by 40 mm steel beam. We would like to determine the maximum bending (axial) stress which develops in the beam due to the loading



Sol: 1) FBD:



$$\sum M_A = 0$$

$$2 * R_B - 1000 * 1 = 0$$

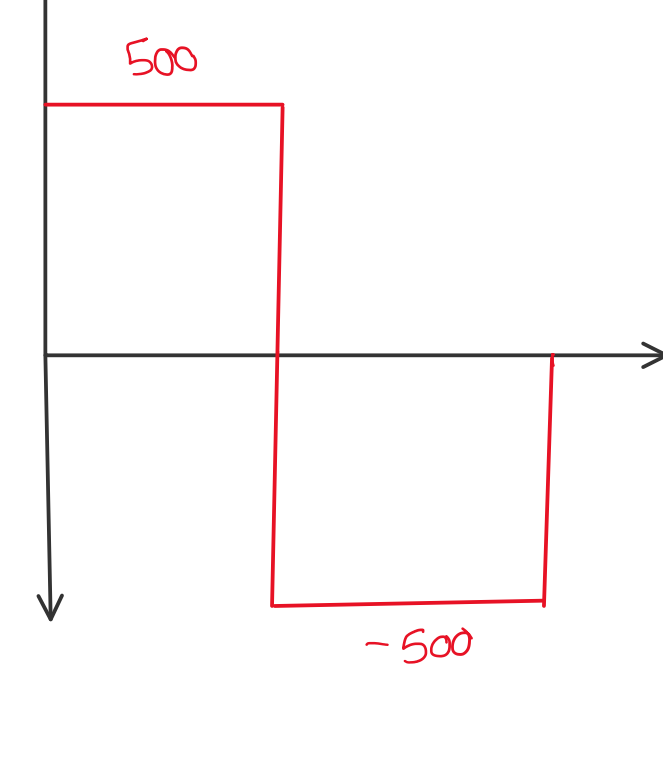
$$\sum F_y = 0$$

$$R_A + R_B - 1000 = 0$$

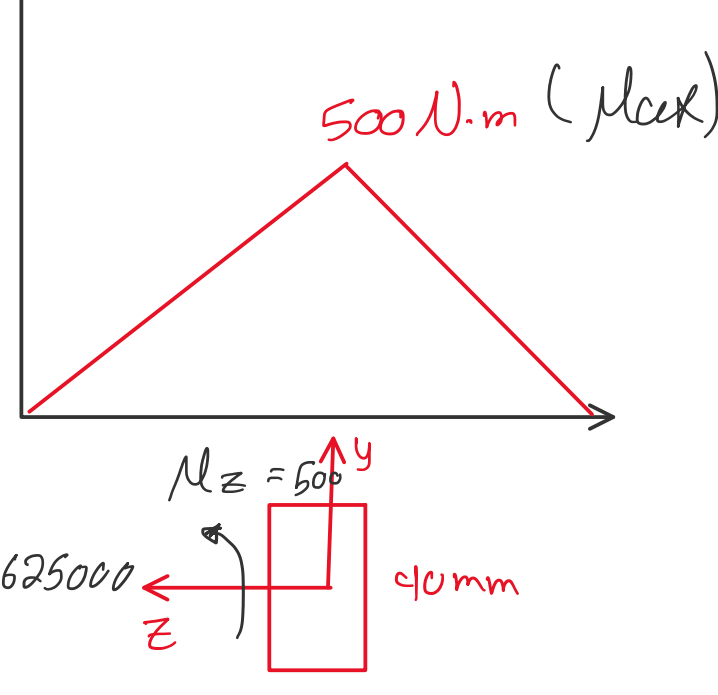
$$R_A + 500 - 1000 = 0$$

$$R_A = 500$$

* Shear force diagram:



* Bending Moment diagram:



$$\sigma_{xx} = \frac{M_z y}{I_z} = \frac{500 * 0.02}{64 * 10^{-8}} = 15625000$$

For rectangle (من المثلث):

$$I = \frac{1}{12} b h^3 = \frac{1}{12} (20 * 40^3) = 640000 \text{ mm}^4$$

$$M = \frac{E I}{\rho}$$

Section Modulus (Z) $\rightarrow \frac{I}{c}$ Second moment of area $\rightarrow$ y coordinate

ال Stress (Stress) $\rightarrow$ ال (Z) $\rightarrow$ ال (Z)

$$\sigma = \frac{M c}{I}$$

$$\sigma = \frac{M}{Z}$$

* ال (Z) $\rightarrow$ ال (Z) $\rightarrow$ ال (Z) $\rightarrow$ ال (Z)

* Centroid: $(\bar{x}, \bar{y})$.

$$\bar{x} = \frac{\sum \bar{x} A}{\sum A}$$

$$\bar{y} = \frac{\sum \bar{y} A}{\sum A}$$

* For rectangle:

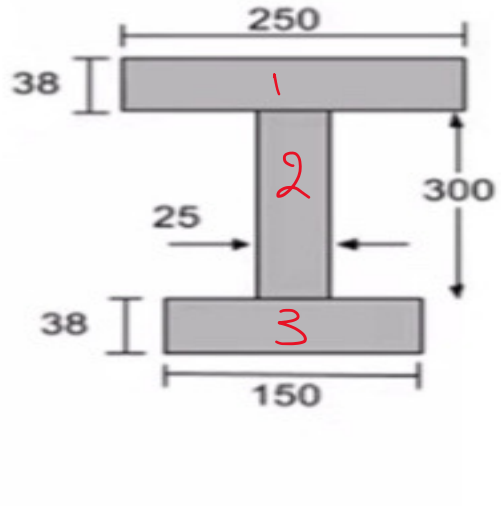
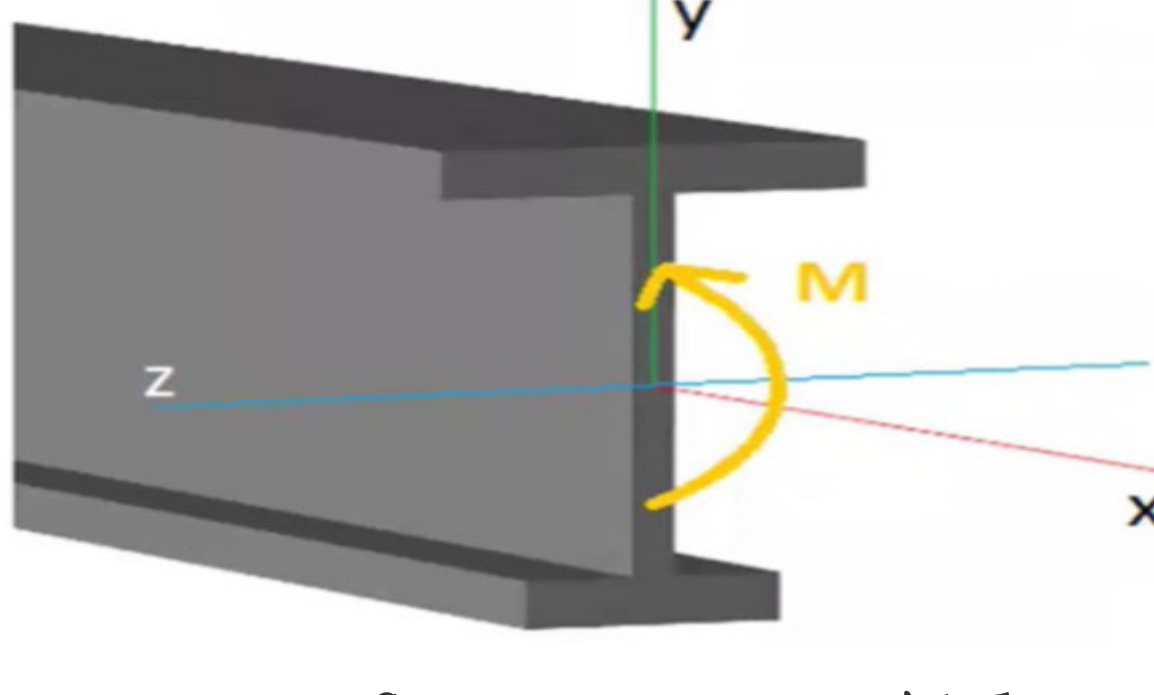
$$\bar{I} = \frac{b \cdot h^3}{12}, \quad \bar{Z} = \frac{\bar{I}}{c} = \frac{b \cdot h^2}{6}$$

* For circle:

$$\bar{I} = \frac{\pi \cdot D^4}{64} = \frac{\pi \cdot R^4}{4}, \quad \bar{Z} = \frac{\bar{I}}{c} = \frac{\pi \cdot D^3}{32} = \frac{\pi \cdot R^3}{4}$$

$$I_{(x,y)} = \bar{I}_{(x,y)} + A d^2$$

Ex: The I beam is made from steel. Find the moment of inertia for the cross section around the centroidal axis parallel to the z-direction



$$A_1 = 250 * 38 = 9500, \quad A_2 = 300 * 25 = 7500, \quad A_3 = 150 * 38 = 5700$$

$$y_1 = 38 + 300 + 38/2, \quad y_2 = 38 + 300/2, \quad y_3 = 38/2$$

$$= 357$$

$$= 188$$

$$= 19$$

$$\bar{y} = \frac{\sum y_i A_i}{\sum A_i} = \frac{(357 * 9500) + (188 * 7500) + (19 * 5700)}{9500 + 7500 + 5700}$$

$$\bar{y} = 216.29 \text{ mm}$$

$$\bar{I}_1 = \frac{1}{12} (250) (38)^3 = 1143166.667 \text{ mm}^4$$

$$A_1 = 9500 \text{ mm}^2$$

$$d_1 = |y_1 - \bar{y}| = |357 - 216.29| = 140.71 \text{ mm}$$

$$\bar{I}_2 = \frac{1}{12} (25) (300)^3 = 56250000 \text{ mm}^4$$

$$A_2 = 7500 \text{ mm}^2$$

$$d_2 = |188 - 216.29| = 28.29 \text{ mm}$$

$$\bar{I}_3 = \frac{1}{12} (150) (38)^3 = 685900 \text{ mm}^4$$

$$A_3 = 5700 \text{ mm}^2$$

$$d_3 = |19 - 216.29| = 197.29 \text{ mm}$$

$$I_{total} = \sum (\bar{I}_i + A_i d_i^2) = (1143166.667 + 9500 * (140.71)^2) + (56250000 + 7500 * (28.29)^2) + (685900 + 5700 * (197.29)^2) = 474037947.7 \text{ mm}^4$$

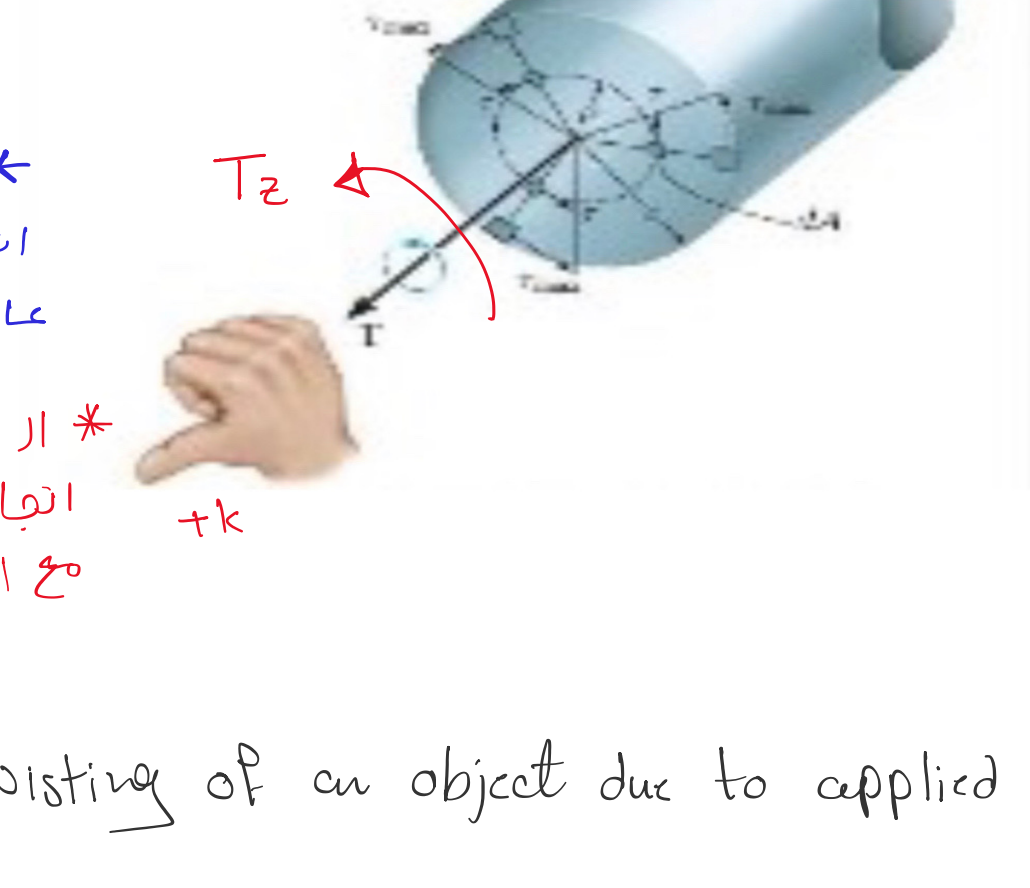
$$I_{total} = 4.74 * 10^8 \text{ mm}^4$$

$$\sigma = \frac{M_z y}{I_z}$$

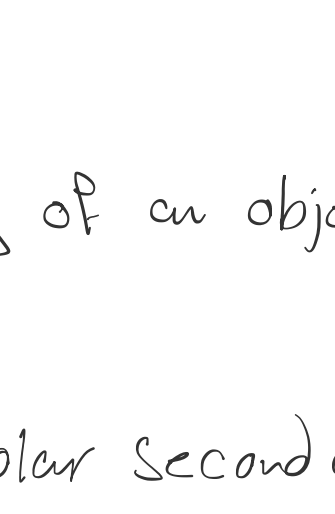
Lecture 5

Thursday, 11 March 2021 9:08 PM

* Torque (إتزان بسيط) ؟
إذا كان على Torque و Body أو Torque و Twisting
بجانب الـ Torsion الفلينة



* Torque دائماً يكونه
اتصالها بالـ Direction
عمودي على الـ Cross section
* Bending moment يكونه
اتصالها على طول الـ Direction
* Cross section



* Torsion:- Is the twisting of an object due to applied torque

$$\tau = \frac{T \cdot r}{J}$$

polar second of area. (الـ Section المزدوجة)

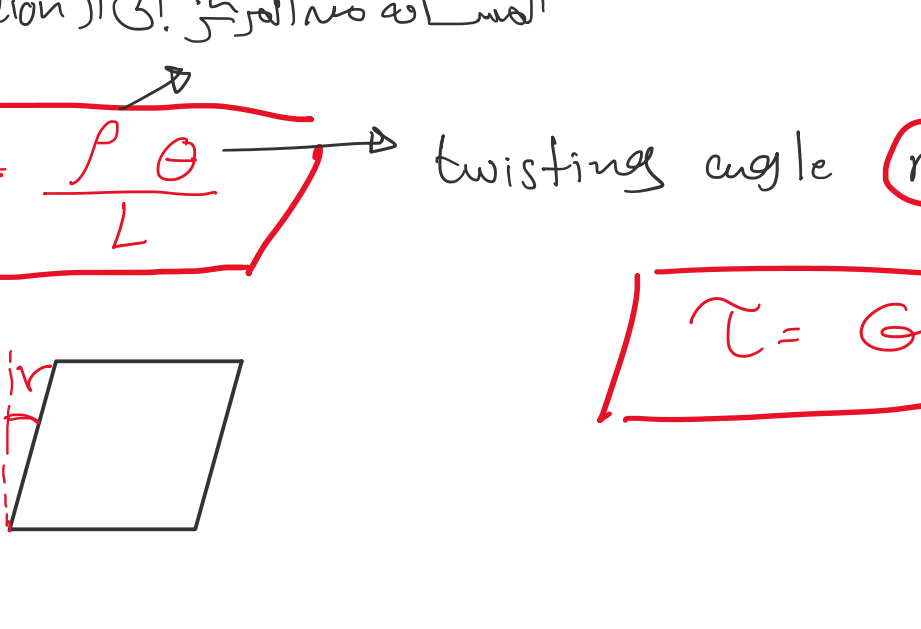
$$T = \vec{r} \times \vec{F}$$

$$\theta = \frac{TL}{GT}$$

$$G = \frac{E}{2(1+\nu)}$$

Example: 120 Newtons of force at 0.3 m

$$\begin{aligned} \vec{T} &= \vec{r} \times \vec{F} \\ &= 0.3 \times 120 \\ &= (36 \text{ Nm}) \hat{k} \end{aligned}$$



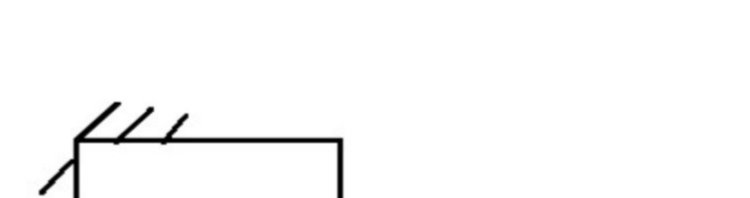
* Shear strain

المساحة من المثلث إلى الـ Cross section

$$\gamma = \frac{\rho \theta}{L}$$

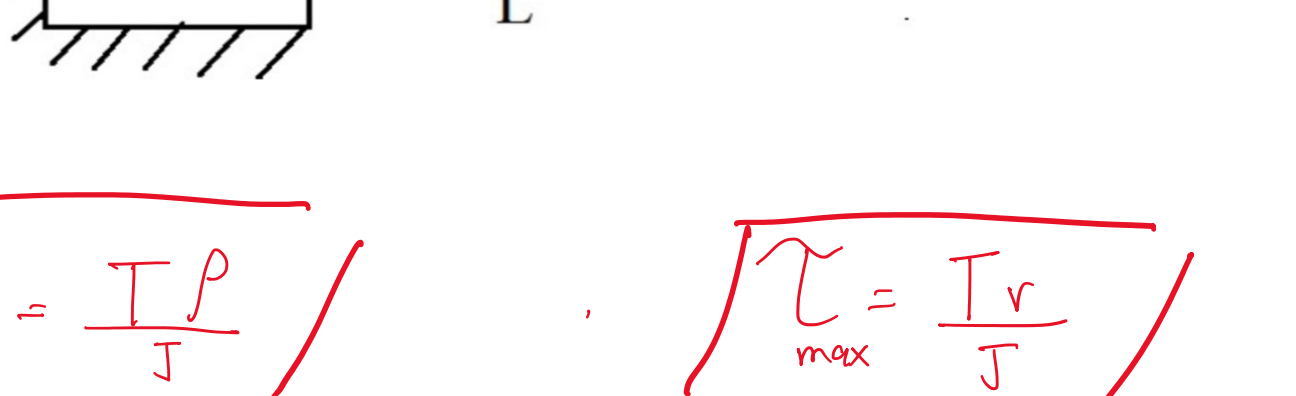
twisting angle (rad)

عبارتها عن (دوية)



$$\tau = G \gamma$$

* The maximum Shear Strain occurs at the outer surface when $\rho = r$



$$\tau = \frac{I \rho}{J}$$

$$\tau_{\max} = \frac{I r}{J}$$

* كل ما قربت من الـ Center الـ Shear stress يقل

Ex: what is the maximum diameter of a solid shaft which will not twist more than 3° in a length of 6 m when subjected to a torque of 12 kN-m. What is the maximum shear stress induced in the shaft. Use G=82 GPa

Sol:-

$$\theta = 3^\circ, L = 6 \text{ m}, T = 12 \text{ kN-m}, G = 82 \text{ GPa}$$

$$\theta = \frac{TL}{GJ}$$

$$J = \frac{12 \times 10^6 \times 6000}{82 \times 10^3 \times \left(\frac{3\pi}{180}\right)}$$

$$J = \frac{\pi \cdot D^4}{32} = D = 114.32$$

$$\tau_{\max} = \frac{16 \times T}{\pi \cdot D^3}$$

$$\tau = \frac{16 \times 12 \times 10^6}{\pi (114.32)^3} = 40.91$$

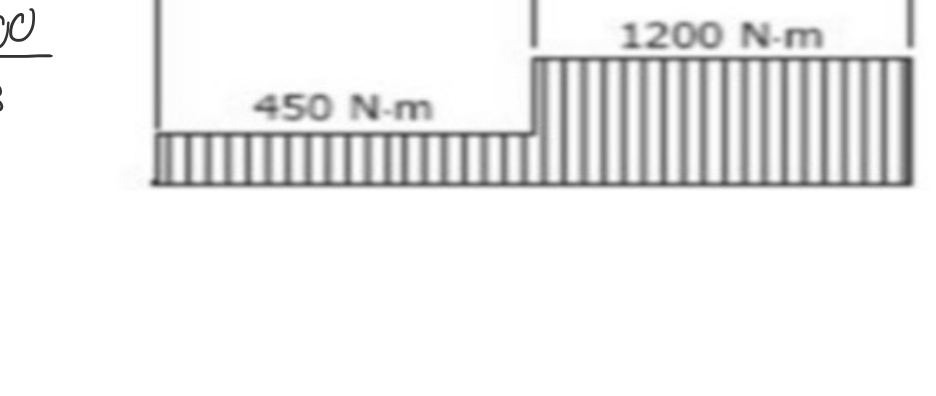
* for rectangular cross section:-

$$\tau_{\max} = \frac{T}{\alpha bc^2} = \frac{T}{bc^2} \left(3 + \frac{1.8}{b/c} \right)$$

$$\frac{\theta}{L} = \frac{T}{B db^3 G}$$

b/c	1.00	1.50	1.75	2.00	2.50	3.00	4.00	6.00	8.00	10	∞
α	0.208	0.231	0.239	0.246	0.258	0.267	0.282	0.299	0.307	0.313	0.333
β	0.141	0.196	0.214	0.228	0.249	0.263	0.281	0.299	0.307	0.313	0.333

Ex: A solid steel shaft is loaded as shown. Using G = 83 GPa, determine the required diameter of the shaft if the shearing stress is limited to 60 MPa and the angle of rotation at the free end is not to exceed 4 deg

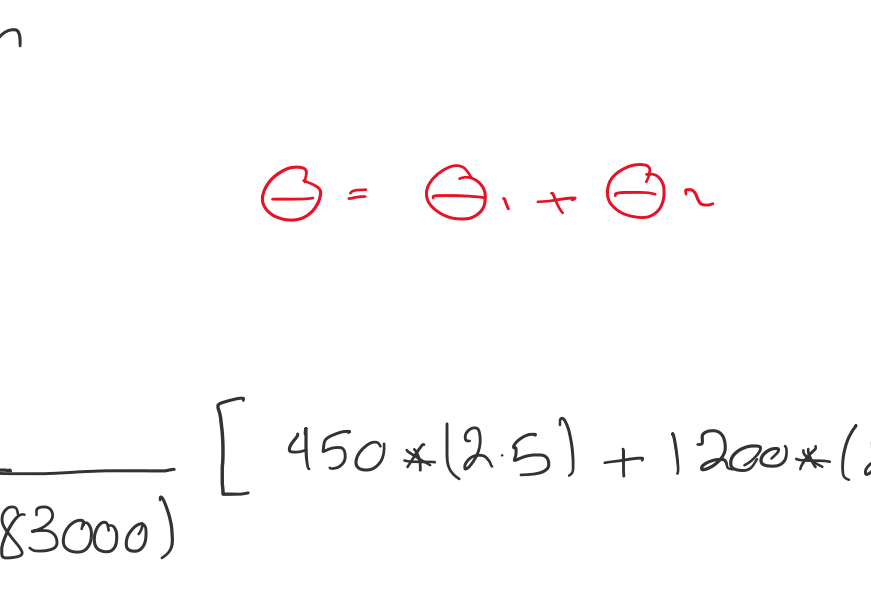


$$\tau_{\max} = \frac{16 T}{\pi D^3}$$

for the 1st segment:-

$$60000000 = \frac{16 \times 1200}{\pi D^3}$$

$$D = 46.89 \text{ mm}$$



for the 2nd segment:-

$$60000000 = \frac{16 \times 450}{\pi D^3}$$

$$D = 33.74 \text{ mm}$$

$$\theta = \frac{TL}{JG} = \frac{1}{JG} \sum TL$$

$$\theta = \theta_1 + \theta_2$$

$$4 \left(\frac{\pi}{180} \right) = \frac{1}{\frac{1}{32} \pi D^4 (83000)} [450 \times (2.5) + 1200 \times (2.5)]$$

$$D = 51.9 \text{ mm}$$

* Shear stresses for Beams in Bending:-

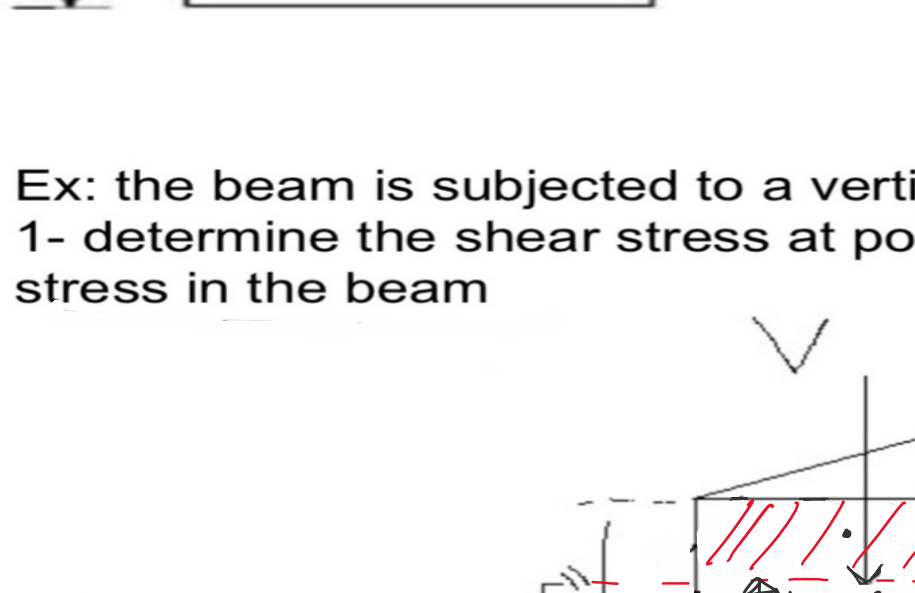
$$\tau = \frac{V Q}{I b}$$

First moment of area

Second moment of area

$$Q_{\max} = \frac{b h^2}{8}$$

* الـ Q والـ b يعتمدان على شكل الـ Cross section
إذا كان الـ rectangle الـ b يكونه موازي الـ N.A

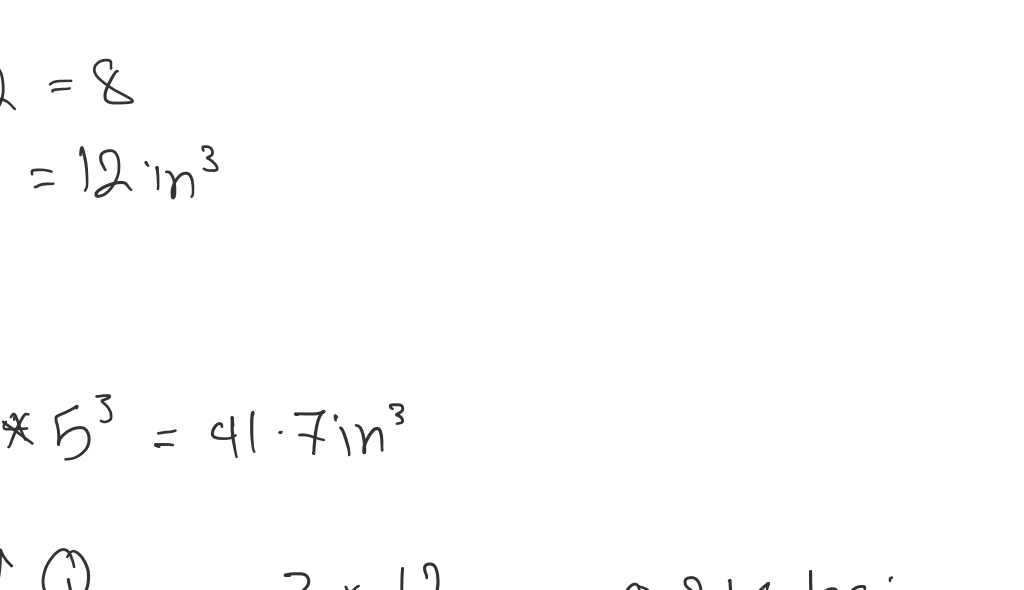


$$Q_{NA} = \frac{c^2 b}{2} - \frac{b y_1^2}{2}$$

$$\tau_{\max} = \frac{3 V}{2 A}$$

total area

Ex: the beam is subjected to a vertical shear force V= 3 kip. 1- determine the shear stress at point D. 2- calculate the maximum shear stress in the beam



$$Q = \bar{y} A_1$$

$$\bar{y} = \frac{(0.5 + 2.5)}{2} = 1.5$$

$$A_1 = 4 \times 2 = 8$$

$$Q = 1.5 \times 8 = 12 \text{ in}^3$$

$$\bar{y} = \frac{y_1 + c}{2}$$

$$I = \frac{1}{2} b h^3$$

$$= \frac{1}{2} \times 4 \times 5^3 = 41.7 \text{ in}^4$$

$$\tau = \frac{V Q}{I b} = \frac{3 \times 12}{41.7 \times 4} = 0.216 \text{ ksi}$$

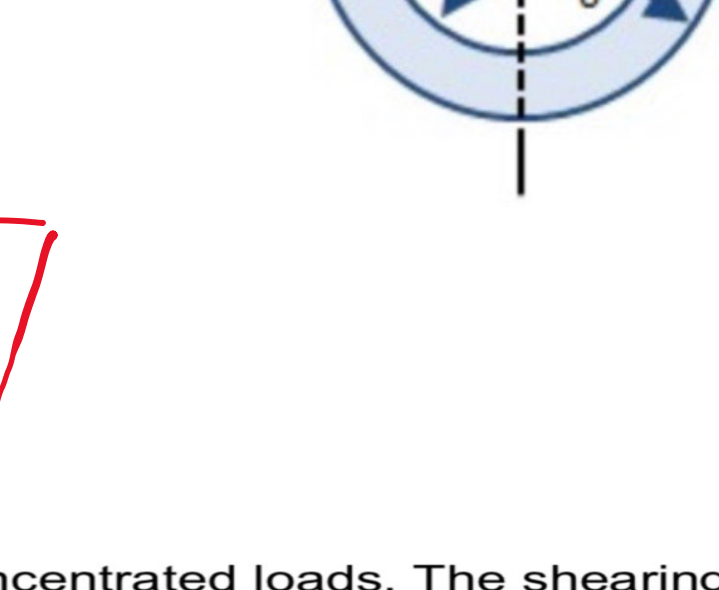
$$\tau_{\max} = \frac{3 V}{2 A} = \frac{3 \times 3}{2 \times (4 \times 5)} = 0.225 \text{ ksi}$$

* Shear stresses in Circular sections:-

$$\tau = \frac{4 V (R^2 - y_1^2)}{3 \pi R^4}$$

$$Q_{\max} = \frac{2 R^2}{3}$$

$$\tau_{\max} = \frac{4 V}{3 \pi R^4} = \frac{4 V}{3 A}$$



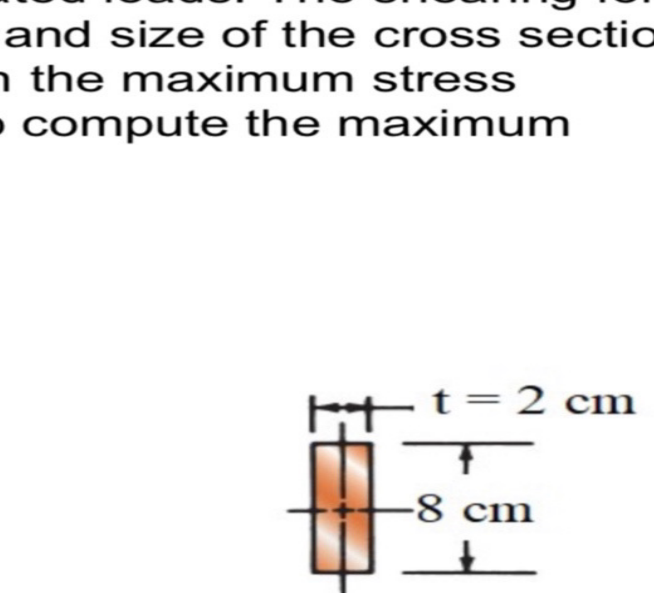
* Shear stresses in Circular tube sections:-

$$A = \pi (r_o^2 - r_i^2)$$

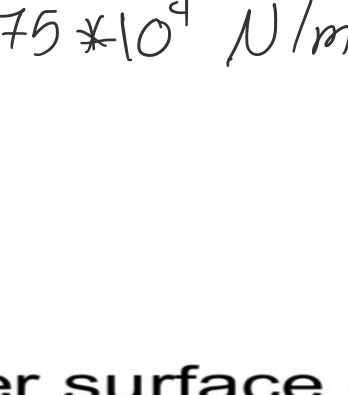
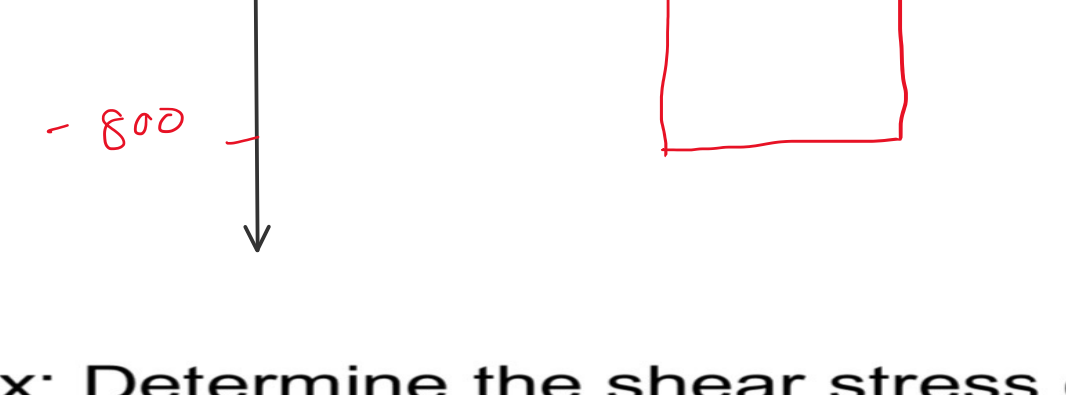
$$Q_{\max} = \frac{2}{3} (r_o^3 - r_i^3)$$

$$I_c = \pi (r_o^4 - r_i^4) / 4$$

$$\tau_{\max} = \frac{4 V}{3 \pi} \times \frac{r_o^2 + r_o r_i + r_i^2}{r_o^4 - r_i^4}$$

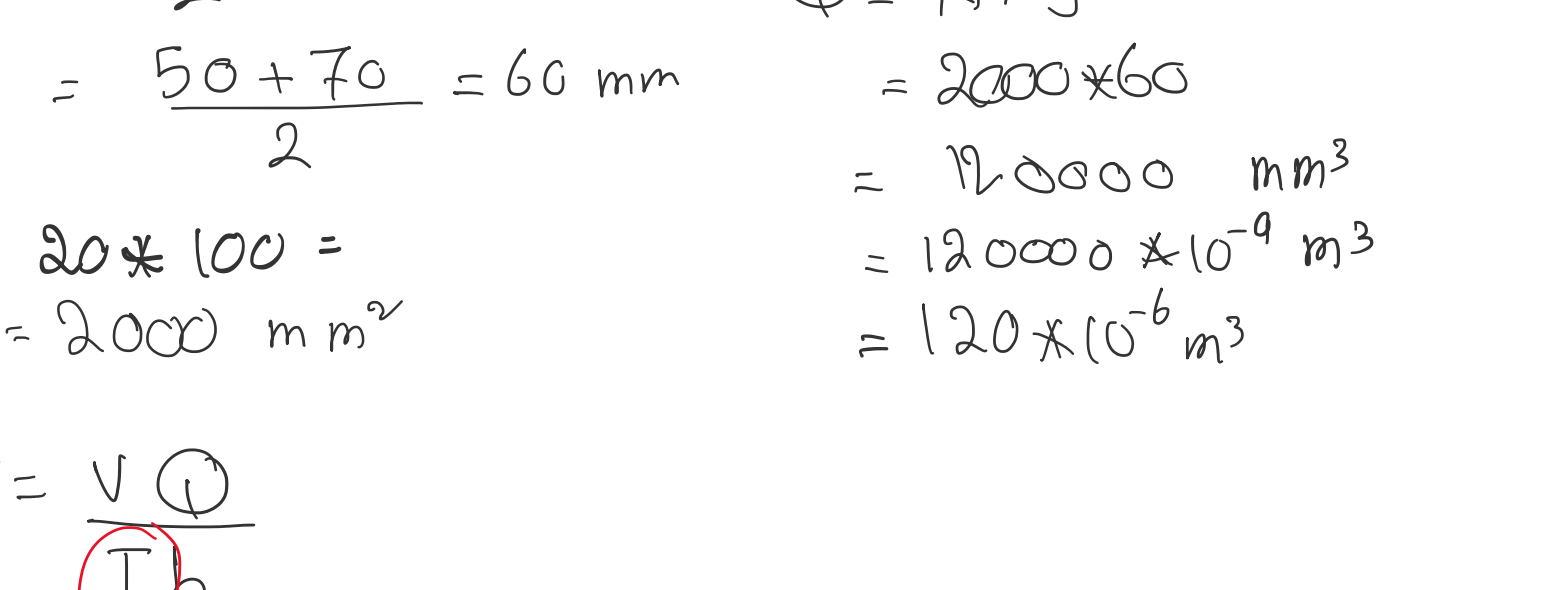


Ex: A simply supported beam carrying two concentrated loads. The shearing force diagram is shown, along with the rectangular shape and size of the cross section of the beam. The stress distribution is parabolic, with the maximum stress occurring at the neutral axis. Use Equation (3-16) to compute the maximum shearing stress in the beam.



$$\begin{aligned} \tau_{\max} &= \frac{3 V}{2 A} \\ &= \frac{3 \times 1000}{2 \times (2 \times 8) \times 10^{-4}} \\ &= 93.75 \times 10^4 \text{ N/m}^2 \end{aligned}$$

Ex: Determine the shear stress on the lower surface of the upper flange . The vertical shear V= 500 N.



$$\bar{y} = \frac{y_1 + c}{2}$$

$$= \frac{50 + 70}{2} = 60 \text{ mm}$$

$$A_f = 20 \times 100 = 2000 \text{ mm}^2$$

$$\begin{aligned} Q &= A_f \bar{y} \\ &= 2000 \times 60 \\ &= 120000 \text{ mm}^3 \\ &= 120000 \times 10^{-9} \text{ m}^3 \\ &= 120 \times 10^{-6} \text{ m}^3 \end{aligned}$$

$$\tau = \frac{V Q}{I b}$$

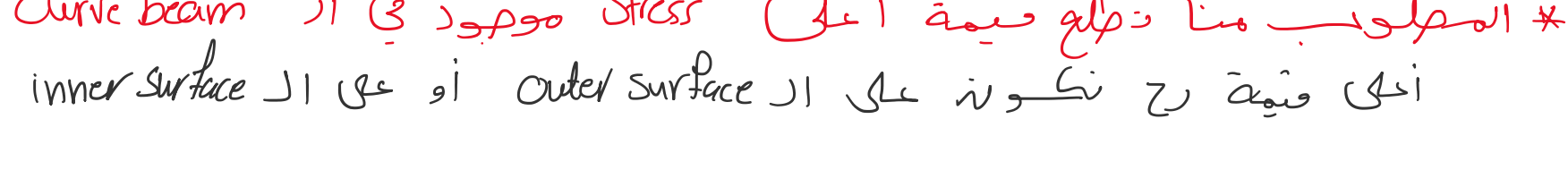
For the hole cross section (you can use a calculator on internet)

$$I = 16.2 \times 10^6 \text{ m}^4$$

$$\tau = \frac{500 \times 120 \times 10^{-6}}{16.2 \times 10^{-6} \times 0.1} = 37500 \text{ N/m}^2$$

Friday, 12 March 2021 11:06 PM

* إلى اصطاف منه قبل ان ياد Beam إلى ح فملو Bending اصطاف في Curve



Center of Curvature (1)

c:- المساقفة بين C.A و N.A

$$V_1 = V_2$$

المسافة من 11

C.A. is center

* بنقیه داننا از y-coordinate منہ از N.A یعنی قیعتہ ی حلی از N.A بنساری صہ.

$$\sin A = 0$$

inner fibre stress $\sigma = \epsilon E$, $r_n - c_i = r_i$

outer fibre stress $y = -C_o$, $r_n + C_o = r_o$

ضمن الجدل

The figure illustrates the calculation of the effective radius r_o for various cross-sections, showing the geometric parameters and the corresponding formulas.

Top Diagram (Rectangular Section): A rectangle with width b_o and height h . The effective radius r_o is shown as the distance from the center to the outer edge. The formula is:

$$r_o = r_i + \frac{h}{2}$$

Middle Diagram (Trapezoidal Section): A trapezoid with top width b_o , bottom width b_i , and height h . The effective radius r_o is shown. The formula is:

$$r_o = r_i + \frac{h}{3} \frac{b_i + 2b_o}{b_i + b_o}$$

Bottom Diagram (Complex Section): A complex cross-section with a top width b_o and a bottom width b_i . The effective radius r_o is shown. The formula is:

$$r_o = r_i + \frac{A}{b_o - b_i + [(b_i r_o - b_o r_i)/h] \ln(r_o/r_i)}$$

Bottom Diagram (I-Section): An I-section with a top flange width b_o and a web width b_i . The effective radius r_o is shown. The formula is:

$$r_o = r_i + \frac{b_i c_1^2 + 2b_o c_1 c_2 + b_o c_2^2}{2(b_o c_2 + b_i c_1)}$$

Bottom Diagram (T-Section): A T-section with a top flange width b_o and a web width b_i . The effective radius r_o is shown. The formula is:

$$r_o = \frac{b_i c_1 c_2}{b_i \ln[(r_i + c_1)/r_i] + b_o \ln[r_o/(r_i + c_1)]}$$

Diagram of a composite figure consisting of a rectangle on top of an inverted triangle. The rectangle has a height of 25 and the triangle has a height of 10. A dashed line separates the two shapes. To the right, the text $\frac{1}{3} \times 0.05$ is written.

$$\begin{aligned}\Sigma A &= \square + \Delta \\ &= (0.05)^2 + \frac{1}{2} * 0.05 * 0.03 \\ &= 3.25 * 10^{-3} \text{ m}^2\end{aligned}$$

$$r_c = \frac{r_{c\Box} A_{\Box} + r_{c\Delta} A_{\Delta}}{\Sigma A} = \frac{0.225 \times (0.05)^2 + 0.26 \times \sqrt{2} \times 0.05 \times 0.03}{3.25 \times 10^{-3}} = 0.23308.$$

$$r_n = \frac{\sum A}{\sum \int dA/r}$$

$$A \square = b(r_o - r_i)$$

$$= 0.05(0.250 - 0.200)$$

$$= 2.5 \times 10^{-3} \text{ m}$$

$$\int_A dA/r = b \ln r_o/r_i$$

$$= 0.05 \ln \left(\frac{0.25}{0.2} \right)$$

$$= 0.011 \text{ m}$$

$$A_{\Delta} = b/2 (r_o - r_i)$$

$$= 0.05/2 (0.28 - 0.25)$$

$$= 7.5 \times 10^{-4}$$

$$\int_A dA/r \approx \frac{b}{(r_o - r_i)} (\ln \frac{r_o}{r_i}) \cdot b$$

$$= 0.0028867 \text{ m}$$

$$r_n = \frac{3.25 \times 10^{-3}}{0.011 + 0.0028867} = 0.232364 \text{ m. } \text{N.A.}$$

$$\begin{aligned} e &= r_c - r_n \\ &= 0.23308 - 0.232364 \\ &= 0.000716 \text{ m} \end{aligned}$$

$$C_i = 0.232364 - 0.200$$
$$= 0.032364$$

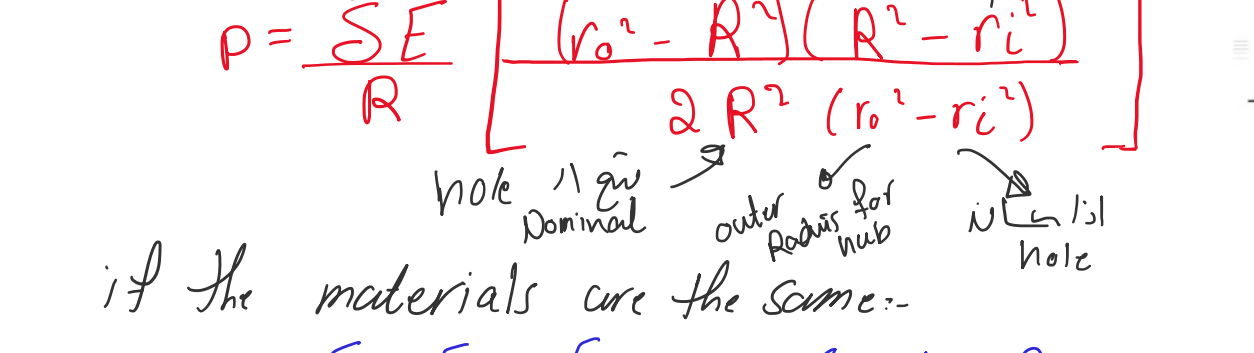
$$C_0 = 0.232364 - 0.28) \\ = -0.047636$$

$$\epsilon_i = \frac{-(4) * 0.032364}{(3.25 * 10^{-3})(0.000716)(0.2)} =$$

$$C = \frac{-(4)(-0.047636)}{(3.25 \times 10^{-3})(0.000176)(0.28)} =$$

$$\sigma = \frac{M y}{I} \frac{r_c}{r}$$

المقصود من نصيب
ال Center



the materials are the same:-

$t = t_i = t_o \rightarrow \text{Steel} = 2000 \text{ ps}$

DLW

D: for Hole
d: for Shaft

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Solid Shaft:-

- Gear hub:-

Sol:-

$$2R + 2.3 \times 10^{-3} = 1.0023 \text{ in (max)}$$

$$2R + 1.8 \times 10^{-3} = 1.0018 \text{ in (min)}$$

Diameter for Gear: (D)

$$2R + 0.8 \times 10^{-3} = 1.0008 \text{ in (max)}$$

$$2A + O = 1 \text{ in (min)}$$

$$P_{\max} = \frac{\sum E}{R} \left[\frac{(r_o^2 - R^2)(R^2 - r_i^2)}{2R^2(r_o^2 - r_i^2)} \right]$$

$$= \frac{0.0023 * 30 * 10^6}{0.5} \left[\frac{(1^2 - 0.5^2)(0.5^2 - 0^2)}{2 * 0.5^2 (1^2 - 0^2)} \right] = 51750$$

لو ضربتو افی ادر Contact Area و ضربتو ب معامل ادمکات
بینه ادر Hub و ادر gear بتوصیل صیغه ادر Frictional force
ای میثم (بتوضیحه ما یصیر انزلاقه بدیهم).

٤. لو يعرف ال hub كم السماكة تبعوا وضرب ال 27RL

صلى بنظر المساحة الخيطة الى صية (Contact Area)

میزان μ و σ و ضریب P و ضریب f بعضی از متغیرات

$$F = 2\pi R L \rho \varphi$$

لو، میٹ صریح اور F ب R بتو صریح اور Fractional Torque

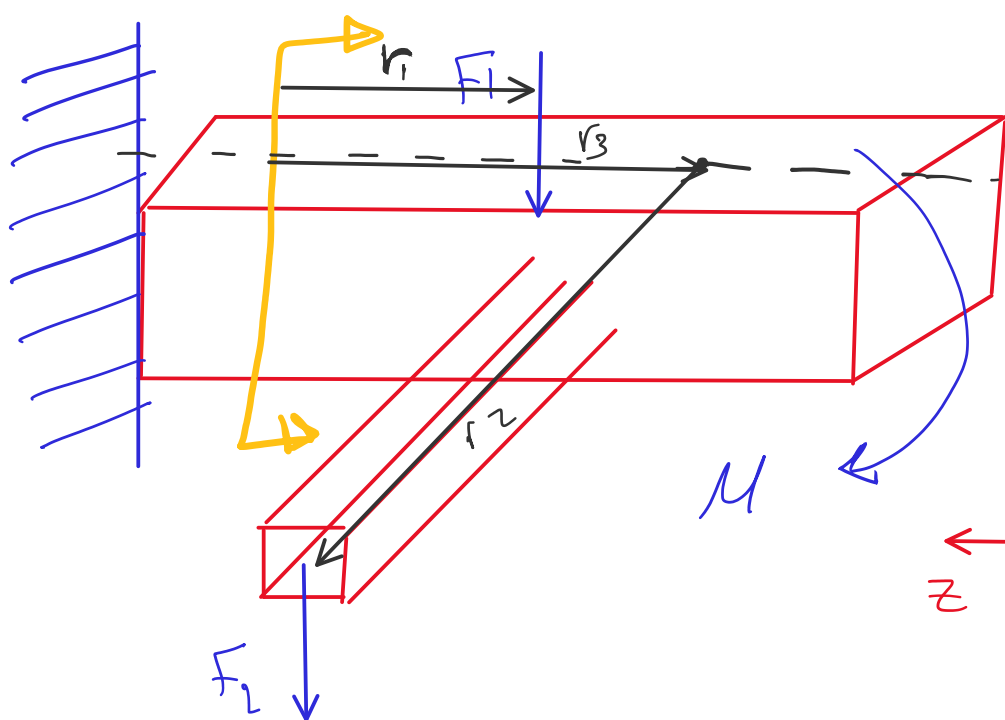
$$T = FR = 2\pi R^2 L \rho f$$

* لو کہنے میں External Torque علی اور Shaft صفا اور Torque مولڈزم ہکونہ
اکیں منہ اور Frictional Torque لو کہنے اکیں ہکونہ میں انزلاقہ۔

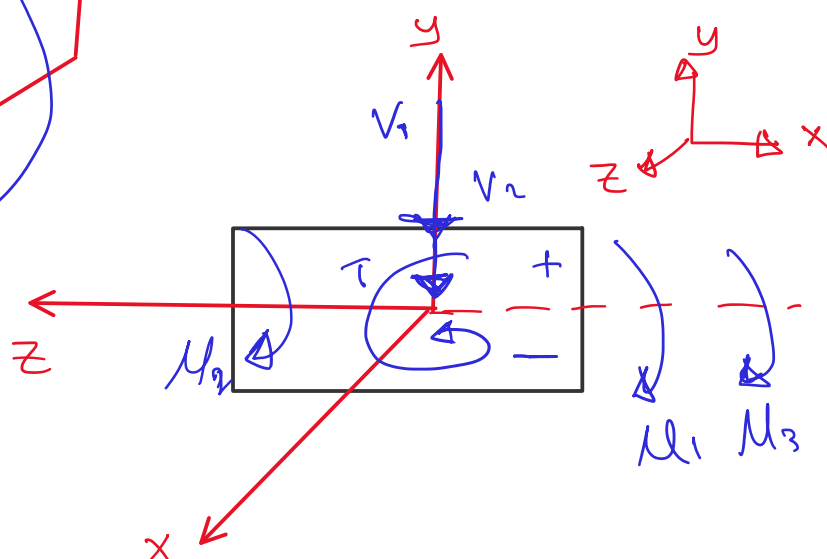
* صلا و صلا لمرحلة استخدام كل اشئ اذنا صق نطلع ار Stresser
داخل ار material ، بين كيف ار material ، ح يصير نيا ار Stress
منه داخل

* دانما ار material ار external force ای علیا اکید بنعل Stresser
های ار Stresser منہ معالما بیگونه ار maximum stress فی لافضل planes
خیر عند ار planes رخا رجبیه .

Principle stresses $\rightarrow$ Normal Stress.
 $\rightarrow$ Shear Stress.



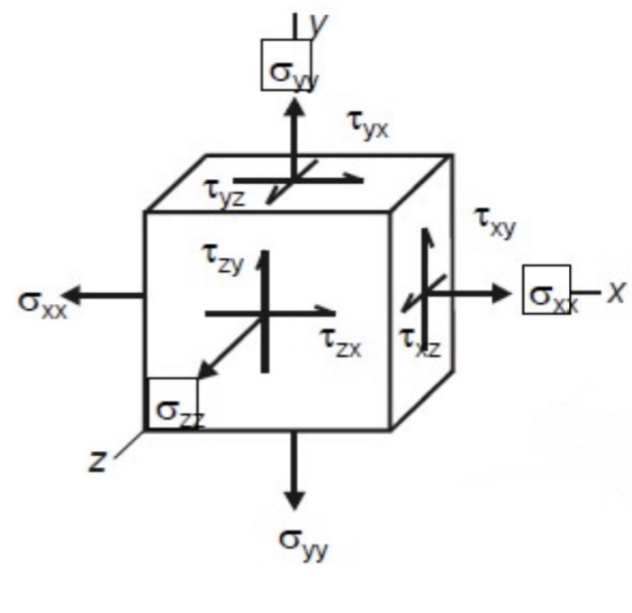
بعداً تصوف فائز ار
 F_1 و F_2 علی ار cross section



-Z ist das Moment längs F_1 //

Lecture9

Sunday, 28 March 2021 4:24 PM



الاجسام صلب اثنى يكونه عليه stress component يكونه

طاي او beam عسجا force بس ما بتتحرك لانها in static equilibrium. راسق اثنى

اثنى ما بتتحرك، اكيد او Normal stress بانجام او Negative (x) لازم يكونه نفسه قبة او Normal stress في اتجاه او (y) positive عسجا ما بتتحرك. بانجام او (x)

* اذا بتسار او Normal component (على نفس او direction) ما يكونه في مركبة قبة لازم ما يلغ صلا صلا يعني لازم يكونه متساويين (tau_y = tau_x)

$$\begin{bmatrix} \sigma_{xx} & \tau_{xy} & \tau_{xz} \\ \tau_{yx} & \sigma_{yy} & \tau_{yz} \\ \tau_{zx} & \tau_{zy} & \sigma_{zz} \end{bmatrix} \rightarrow \text{External applied stress.}$$

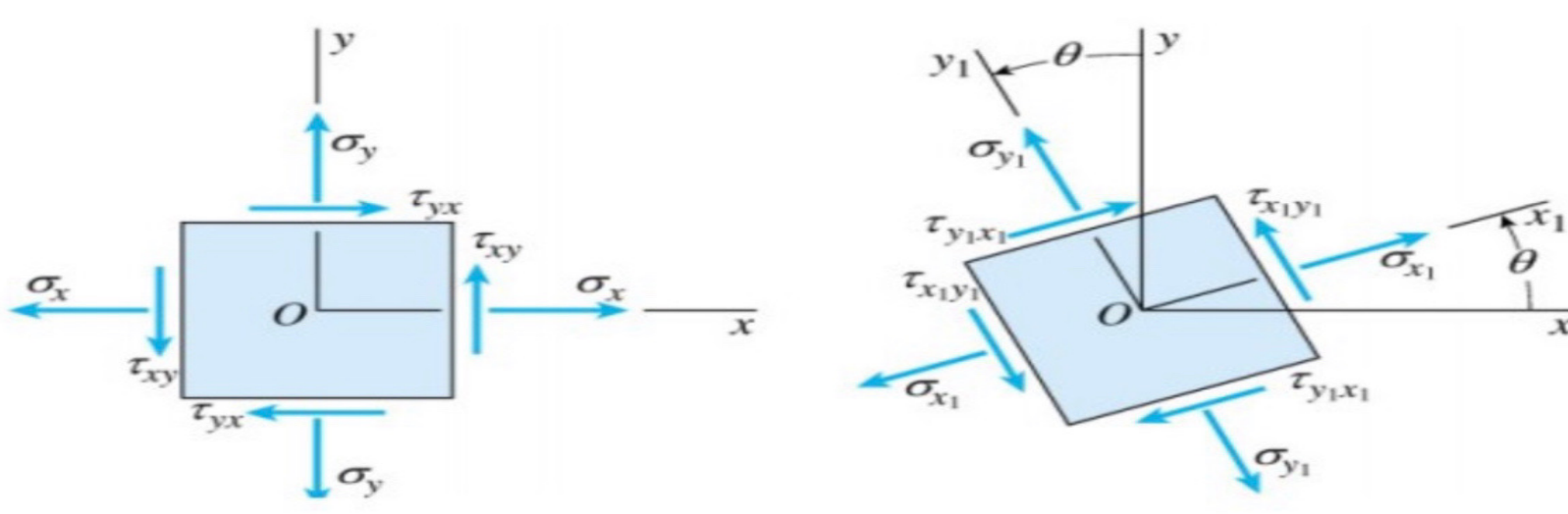
* كل اي رح نرسوا رح نمرهاد او body على plane يكونه قبال stress عليه (3 component) لازم طاي القبة يكونه اثنى من او External

* اذا لقيت plane او Normal stress الوصو او Maximum بس اسو principle plane

* اذا لقيت plane عليه Maximum shear يكونه اسو plane Maximum shear stress

2-D Stress state → plane stress

1-D stress state → uni axial (بكونه بس بانجام واحد)



* في اي جسم او Normal يتعو بيتو دينه او x axis في زاوية theta بتقتر نطلع على صلا او plane او component بتقتر.

2-D

$$\sigma_{x_1} = \frac{\sigma_{xx} + \sigma_{yy}}{2} + \frac{\sigma_{xx} - \sigma_{yy}}{2} \cos 2\theta + \tau_{xy} \sin 2\theta$$

$$\sigma_{y_1} = \frac{\sigma_{xx} + \sigma_{yy}}{2} - \frac{\sigma_{xx} - \sigma_{yy}}{2} \cos 2\theta - \tau_{xy} \sin 2\theta$$

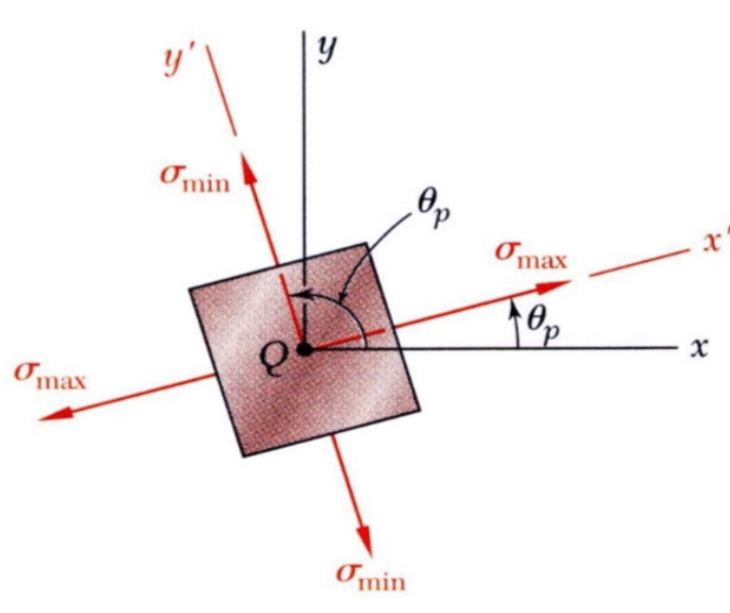
$$\tau_{x_1 y_1} = -\frac{\sigma_{xx} - \sigma_{yy}}{2} \sin 2\theta + \tau_{xy} \cos 2\theta$$

مايستخدموا كتي plane داخل او body بس لازم تقرب او theta ولما اعربها لازم ادور دينه او Maximum

* الهمد! اثنى شور على او plane الى يعل زاوية معينة عسجا او x رقبصا Maximum Normal او shear وينه طاي او planes كيت بنطلفها! بنسقة بالنسبة ل theta بنساويها بس

$$\sigma_{\max} = \frac{\sigma_{xx} + \sigma_{yy}}{2} + \sqrt{\left(\frac{\sigma_{xx} - \sigma_{yy}}{2}\right)^2 + \tau_{xy}^2}$$

$$\sigma_{\min} = \frac{\sigma_{xx} + \sigma_{yy}}{2} - \sqrt{\left(\frac{\sigma_{xx} - \sigma_{yy}}{2}\right)^2 + \tau_{xy}^2}$$



$$\tan 2\theta_p = \frac{2\tau_{xy}}{\sigma_{xx} - \sigma_{yy}}$$

بتعطين او max او min 90 بتعطين او

* او plane الى عليه او Maximum او او minimum قبة او shear stress يكونه صفر، لان لو عوضنا theta في القانونه الاولي رح يطلع tau بتساوي صفر معانق او principle plane معانق صو او plane الى عليه اثنى Normal stress ويتكونه قبة او shear عليه صفر

$$\tau_{\max} = R = \sqrt{\left(\frac{\sigma_{xx} - \sigma_{yy}}{2}\right)^2 + \tau_{xy}^2}$$

$$\tan 2\theta_s = -\frac{\sigma_{xx} - \sigma_{yy}}{2\tau_{xy}}$$

* كل plane عليه Normal، shear او Normal على صلا او plane الى عليه maximum shear صو عسجا

$$\sigma_{ave} = \frac{\sigma_{xx} + \sigma_{yy}}{2}$$

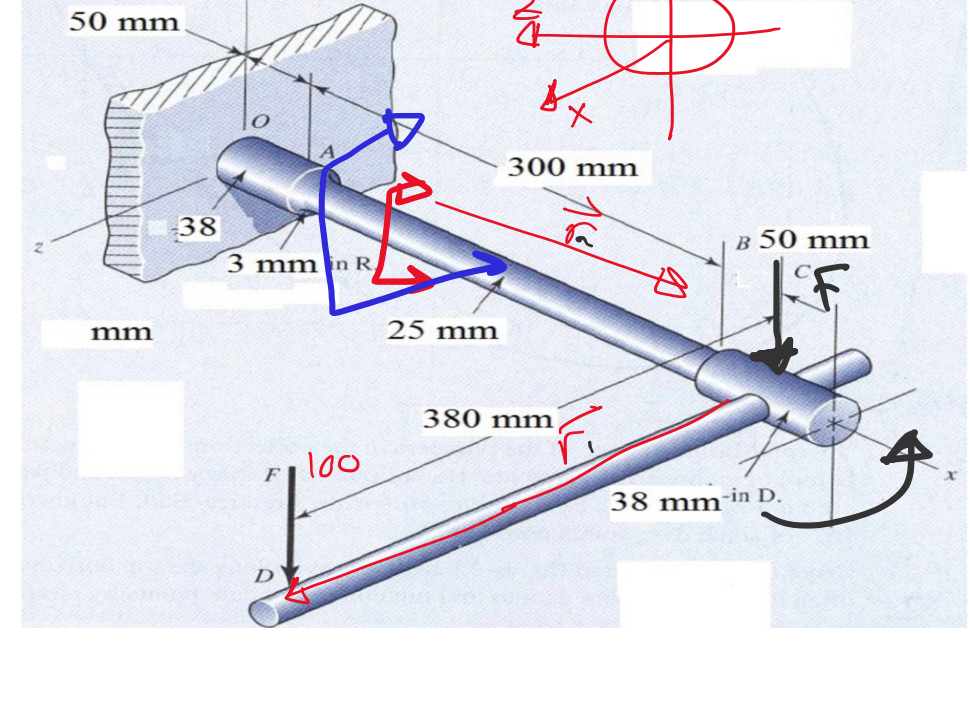
* معانق او plane الى عليه maximum shear يكونه او Normal component او صو

* او theta و او theta_p بينهم زاوية متساوية 45 درجة

Ex:- A force 100 N is applied at D near the end of the lever. The bar OABC is made of AISI 1035 steel, forged and heat treated so that it has a minimum (ASTM) yield in strength of 55.8 Mpa. Find

1. The maximum shear.
2. The maximum shear required to initiate yielding According to Tresca

Assume that the lever DC will not yield and that there is no stress concentration at A



$$T = \vec{r} \times \vec{F} = 0.38 \times 100 = 38 \text{ Nm}$$

$$\hat{k} \times -\hat{j} = +\hat{i}$$

$$\vec{M}_z = \vec{r} \times \vec{F} = 0.35 \times 100 = 35$$

$$= \hat{i} \times -\hat{j} = -\hat{k}$$

$$\sigma = \frac{My}{I}$$

$$\sigma_x = \frac{My}{I} = \frac{35 \times 12.5}{\pi d^3} = 22.8 \text{ Mpa}$$

$$\frac{\pi d^4}{64}$$

$$\tau = \frac{Tr}{J} = \frac{38 \times 12.5}{\pi d^4/32} = 0.39 \text{ MPa}$$

$$\tau = \sqrt{\left(\frac{\sigma_{xx} - \sigma_{yy}}{2}\right)^2 + \tau_{xy}^2}$$

$$= \sqrt{11.4^2 + 0.39^2}$$

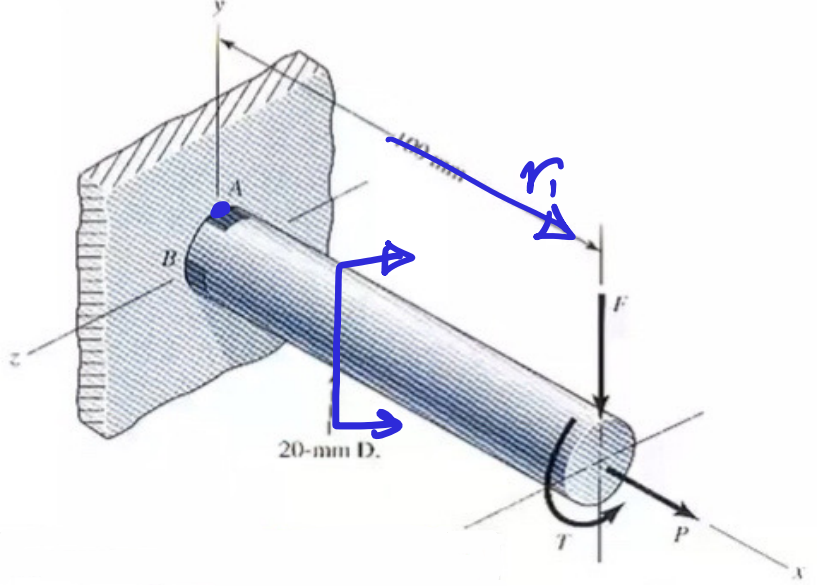
Lecture 10

Sunday, 28 March 2021

9:51 PM

Ex:- A Bar is AISI 1020 hot-rolled steel, $S_y = 331 \text{ MPa}$, $F = 0.55 \text{ kN}$, $P = 8.0 \text{ kN}$, $T = 30 \text{ Nm}$. Find:

1. principle stresses and Max. Shear stress.
2. Factor of safety (n) at A.



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

$$M = \vec{r} \times \vec{F} \quad , \quad \sigma = \frac{My}{I}$$

$$= 0.1 \times 0.55 \times 10^3$$

$$=$$

$$\sigma = \frac{P}{A} = \frac{8 \times 10^3}{\frac{\pi (20/2000)^2 \pi}{4}}$$

$$\sigma_{xx} = \frac{0.1 \times 0.55 \times 10^3 \times \frac{20}{2000}}{\frac{\pi (20/2000)^4}{64}} + \frac{8 \times 10^3}{\frac{\pi (20/2000)^2 \pi}{4}} = 95.5 \text{ MPa}$$

$$\tau_{xz} = \frac{16T}{\pi D^3} = \frac{16 \times 30}{\pi D^3} = 19.1 \text{ MPa (Max applied stresses)}$$

$$\sigma_1 = \frac{\sigma_{xx} + \cancel{\sigma_{zz}}}{2} + \sqrt{\left(\frac{\sigma_{xx} - \cancel{\sigma_{zz}}}{2}\right)^2 + \tau_{xz}^2}$$

$$\sigma_1 = 99.2 \text{ MPa}$$

$$\sigma_2 = \frac{\sigma_{xx} - \cancel{\sigma_{zz}}}{2} - \sqrt{\left(\frac{\sigma_{xx} - \cancel{\sigma_{zz}}}{2}\right)^2 + \tau_{xz}^2}$$

$$\sigma_2 = -3.63 \text{ MPa}$$

$$\tau_{xz} = \sqrt{\left(\frac{\sigma_{xx} - \cancel{\sigma_{zz}}}{2}\right)^2 + \tau_{xz}^2}$$

$$\tau_{xz} = 51.4 \text{ MPa}$$

yielding criteria :-

Tresca بااختیار بیلش حسب Tresca yielding بین اور Material
 بیلش میں plastic deformation بیلش لما يكون τ_{max} ای حسبها ایها
 اذا كانت بیلش $\tau_{max} = \frac{\sigma_y}{2}$ اذا تساوا هاتو فيه
 yielding في plastic deformation اذا كانت τ_{max} اقل منه $\frac{\sigma_y}{2}$
 هاتو No yielding اذا كانت اكبر منه $\frac{\sigma_y}{2}$ اكبر ح یس
 yielding

* حسب اور Tresca

$$\tau_{max} = 51.4 \text{ MPa}$$

$$\sigma_y = 331/2 > \tau_{max}$$

No yielding.

$$n = \frac{\sigma_y/2}{\tau_{max}} = \frac{331/2}{51.4} = 3.28$$

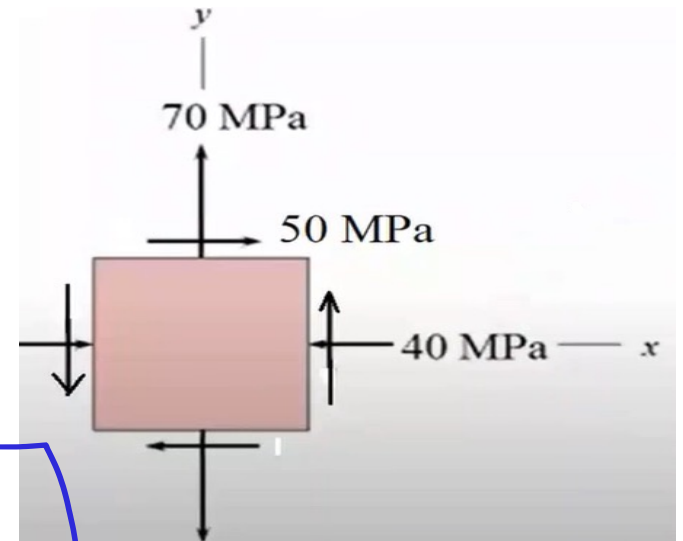
عنايه مانی yielding اكبر
 اور (n) ح تكونه اكبر منه (1)

Ex:- Determine the principal stresses and the maximum in plane shear stress of the element.

$$\sigma_x = -40 \text{ MPa}$$

$$\sigma_y = 70 \text{ MPa}$$

$$\tau_{xy} = -50 \text{ MPa}$$



$$\sigma_1 = \frac{\sigma_x + \sigma_y}{2} + \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$$

$$= 89.3 \text{ MPa}$$

Shear stress = 0

$$\sigma_2 = \frac{\sigma_x + \sigma_y}{2} - \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$$

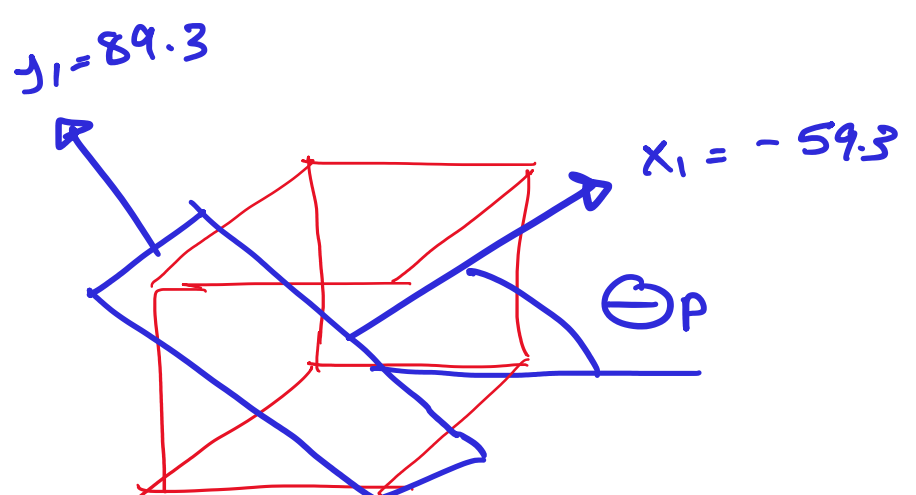
$$= -59.3$$

$$\tau_{max} = \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$$

$$= 73.3 \text{ MPa}$$

$$\tan 2\theta_p = \frac{\tau_{xy}}{(\sigma_x - \sigma_y)/2}$$

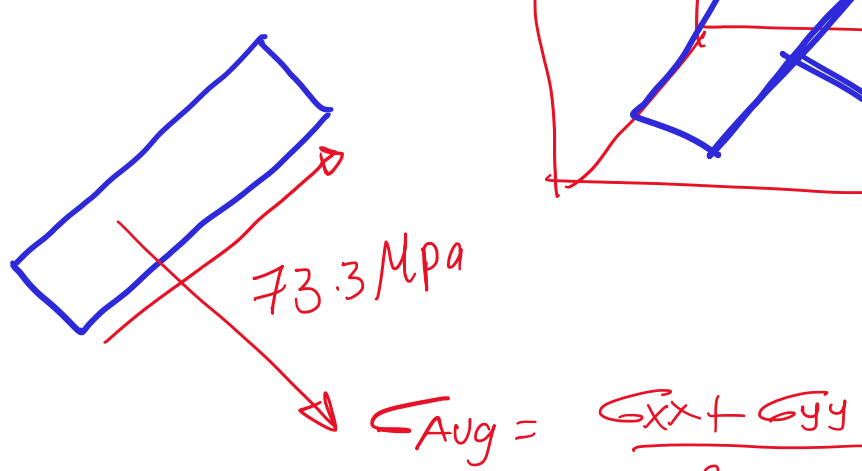
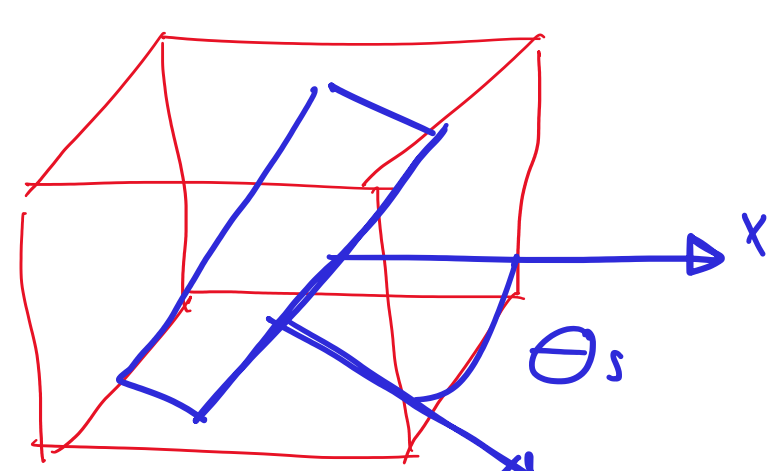
$$\theta_p = \frac{1}{2} \tan^{-1} 0.909 = 21.1^\circ$$



* اور انلا اور plane ای علی Max normal stress و Min normal stress بیلش هاتو ایها
 Shear بیلش

$$\tan 2\theta_s = -\frac{(\sigma_x - \sigma_y)/2}{\tau_{xy}}$$

$$\theta_s = \frac{1}{2} \tan^{-1} (-1.1) = -23.9$$



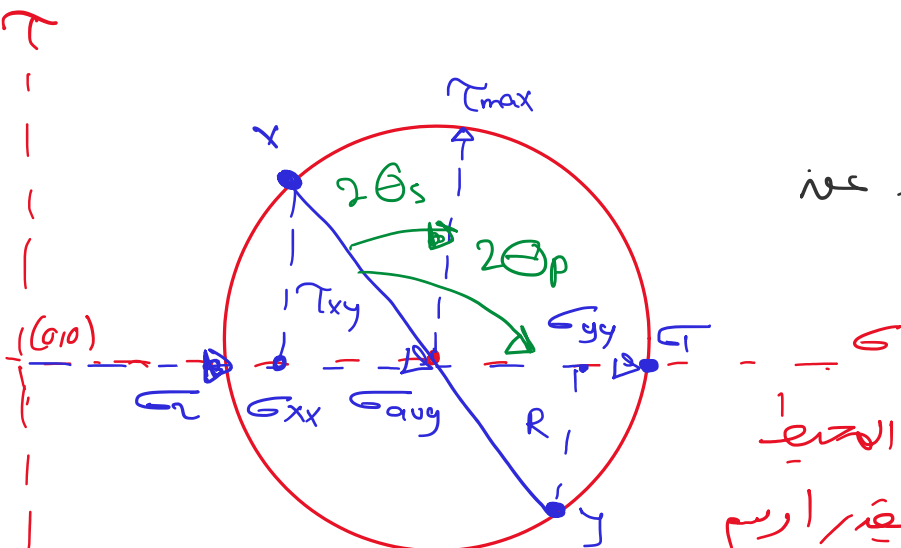
Lecture12

Saturday, 3 April 2021

12:20 AM

Mohr Circles:-

هي طريقة لإيجاد σ_1 و σ_2 principle stresses و τ_{max} Maximum Shear عن طريق الرسم ، الرسم
 2-D Stress State يكون دائرة اسمها Mohr circle تستخدم لإيجاد 2-D Stress State وبنفسه تستخدمها
 3-D Stress State لإيجاد 3-D Stress State



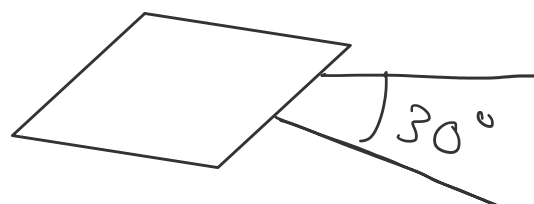
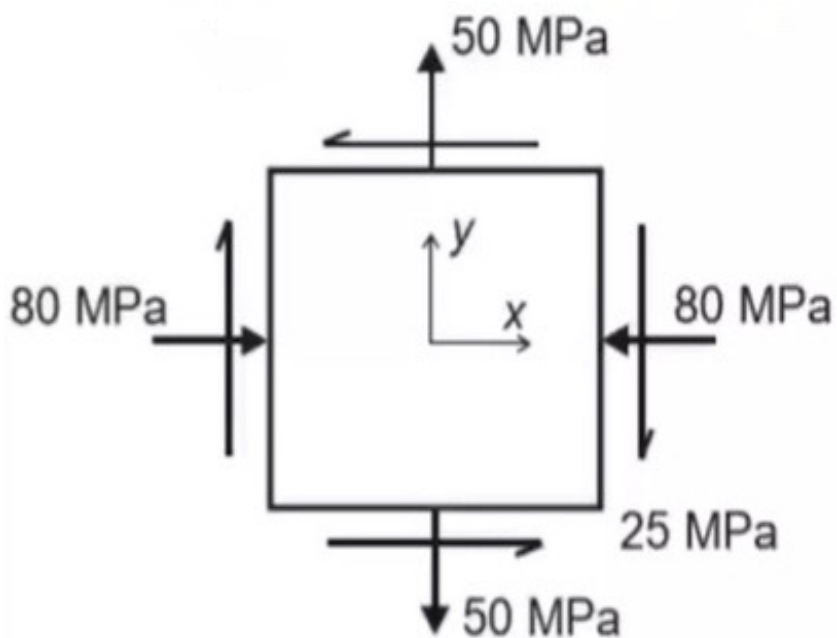
دائرة إليها Center صيا أو Center يبع عنه
 نقطة أو (0,0)

* Mohr circle لازم يكون عندي نقطتين على المحاور
 إذا وصلت بينهم برف أو diameter وبالتالي بقدر ارس
 دائرة . كل نقطة إليها Normal stress وإليها Shear stress.

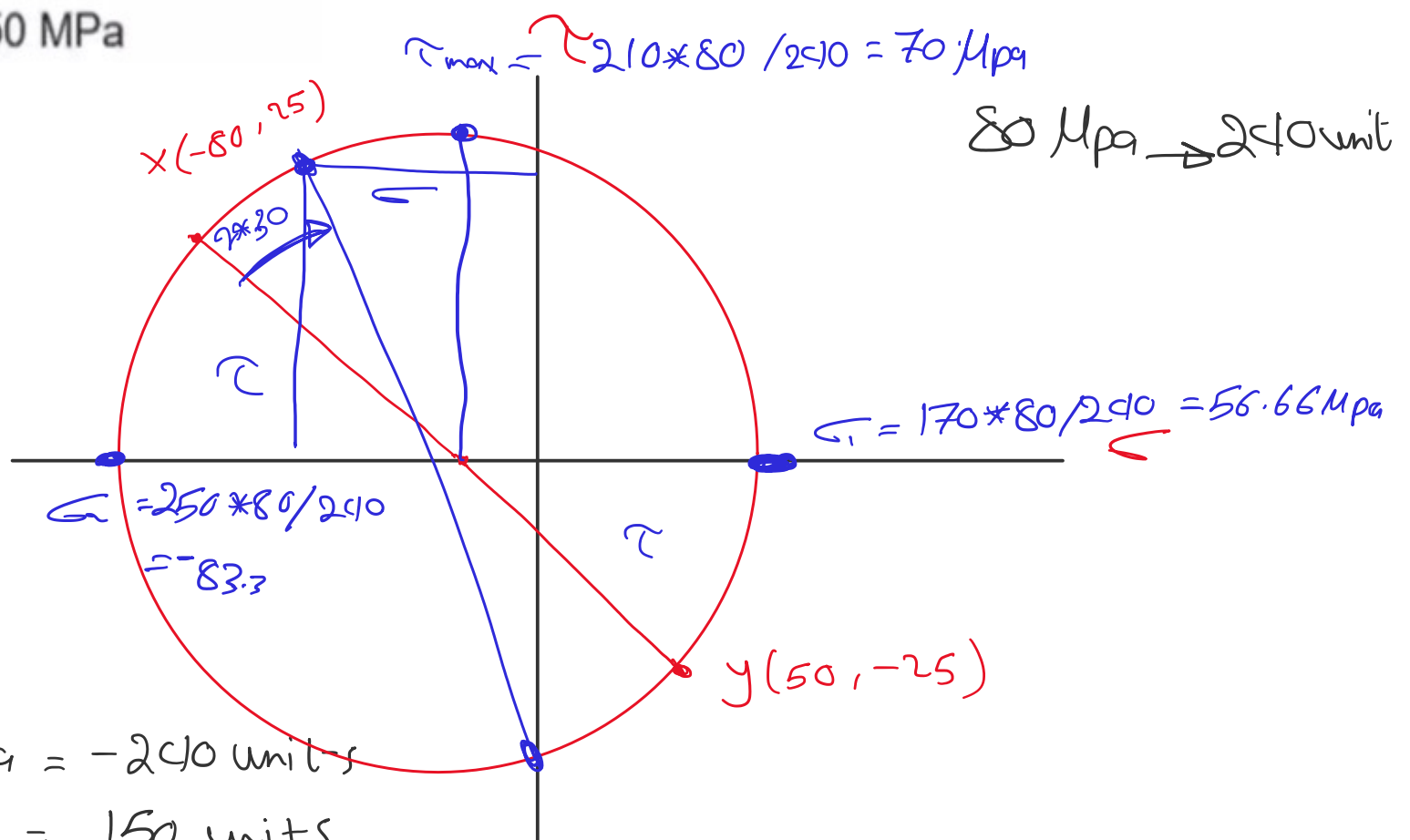
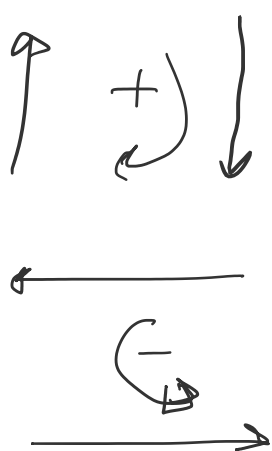
MPa → unit length

10 MPa → 1 cm

Ex:- The State of plane stress at a point is represented by the Stress element below. Find the stresses on an element inclined at 30° clockwise.



σ_{xx} τ_{xy}
 $x(-80, 25)$
 $y(50, -25)$
 σ_{yy} τ_{yx}



$$\sigma = -80 \text{ MPa} = -240 \text{ units}$$

$$\sigma = 50 \text{ MPa} = 150 \text{ units}$$

$$\tau = 25 \text{ MPa} = 75 \text{ units}$$

Lecture14

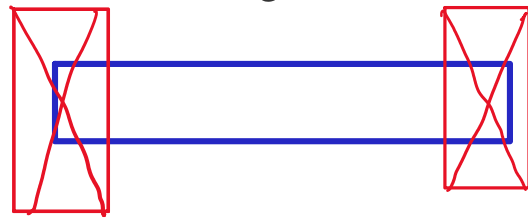
Wednesday, 14 April 2021

8:10 PM

Rolling- contact Bearings:-

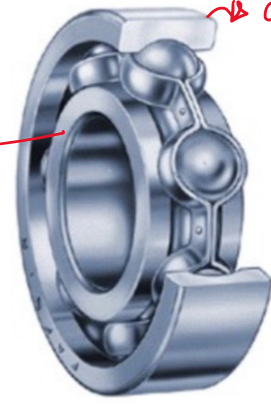
Friction في شفت Support

المعرف في Bearings



Ball bearing

inner race
outer race

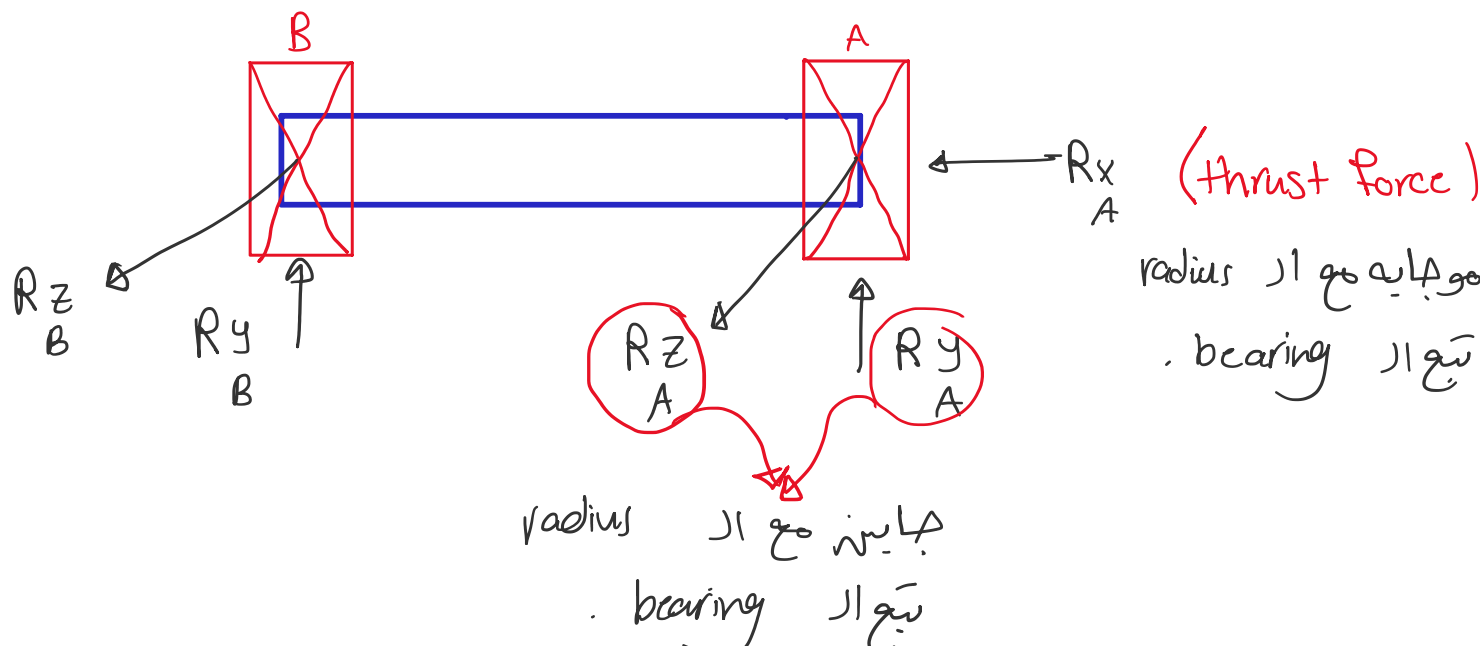


Thrust bearing

Tapered roller bearing

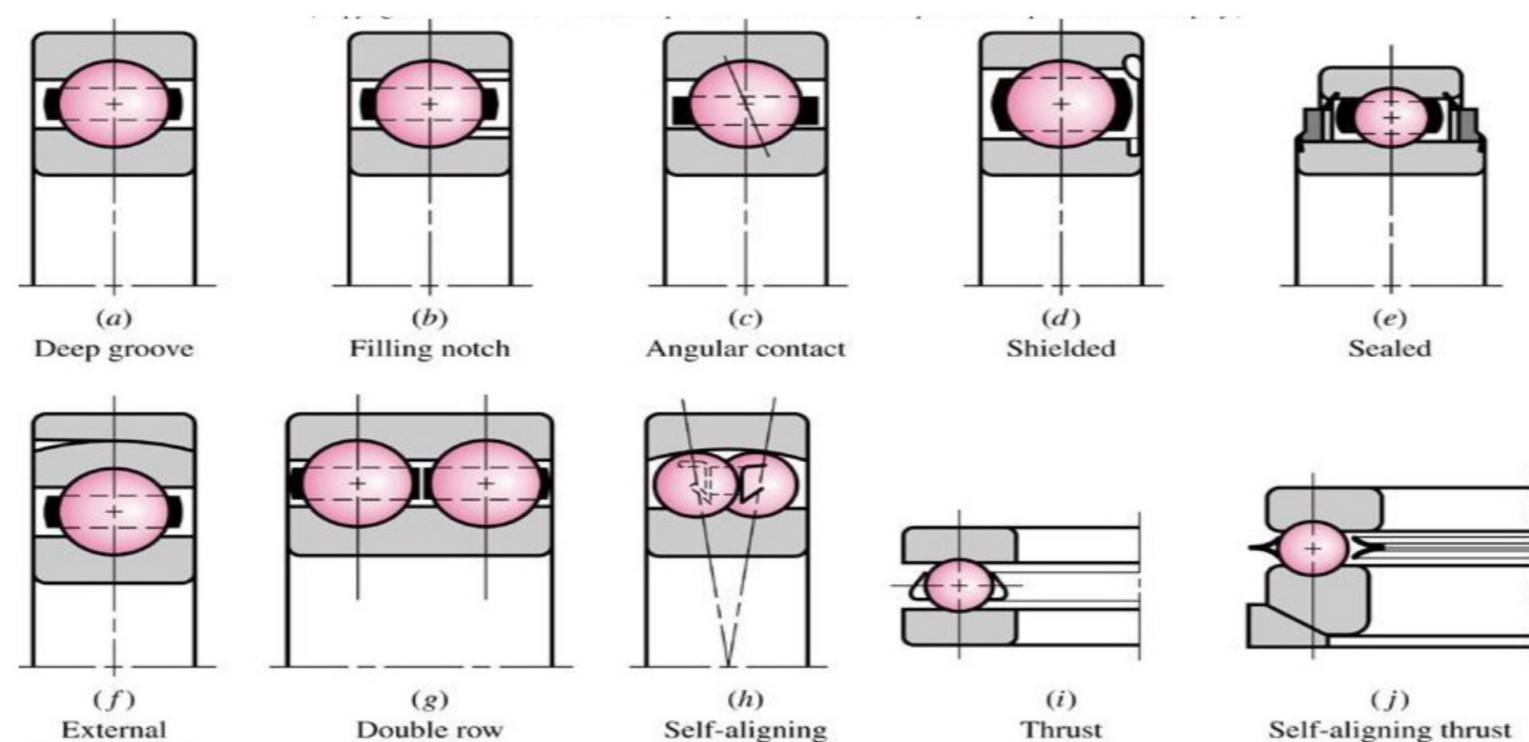


Needle roller bearing



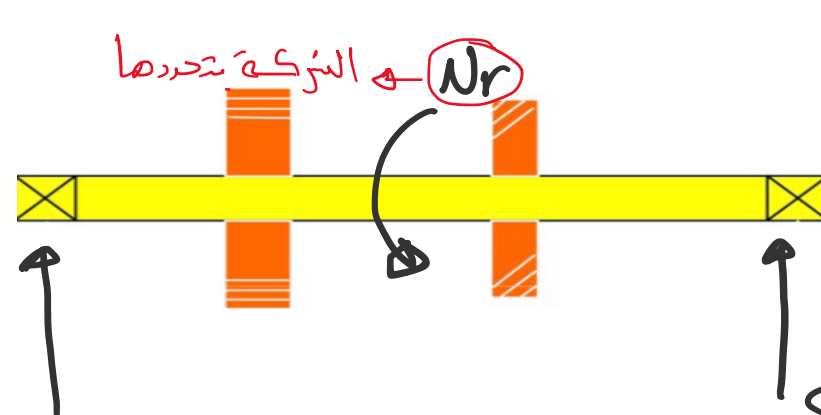
* ball bearings cylindrical bearings تتحمل radial force التي من ball bearings

Types of ball bearings:-



* Design selection:-

عنا إني إسر Reliability rated (Rr) ball bearings إلى شركة SKF
Reliability rated bearings حسب الشركة يكون 90%
كيف تم قياسه أو reliability:-



عنا Load معدل (C10) أو Shaft يتحمل في rated speed (rpm) الشركة يتحمل
صحة الشركة، إن بعد 1 million rev (10^6) على هذا أو Load (C10) أو reliability ر الشركة
90%.

* عنا نوعين من الأسلاك:-

1) طبق Reliability rated يعني صوة من أو bearing يكون Reliability 90%
2) طبق من 90% طبق من 95% Reliability-life trade off

* الحالة الأولى:-

$$C_{10} L_R^{1/q} = F_D L_D^{1/q}$$

L: عدد الدورات أو الساعات
L_R: 10^6 rev
L_D: حسب السؤال عني
q: يعتمد على نوع أو bearing

cylindrical and tapered q=10/3 ball bearing q=3

$$d_d = L_d * N_D * 60$$

Ex:- Select a deep groove ball bearing for a desired life of 5000 hours at 1725 rpm with 90% reliability. The bearing radial load is 400 Ib

$$L_d = 5000, F_D = 400$$

$$n_d = 1725, L_R = 10^6$$

$$C_{10} L_R^{1/q} = F_D L_D^{1/q}$$

$$C_{10} (10^6)^{1/3} = 400 * (5000 * 1725 * 60)^{1/3}$$

$$C_{10} = 3211.42 \text{ Ib} = 14.3 \text{ kN}$$

$$\text{Bore} = 30 \text{ mm}$$

$$\text{OD} = 62 \text{ mm}$$

* الحالة الثانية: R_D ≠ R_r ≠ 90%

$$C_{10} = a_f F_D \left[\frac{X_D}{x_0 + (\Theta - x_0) (L_n / R_D)^{1/b}} \right]^{1/q}$$

a_f = application factor .
X_D = L_D / L_R , x_0, Θ, b := constant parameters.
x_0 = 0.02 .
Θ - x_0 = 4.439 .
b = 1.483 .

Ex:- Select a deep groove ball bearing for a desired life of 5000 hours at 1725 rpm with 99% reliability. The bearing radial load is 400 Ib

$$L_d = 5000, R_D = 99\%$$

$$F_D = 400$$

$$C_{10} = a_f F_D \left[\frac{X_D}{x_0 + (\Theta - x_0) (L_n / R_D)^{1/b}} \right]^{1/q}$$

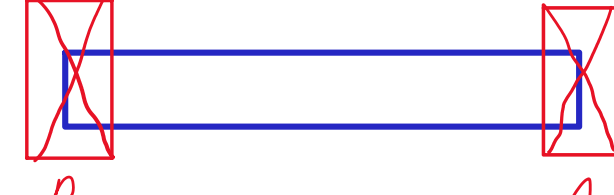
$$X_D = \frac{5000 * 60 * 1725}{10^6}$$

$$C_{10} = 1 * 400 \left[\frac{5000 * 60 * 1725 / 10^6}{0.02 + 4.439 (L_n / 0.99)^{1/1.483}} \right]^{1/3} = 5323 \text{ Ib} = 23.7 \text{ kN}$$

$$\text{Bore} = 35 \text{ mm}$$

$$\text{OD} = 72 \text{ mm}$$

* إذا كان من Two bearings



$$R_{\text{system}} = R_A R_B$$

$$R_{\text{system}} = R^2$$

Lecture15

Wednesday, 14 April 2021

10:04 PM

Ex:- A gear-reduction unit uses the countershaft depicted in the figure. Find the two bearing reaction. The bearings are to be angular-contact ball bearings, having a desired life of 50 kh when used at 400 rev/min. Use 1.2 for the application factor and reliability goal for the bearing pair of 0.98.

a- select the bearings from table 11.2.

$$L_d = 50 \text{ kh}$$

$$a_f = 1.2$$

$$R = \sqrt{0.98} = 0.99 \text{ (Not rated).}$$

$$C_{10} = a_f F_D \left[\frac{X_D}{X_D + (\theta - X_D) (L_n / R_D)^{1/b}} \right]^{1/a}$$

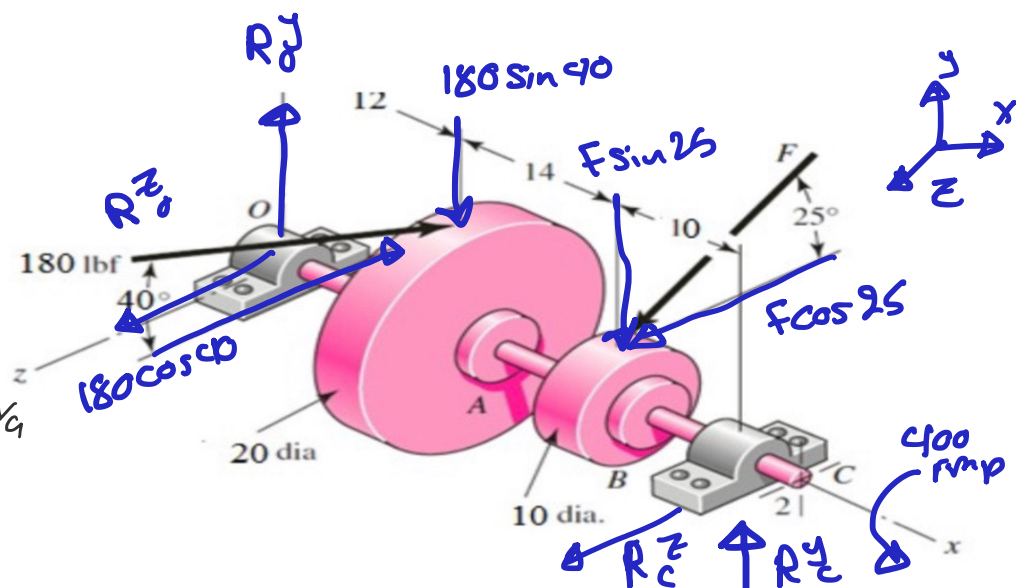
$$= 1.2 * 201.83 \left[\frac{1200}{0.02 + 4.439 (L_n / 0.99)^{1/4.83}} \right]^{1/3}$$

$$= 4270.07 \text{ Ib}$$

$$= 18.9 \text{ kN.}$$

$$\text{Bore} = 30.$$

$$\text{OD} = 62.$$



$$X_D = \frac{L_D}{L_R} = \frac{50000 * 400 * 60}{10^6} = 1200$$

$$R_D = 0.99$$

$$\sum T = 0$$

$$5 * F \cos 25$$

$$- 10 * 180 \cos 40$$

$$5 F \cos 25 - 10 * 180 \cos 40 = 0$$

$$F = \frac{10 * 180 \cos 40}{5 \cos 25}$$

$$F = 304.28$$

$$\sum M_o^z = 0$$

$$0 = 36 * R_c^y - 26 * 304.28 * \sin 25 - 12 * 180 * \sin 40$$

$$R_c^y = 131.4$$

$$\sum F_y = 0$$

$$131.4 - 304.28 \sin 25 - 180 \sin 40 + R_o^y = 0$$

$$= 112.86$$

$$\sum M_o^y = 0$$

$$- 36 * R_c^z - 26 * 304.28 \cos 25 + 12 * 180 \cos 40 = 0$$

$$= -153.2$$

$$\sum F_z = 0$$

$$- 153.2 + 304.28 \cos 25 - 180 \cos 40 + R_o^z = 0$$

$$= 15.316$$

$$R_c = \sqrt{(R_c^y)^2 + (R_c^z)^2} = \sqrt{131.4^2 + (-153.2)^2} = 201.83$$

$$R_z = \sqrt{(R_o^y)^2 + (R_o^z)^2} = \sqrt{(112.86)^2 + (15.316)^2} = 113.84$$

Lecture16

Thursday, 15 April 2021

11:34 PM

Combined Radial and Thrust Loading:-

radial و التآلية و Thrust و دو Two Components بنفسها bearing اذا كان على او كيف نعمل او Selection

$$F_c = X_i V F_{ri} + Y_i F_a$$

V:- outer ring rotation ص او inner ring rotation ص او Constant بقیه على او rotating bearing

اذا كان outer ring rotating او $V=1.2$

اذا كان inner ring rotating او $V=1$

X_i, Y_i من Table و الیها صالینہ: X_1, Y_1 او X_2, Y_2

F_a/C_0	e	$F_a/(V F_r) \leq e$		$F_a/(V F_r) > e$	
		X_1	Y_1	X_2	Y_2
0.014*	0.19	1.00	0	0.56	2.30
0.021	0.21	1.00	0	0.56	2.15
0.028	0.22	1.00	0	0.56	1.99
0.042	0.24	1.00	0	0.56	1.85
0.056	0.26	1.00	0	0.56	1.71
0.070	0.27	1.00	0	0.56	1.63
0.084	0.28	1.00	0	0.56	1.55
0.110	0.30	1.00	0	0.56	1.45
0.17	0.34	1.00	0	0.56	1.31
0.28	0.38	1.00	0	0.56	1.15
0.42	0.42	1.00	0	0.56	1.04
0.56	0.44	1.00	0	0.56	1.00

*Use 0.014 if $F_a/C_0 < 0.014$.

* كيف نعرف اذا كانت 1 او 2 :-

منه نفس او Table عنا F_a/C_0 او F_a بنكونه موضعي من السؤال C_0 بتبعته على نوع او bearing اي ح اعلى بقسم F_a/C_0 وطلع او ratio وبيع ل Table F_r تانيه اذا كانت $F_a/V F_r$ اقل من او تساوي e معناه بنكون $i=1$ اذا كانت اكبر منه e بنكون $i=2$.

(سبه اذا كنت يعرف او bearing).

* لو ما كنت يعرف نوع او bearing :-

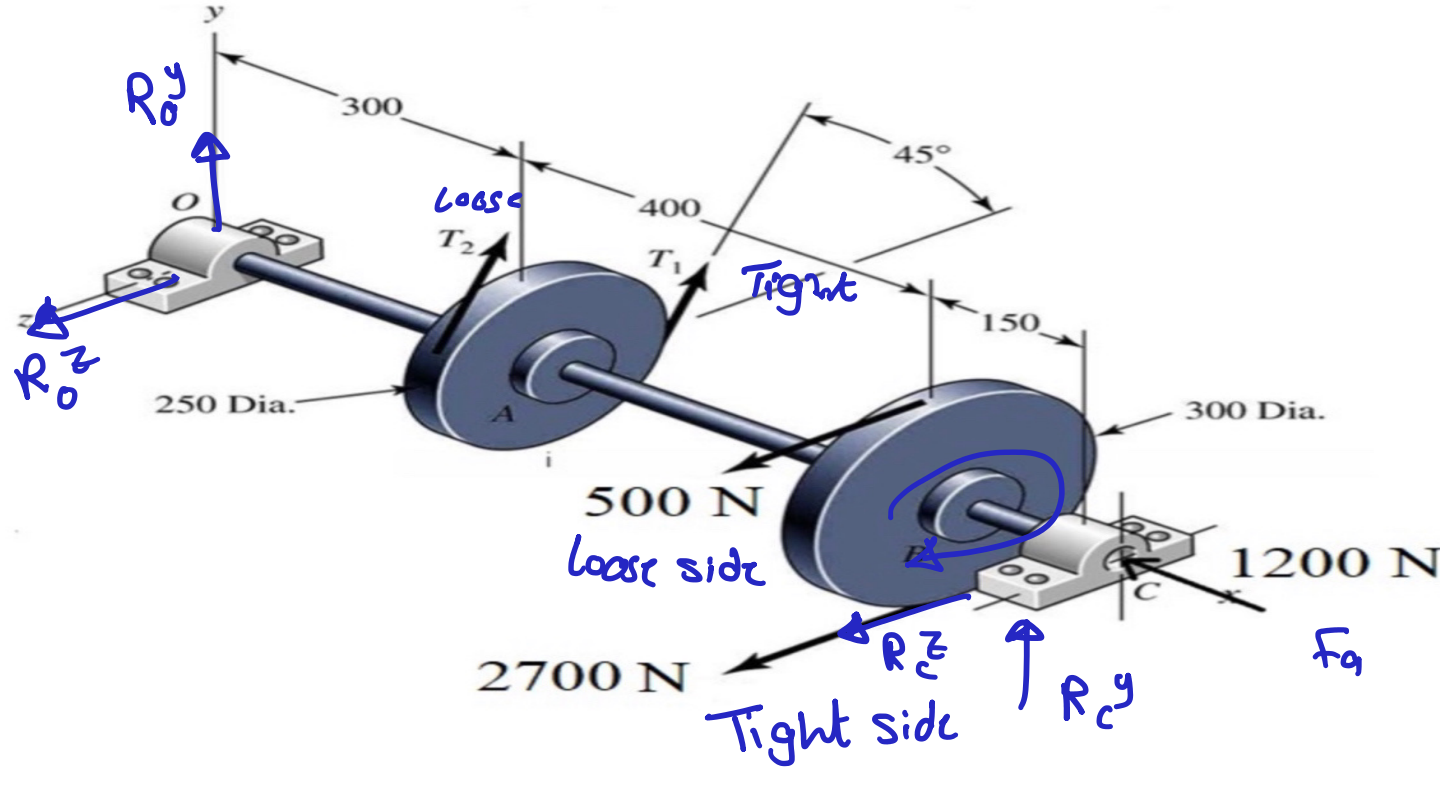
ح اعتراضه بالسؤال لو كانت او C_0 منه معطام بي اعتراضه

1- Assume $L=2$

وبدي افرضه قيمه ل L وائي بتبعته عليها ابو نيلته من قيمه و e ح نفرضها 1.63

منه F_{eq} بنجمل C_{10} و منها بنجمل C_0

Ex:- The figure is a schematic drawing of a counter shaft that supports two v-belt pulleys (They are held in place using keys) The countershaft runs at 1200 r/min and the bearings are to have a life of 10 kh at a combined reliability of 0.98, for the weibull parameters are $b=1.483$, $x_0=0.02$ $\Theta=4.439+0.02$. The application factor is to be 1.2. The belt tension on the loose side of pulley A is 15 percent of tension on the tight side angular



$$R_B R_C = 0.98 \quad T_2 = 0.15 T_1$$

$$R_y = 0.98$$

$$R = 0.99$$

$$\sum T_x = 0$$

$$(2700 - 500) \times 150 - (T_1 - 0.15 T_1) \times 125 = 0$$

$$T_1 = 3106 \text{ N}$$

$$T_2 = 466 \text{ N}$$

$$\sum M_y = 0$$

$$R_B y \times 850 + (T_1 + T_2) \sin 45 \times 300 = 0$$

$$R_B y = -891 \text{ N}$$

$$\sum F_y = 0$$

$$-891 + (T_1 + T_2) \sin 45 + R_C y = 0$$

$$R_C y = -1634.7 \text{ N}$$

$$\sum F_x = 0$$

$$-(2700 + 500) \times 700 + (T_1 + T_2) \cos 45 \times 300 + R_C x \times 850 = 0$$

$$R_C x = 1743.8 \text{ N}$$

$$\sum F_z = 0$$

$$1743.8 + 2700 + 500 - (T_1 + T_2) \cos 45 + R_B z = 0$$

$$R_B z = -2418.3 \text{ N}$$

$$F_B = \sqrt{(-1634.7)^2 + (-2418)^2}$$

$$= 2918.97$$

$$F_C = \sqrt{(-891)^2 + (1744)^2}$$

$$= 1958.4$$

at C:-

$$F_{eq} = V F_r x_2 + y_2 F_a$$

$$= (1) \times 1958.4 \times 0.56 + 1.63 \times 1200$$

$$= 3052.8 \text{ N}$$

$$C_{10} = 1.2 \times 3052.8 \left[\frac{x_D}{x_0 + (\Theta - x_0) (1 - R_D)^{1/b}} \right]^{1/4} \rightarrow 3$$

$$C_{10} = 44.52 \text{ kN}$$

$$\text{Bore} = 55$$

$$\text{OD} = 100$$

$$C_0 = 28.5$$

$$\frac{F_a}{C_0} = \frac{1200 \times 10^{-3}}{28.5} = 0.0421$$

$$e = 0.24$$

$$F_a / V F_r = 1200 / 1 \times 1958.4$$

$$= 0.61 > 0.26 \quad i=2 \quad x_2 = 0.56 \quad y_2 = 1.85$$

$$\bar{F}_{eq} \text{ نطالع } \rightarrow$$

$$F_{eq} = V x_2 F_r + y_2 F_a$$

$$= (1) \times (0.56) \times 1958.4 + 1.85 \times 1200$$

$$= 3316.82 \text{ N}$$

$$C_{10} = 1.2 \times 3316.82 \left[\frac{x_D}{x_0 + (\Theta - x_0) (1 - R_D)^{1/b}} \right]^{1/4}$$

$$C_{10} = 48.35$$

$$\text{Bore} = 60$$

$$\text{OD} = 110$$

$$C_0 = 35.5$$

$$\frac{F_a}{C_0} = \frac{1200 \times 10^{-3}}{35.5} = 0.034$$

$$e = 0.23$$

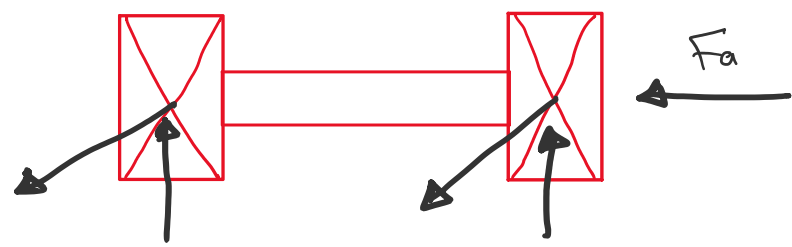
$$F_a / V F_r = 0.61 > 0.23$$

$$i=2 \quad x_2 = 0.56 \quad y_2 = 1.93$$

له F_{eq} صديده (بتطلع نفسه اي قبلها) معانته بنوتت

Tapered Bearings:-

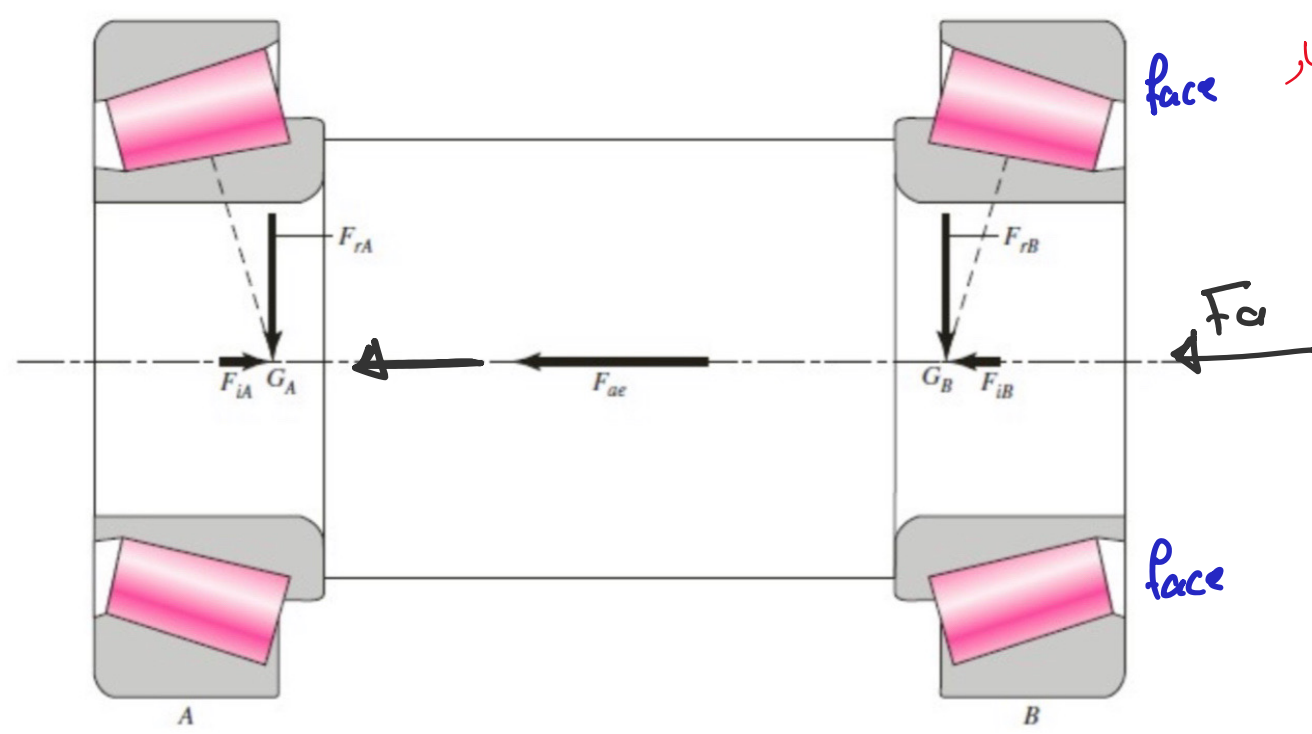
يستخدم في الأساس عملاق أو Thrust force



* أو Roller إلى تركيبها على أو Shaft يكون التركيب تبعها إما back-face face-face

face-face → indirect mounting .

back-back → direct mounting .



لو كان على Fa من اليمين إلى اليسار
أو Force إذا كانت تتوجه إلى
face صافي أو Bearing بعين
اسمها "B"
لما تتوجه إلى back يكون
اسمها "A"

* سبب التسمية إنما A, B لأن في إلهما قوانين مختلفة.

* طريقة الحل :-

(1) لازم نطلع F_{rA} , F_{rB} (2) بعد ما نطلعهم بنحسب C_{10} (3) اذن نحصل F_c لازم نطلع متية اسمها induced thrust F_{iA} , F_{iB}

$$F_i = \frac{0.47 F_r}{k} \quad k=1.5$$

$$\text{If } F_{iA} \leq (F_{iB} + F_{ae}) \left\{ \begin{array}{l} F_{eA} = 0.4 F_{rA} + K_A \left(\frac{0.47 F_{rB}}{K_B} + F_{ae} \right) \\ F_{eB} = F_{rB} \end{array} \right.$$

$$\text{if } F_{iA} \geq (F_{iB} + F_{ae}) \left\{ \begin{array}{l} F_{eB} = 0.4 F_{rB} + K_B \left(\frac{0.47 F_{rA}}{K_A} - F_{ae} \right) \\ F_{eA} = F_{rA} \end{array} \right.$$

$$C_{10} = F_D \left[\frac{x_D}{x_0 + (\theta - x_0)(1 - R_D)^{1/b}} \right]^{1/a}$$

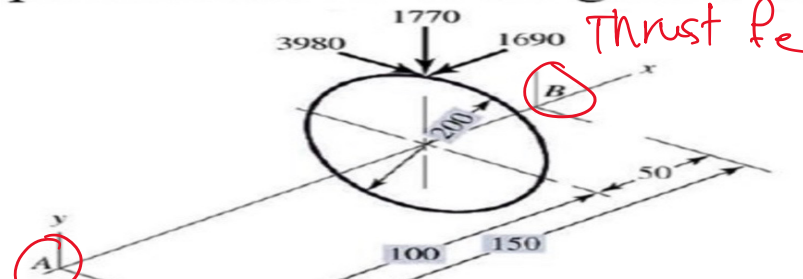
$$x_0 = 0, \quad \theta = 4.48$$

$$b = 3/2, \quad a = 10/3$$

$$L_{10} = 90 \times 10^6$$

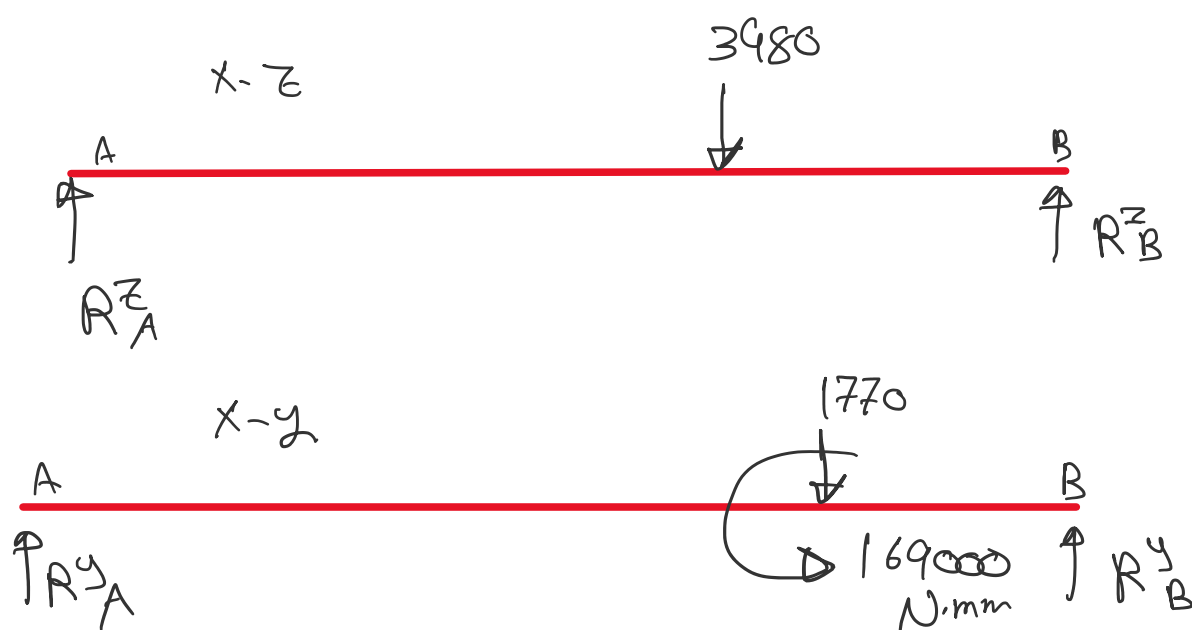
$$x_D = \frac{L_D}{L_R}$$

Ex: The shaft depicted in Fig. 11-18a carries a helical gear with a tangential force of 3980 N, a separating force of 1770 N, and a thrust force of 1690 N at the pitch cylinder with directions shown. The pitch diameter of the gear is 200 mm.



The shaft runs at a speed of 800 rpm, and the span (effective spread) between the direct-mount bearings is 150 mm. The design life is to be 5000 h and an application factor of 1 is appropriate. If the reliability of the bearing set is to be 0.99, select suitable single-row tapered-roller Timken bearings.

$$L_D = 5000 h, \quad a_f = 1, \quad R = 0.995$$



$$\sum T = 0 \quad \dots \quad R_A^z, R_B^z, R_A^y, R_B^y$$

$$\sum M = 0 \quad \dots$$

$$\sum F = 0 \quad \dots$$

$$R_A = \sqrt{(R_A^z)^2 + (R_A^y)^2}$$

$$R_B = \sqrt{(R_B^z)^2 + (R_B^y)^2}$$

* نفرضه ان $k_A = k_B = 1.5$ نطلع F_{iA} , F_{iB}

$$F_{iA} = \frac{0.47 F_{rA}}{1.5}$$

$$F_{iA} \leq (F_{iB} + F_a)$$

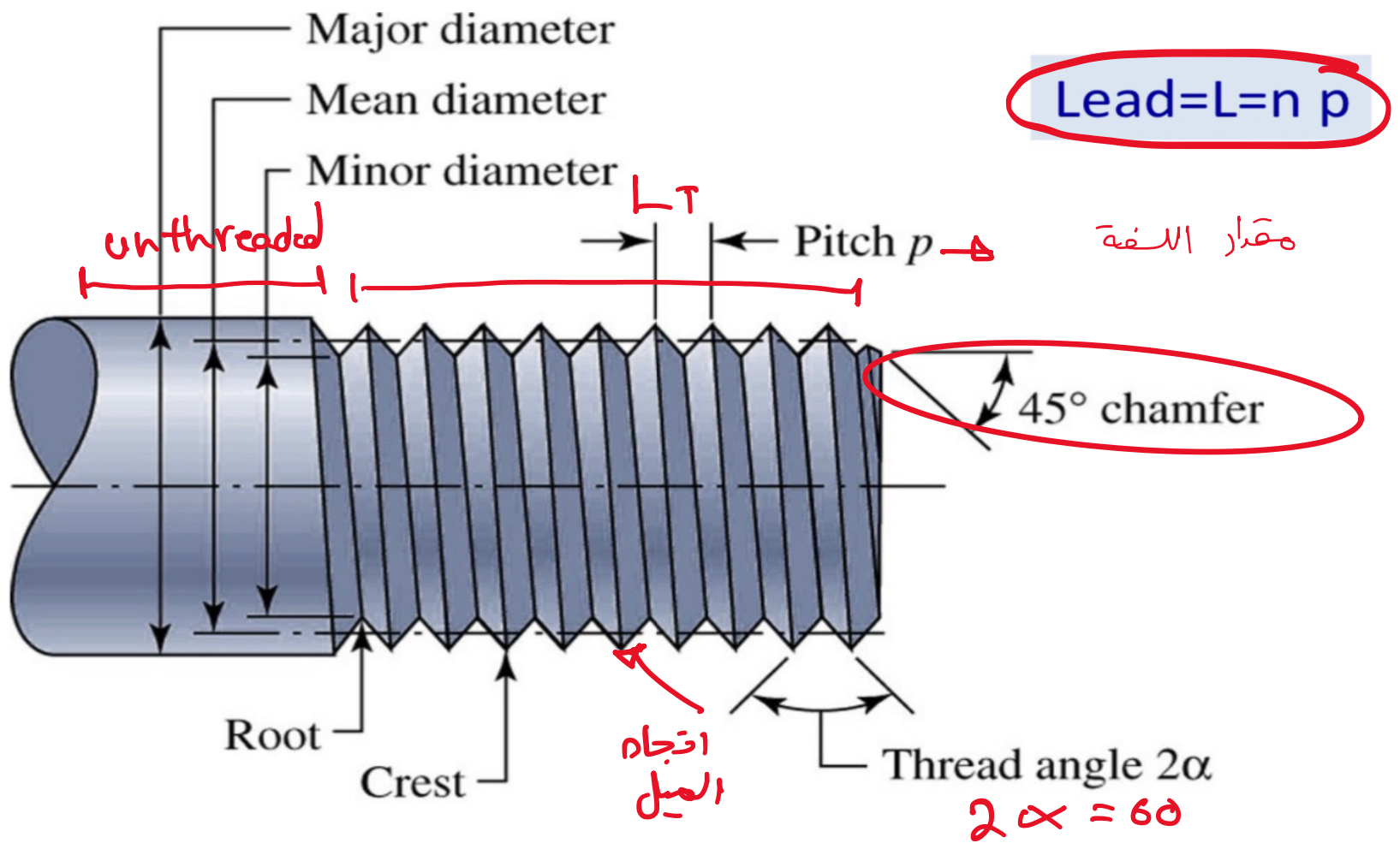
$$F_{iB} = \frac{0.47 F_{rB}}{1.5}$$

ح نستخدم القوانين الأتي

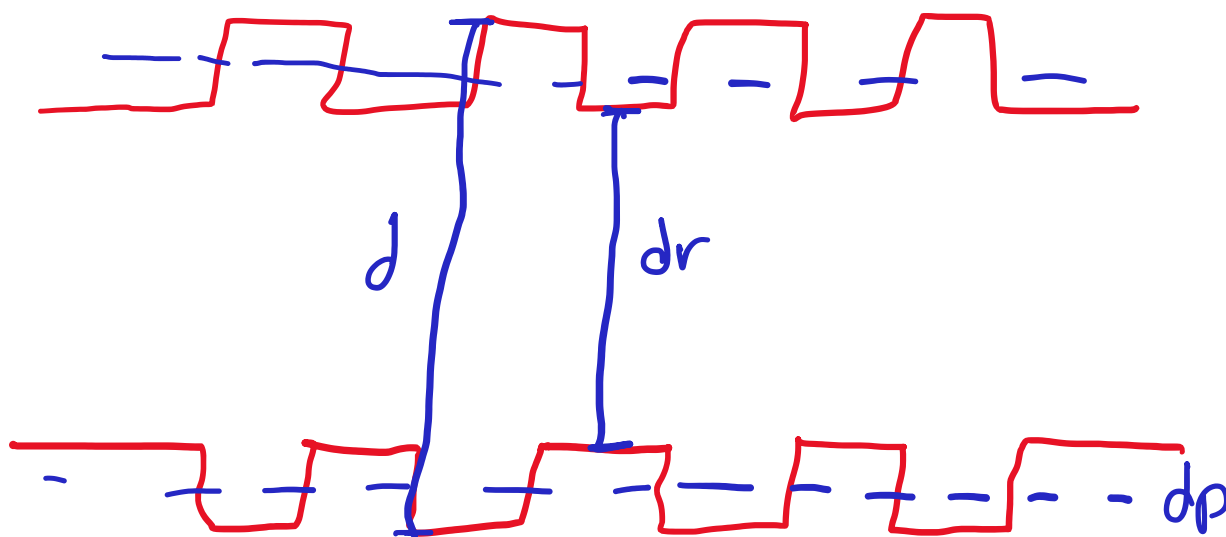
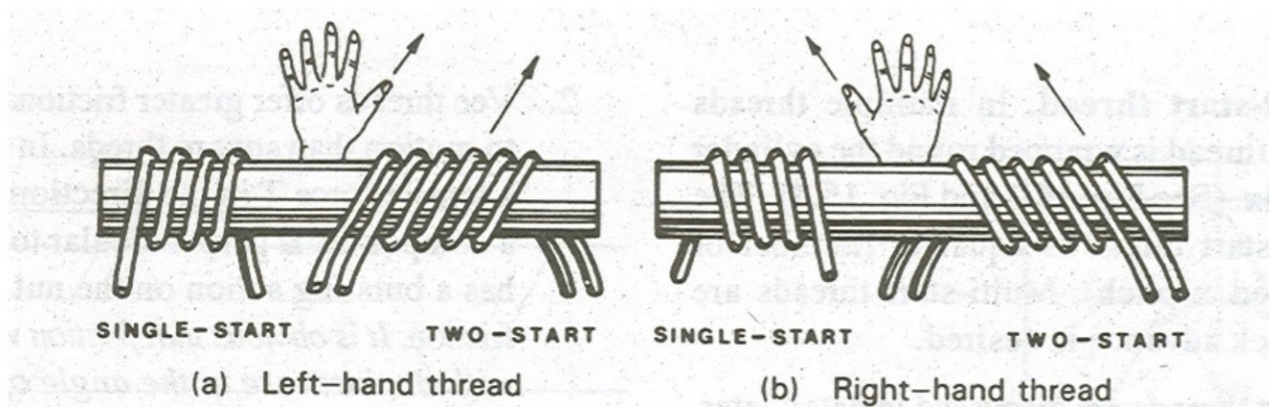
Lecture18

Thursday, 29 April 2021

5:27 PM



* إذا يكون مائل لليمين يكون Right hand وإذا كان مائل لليسار يكون left hand



$$d_p = \frac{d + d_r}{2}$$

Friday, 7 May 2021 3:33 PM

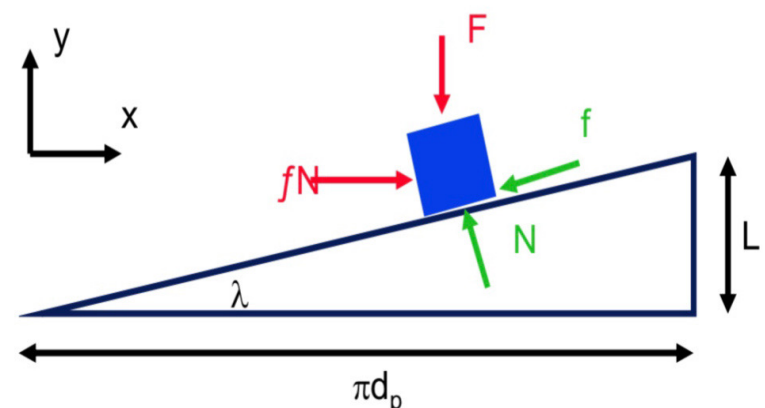
Diagram illustrating a screw mechanism. A vertical screw is shown with a nut at the top. A downward force P is applied to the nut. A torque T is applied to the screw. The screw is supported by a base. Labels include P , T , nut, screw, and base.

* power screw applications:-

- 1) jacks for cars
- 2) C-clamps
- 3) vises
- 4) instron material testing machines
- 5) machine tools

- ❖ **Square**
 - strongest
 - no radial load
 - hard to manufacture
- ❖ **Acme**
 - 29° included angle
 - easier to manufacture
 - common choice for loading in both directions
- ❖ **Buttress** (contrafuerte)
 - great strength
 - only unidirectional loading

P_R :- highest load used, $P_R > P_L$
 P_L :- lower load used



Lead angle :-

$$\alpha = \tan^{-1} \frac{\text{Lead}}{\pi d m} \rightarrow \text{diameter of bolt}$$

$$P_R = \frac{F (\sin \alpha + \mu \cos \alpha)}{\cos \alpha - \mu \sin \alpha}$$

$$PL = \frac{F(\cos \lambda - \sin \lambda)}{\cos \lambda + \sin \lambda}$$

$$P_R = \frac{F[(1/\kappa_{dm}) + f]}{1 - (fL/\kappa_{dm})}$$

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

درد ای! ایستادن

$$T_R = \frac{f_{dm}}{2} \left(\frac{L + \pi f_{dm}}{\pi f_{dm} - f_L} \right)$$

$$T_L = \frac{F_{dm}}{2} \left(\frac{\pi p_{dm} - 2}{\pi p_{dm} + p_L} \right)$$

$$e = \frac{T_0}{T_R} = \frac{FL}{2\pi T_R}$$

ملاحظة كل الى متوقه كانوا على اد Squar

* Acme Threads:-

$$T_R = \frac{f d m}{2} \left(\frac{1 + \pi f d m \sec \alpha}{\pi d m - f l \sec \alpha} \right)$$

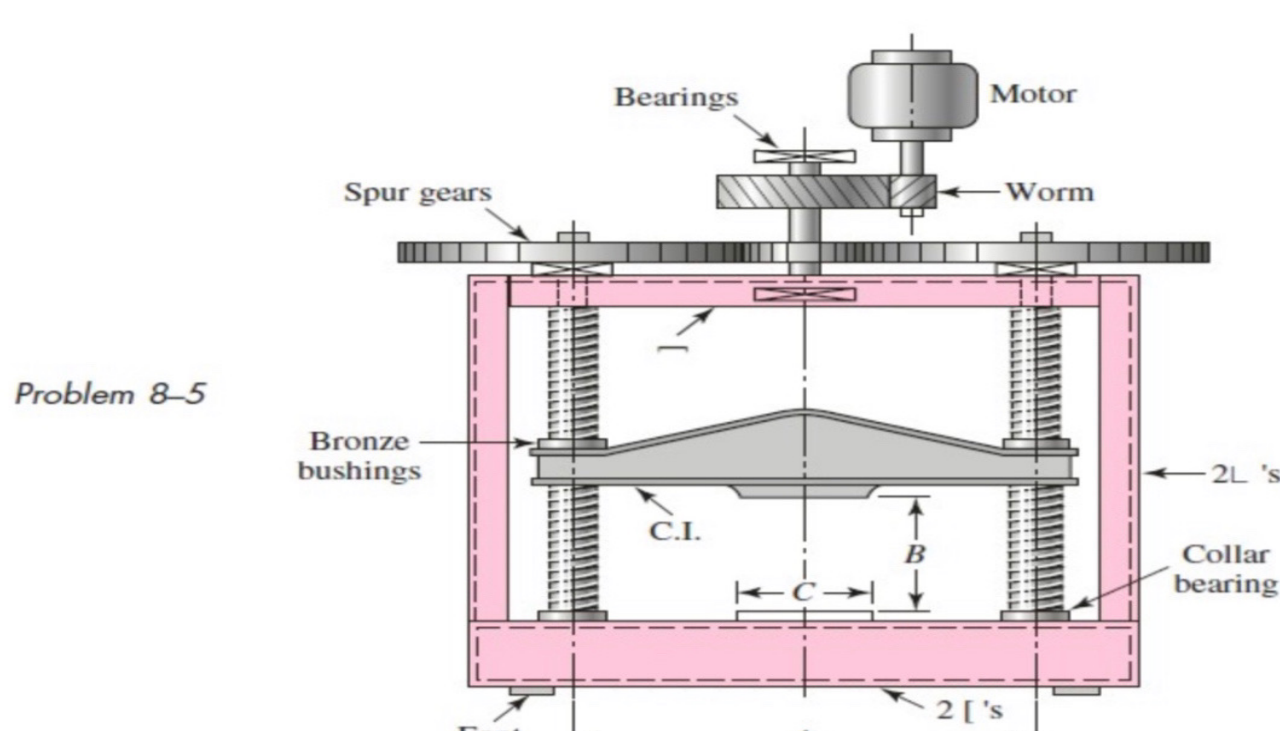
$$2\alpha = 29^\circ$$

$$T_c = \frac{f \cdot f_c \cdot d_c}{2}$$

$$T_A = \frac{F d m}{2} \left(\frac{2 + \pi F d m \sec \alpha}{\pi d m - \pi \sec \alpha} \right) + \frac{F_c d c}{2}$$

The press shown for Prob. 8–5 has a rated load of 5000 lbf. The twin screws have Acme threads, a diameter of 2 in, and a pitch of $\frac{1}{4}$ in. Coefficients of friction are 0.05 for the threads and 0.08 for the collar bearings. Collar diameters are 3.5 in. The gears have an efficiency of 95 percent and a speed ratio of 60:1. A slip clutch, on the motor shaft, prevents overloading. The full-load motor speed is 1720 rev/min.

- (a) When the motor is turned on, how fast will the press head move?
(b) What should be the horsepower rating of the motor?



$$d = 2 \quad p = 1/4 \quad f = 0.05 \quad f_c = 0.08 \quad d_c = 3.5$$

V head 2

g) $N_{\text{screw}} = \frac{N_{\text{motor}}}{60} = \frac{1720}{60} = 28.67 \text{ rev/min}$ $1 \text{ rev} = 1^\circ$

$$V = 28.67 \times 0.25 = 7.17 \text{ in/min}$$

$$b) \quad H = \frac{T_m N}{63025}$$

$$T_R = \frac{2500(1.875)}{2} \left(\frac{0.25 + \pi(0.05)(1.875)(1.033)}{\pi(1.875) - (0.05)(0.25)(1.033)} \right) = 221.0 \text{ Ib/in}$$

$$T_c = \frac{2500(0.08)(3.5)}{9} = 350 \text{ lbf.in}$$

$$T_{total} = 350 + 221.0 = 571 \text{ TLP in / screw}$$

$$T_{motor} = \frac{571(2)}{60(0.95)} = 20.04 \text{ Ibf. in}$$

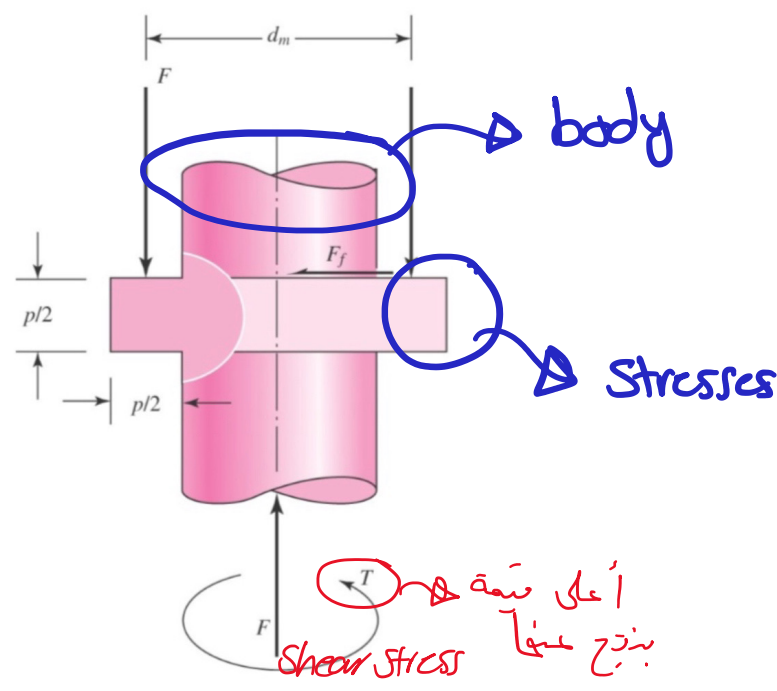
$$H = \frac{20.04 (1720)}{62.86} = 0.517 \text{ hp}$$

Lecture20

Sunday, 9 May 2021

12:28 AM

* Stresses في ال power screws تكون موجودة اول في ال screw body ال



$$\tau = \frac{T_c}{J}$$

$$c = d/2, J = \pi d^4/32$$

$$\tau_{yz} = \frac{16T}{\pi d r^3}$$

$$\sigma_{yy} = \frac{F}{A} = -\frac{4F}{\pi d r^2}$$

$$\sigma_B = -\frac{2F}{\pi d_m n_t p}$$

$$n_t = t/p$$

$$\sigma_{xx} = \frac{6F}{\pi d r n_t p}$$

$$M = \frac{Fp}{4}$$

لو بدنا نطلع الحصة بنطلعها من طريقة معادلة ال Von mises :-

$$\sigma' = \frac{1}{\sqrt{2}} \left[(\sigma_{xx} - \sigma_{yy})^2 + (\sigma_{yy} - \sigma_{zz})^2 + (\sigma_{zz} - \sigma_{xx})^2 + 6(\tau_{xy}^2 + \tau_{yz}^2 + \tau_{zx}^2) \right]^{1/2}$$

A screw clamp similar to the one shown in the figure has a handle with diameter $\frac{3}{8}$ in made of cold-drawn AISI 1006 steel. The screw is $\frac{3}{4}$ in-10 UNC made of steel (dry) and the nut material is steel

A force will be applied to the handle at a radius of 3.5 in from the screw centerline."

The clamp will accommodate parts up to 6 in high.

(a) What screw torque will cause the handle to bend permanently?

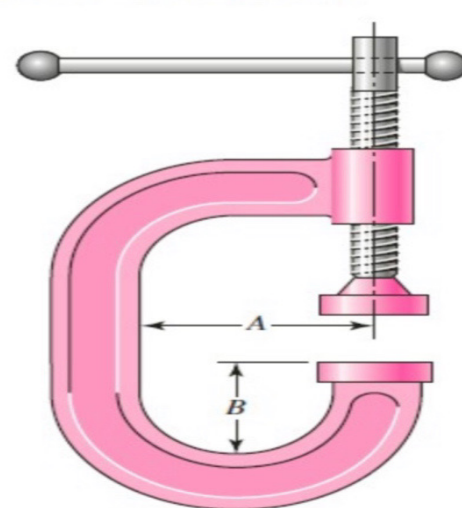
(b) What clamping force will the answer to part (a) cause if the collar friction is neglected

c) calculate the stresses in the screw threads

Given that $n_t=4$

ACME thread

Problem 8-7



$$a) M = (3.5 - 3/8) F$$

$$\text{Yield strength} = 41000 \text{ من الكتاب}$$

$$\text{Yield strength} = \frac{32M}{\pi d^3} = \frac{32 \times 3.125 F}{\pi (3/8)^3} = 41000$$

$$F = 8.5 \text{ Ib} \cdot f$$

$$T = 3.5 \times 8.5 = 30 \text{ Ib} \cdot f \cdot \text{in}$$

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

Table 8-5 من الكتاب

$$2\alpha = 29$$

$$d_m = d - \text{pitch}/2 = 3/4 - 1/20 = 0.125$$

$$d_r = d - p/4 = 3/4 - 1/40 = 0.65$$

$$30 = \frac{F \times 0.7}{2} \left(\frac{0.1 + \pi (0.2) (0.7) (1.155)}{\pi (0.7) - (0.2) (0.1) (1.155)} \right)$$

$$F = 309.38 \text{ Ib} \cdot f$$

$$c) \sigma_x = \frac{6F}{\pi d r n_t p} = \frac{6 \times 309.38}{\pi (0.65) (4) (0.1)} =$$

$$\sigma_y = -\frac{4F}{\pi d r^2} = -\frac{4 \times 309.38}{\pi (0.65)^2} =$$

$$\tau_{yz} = \frac{16T}{\pi d r^3} = \frac{16 \times 30}{\pi (0.65)^3} =$$

* Table 8-9 إذا أضنا ال bearing stress وعرفنا ال screw material وال nut material بنقدر نعرف ال range الذي نقدر نحكي عنها Safe Bearing إذا تجاوزنا بنطل في safety

A square-thread power screw has a major diameter of 32 mm and a pitch of 4 mm with double threads, and it is to be used in an application similar to that in Fig. (5-4). The given data include $f=f_c=0.08$, $d_c=40$ mm, and $F=6.4$ kN per screw.

(a) Find the thread depth, thread width, pitch diameter, minor diameter, and lead.

(b) Find the torque required to raise the load.

c Find the body stresses, torsional and compressive.

(d) Find the thread stresses bending at the root, shear at the root, and von Mises stress and maximum shear stress at the same location.

(e) Find the bearing stress.

(f) factor of safety



$$a) d_m = d - p/2 = 32 - 4/2 = 30 \text{ mm}$$

$$d_r = d - p = 32 - 4 = 28 \text{ mm}$$

$$l = np = 2 \times (4) = 8 \text{ mm}$$

$$b) T_R = \frac{F d_m}{2} \left(\frac{l + \pi f d_m}{\pi d_m - f l} \right) + \frac{F f_c d_c}{2} = 26.18 \text{ N} \cdot \text{m}$$

$$c) \tau = \frac{16T}{\pi (d_r)^3} = 6.57 \text{ MPa}$$

$$\sigma = -\frac{4F}{\pi d_r^2} = -10.39 \text{ MPa}$$

$$\sigma_B = \frac{6(0.38 F)}{\pi d_r (l) p} = 41.5 \text{ MPa}$$

$$d) \text{Von Mises} = 48.7 \text{ MPa}$$

$$f) \text{AISI 1010 } S_y = 305 \text{ MPa}$$

$$n = \frac{S_y}{\sigma'} = \frac{305}{48.7} = 6.4$$

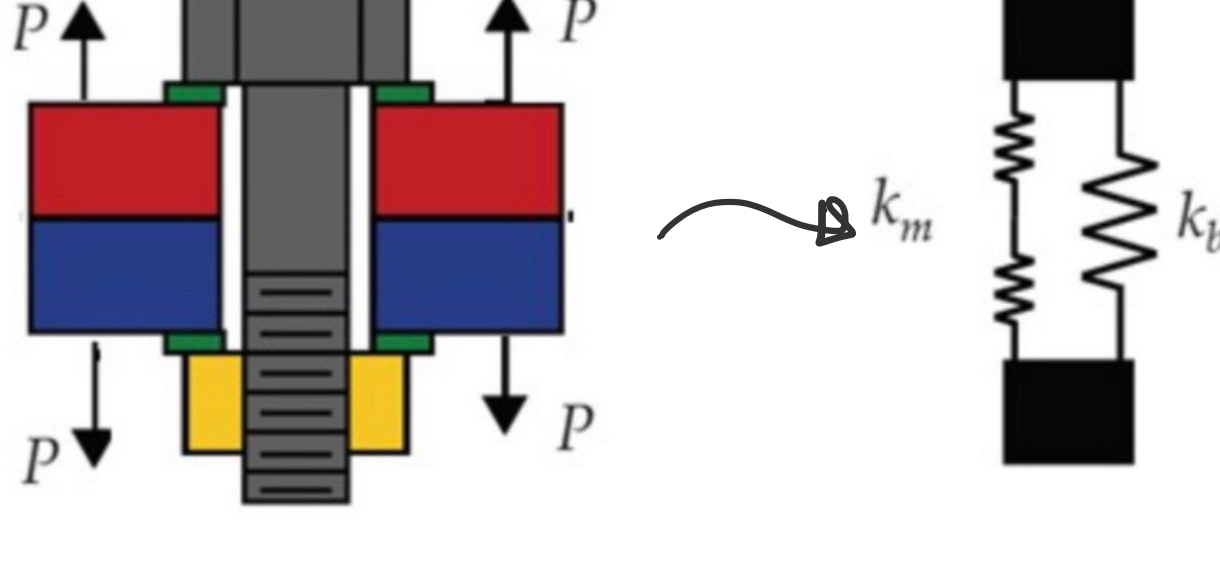
Lecture 21

Sunday, 9 May 2021 12:39 AM

- Joint عبارت از member بشکونده قطعتين صديء مثلثي بيهم hole بنرکب
غيا ا Bolt و Bolt بكونه عليها nut

- Joint stiffness غيا ، Bolt بنفوا زي زيرك دار Two members
بنفوصم لزيرك ف Bolt صار ايها Stiffness اسو k_b و k_m و k_m Stiffness اسو

- داننا رح نفوذه در members اهم نفس در material



- اي بصير انو اي External force عى در Joint (P) جرد منه طاي در P رح يتصلو
در Bolt بنسبه P_b و جرد رح يرح عى در member رح بنسبه P_m يعني مجموع
 $P = P_b + P_m$

- الجزء در External توزع كنه در Joint نفسجا قبل ما بكونه عليها External force
اصلا بنديها ، بيب در bolt و بيلف در nut مول در (Screw بعد نه يتصوظ عى)
در two members فقي Force منه در nut عى در member بنسبه F_i (Pre load)
بكونه Comp on member و عى كانه بنسب در bolt يعني بكونه
Tension on bolt رح يعنى عى در Total Load on bolt

$$F_b = F_i + P_b$$

$$F_m = P_m - F_i$$

$$P_b = C P = \frac{k_b}{k_b + k_m} P$$

$$P_m = (1 - C) P$$

$$F_b = F_i + C P$$

$$F_m = (1 - C) P - F_i$$

- deflection :-

$$\Delta_b = \Delta_m = \frac{P_b}{k_b} = \frac{P_m}{k_m}$$

- عشان نه نطلع در F_i بزج عى در text بيع السؤال ادا كانه مكتوب
در Joint ايها Permanent او non permanent

- ادا كانه permanent بكونه در bolt و در nut ما بنفكم لا بعد نرايت
طويله . $F_i = 0.9 F_p$
در non permanent بنفكم $F_i = 0.75 F_p$

$$F_p = S_p A_t E$$

tensile Area from tables
Proof stress = 0.85 G

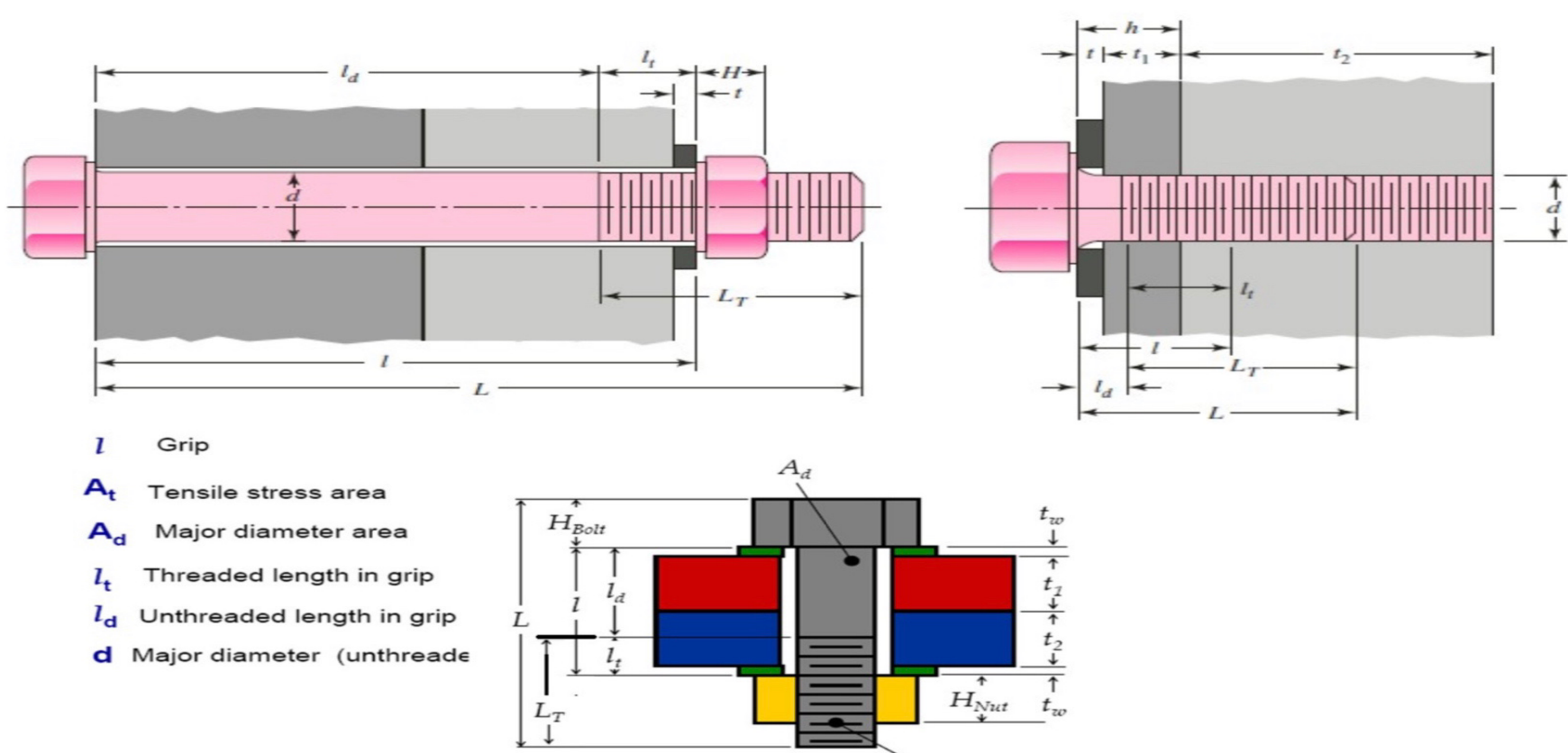
- load factor :-

$$n_L = \frac{S_p A_t - F_i}{C P}$$

- ادا كانه در External load عالي ممكنه بانهاية بدل Separation كى در
P رح تكونه عى در bolt .

$$n_o = \frac{F_i}{P(1 - C)}$$

- اقل قيمة يرنه در n_L , n_o بكونه در the load factor of safety for the joint



$$k_b = \frac{A_d A_t E}{A_d l_t + A_t l_u}$$

$$k_m = \frac{0.5774 \pi E d}{2 \ln \left(\frac{0.5774 L + 0.5 d}{0.5774 l + 2.5 d} \right)}$$

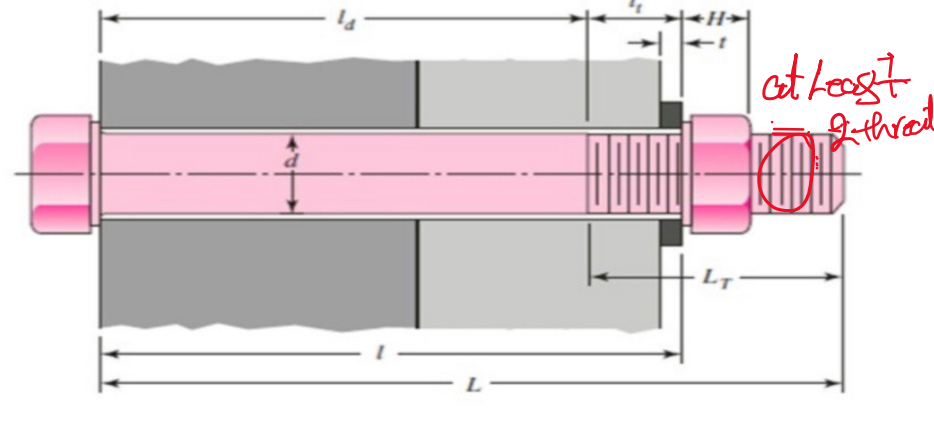
Prob. 8-11 : An M14 × 2 hex-head bolt with a nut is used to clamp together two 15-mm steel plates.

(a) Determine a suitable length for the bolt, rounded up to the nearest 5 mm.

(b) Determine the bolt stiffness.

(c) Determine the stiffness of the members

Table A-31, nut height $H = 12.8$ mm. $L \geq l + H = 2(15) + 12.8 = 42.8$ mm.



Sol :-

$$d = 14 \text{ mm} \quad \text{pitch} = 2 \quad L = 2 \times 15 = 30 \text{ mm}$$

$$A) \quad L = d + H + 2 \text{ threads} = 2 \times 15 + 12.8 + 2 \times 2 = 46.8 \text{ mm} = 47 \text{ mm}$$

$$B) \quad k_b = \frac{A_d A_t E}{A_d l_t + A_t l_u} = \frac{E = 207 \text{ GPa}}{A_t = \text{table 8-1} = 115 \text{ mm}^2}$$

$$A_d = \pi d^2 / 4 = \pi (14)^2 / 4 = 153.9 \text{ mm}^2$$

$$l_t = L - L_d \quad L_d = \text{"table"} \quad L - L_T$$

$$L_d = 30 - 11 = 19 \text{ mm}$$

$$k_b = \frac{153.9 \times 115 \times 207}{153.9 \times (19) + (115)(11)}$$

$$C) \quad k_m = \frac{0.5774 \pi E d}{2 \ln \left(\frac{0.5774 L + 0.5 d}{0.5774 l + 2.5 d} \right)}$$

- For a shear joint loaded by a shear force and moment

- Shear joint بكونه عى تقويتين را كينز عى بينه و بكونه عليها Bolt
بهم بكونه عليها اكنز منه Bolt فجاى در joint بكونه عليها Shear stress و بكونه
force نه نقلها لا center بصر اسها Shear درج يتقل معها
Bending moment

- المطلوب نرن كم در Stress عى كل bolt

$$F_n = V/n$$

في ار Shear joint ، ار moment لازم نعمل خطوات

1) نطلع ار G ل joints وقتي منتقل ار F و ار moment .

$G(\bar{x}, \bar{y})$ لازم اول اسي نختار محور (0,0) بعدين بنسوف كل bolt كم بعد عن نقطة ار (0,0) بعدين نطلع ار

$$\bar{x} = \frac{A_1 x_1 + A_2 x_2 + A_3 x_3 + \dots}{A_1 + A_2 + A_3 + \dots}$$

$$\bar{y} = \frac{A_1 y_1 + A_2 y_2 + A_3 y_3 + \dots}{A_1 + A_2 + A_3}$$

2) منتقل ار F الي بصير! سجا Shear force البعدين ار F ، ار G سنالو r مافات ار M ح تساري يعني $r \times F$ نحسب قيمة ار M .

3) ار V بتوزع على ار bolts فادنا كانه اعم نفس المساحة بتوزع

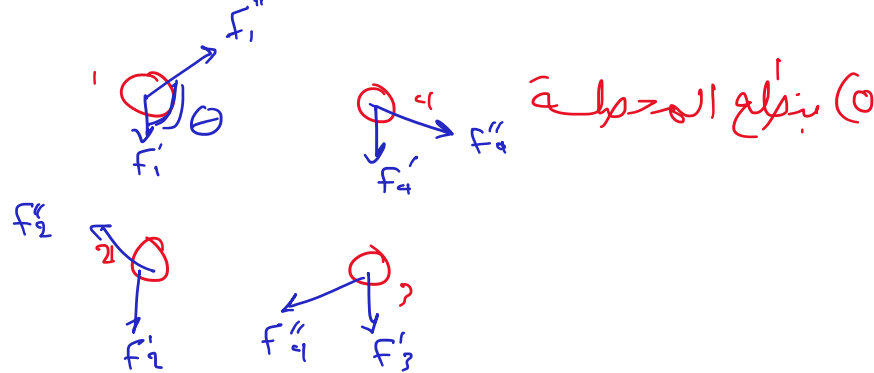
$$F'_1 = V/4 = F'_2 = F'_3 = F'_4$$



4) نتوزع ار M ح ينتج معنا F على كل ار bolts

$$F''_n = \frac{M r_n}{r_1^2 + r_2^2 + r_3^2 + \dots}$$

$$F_n = \sqrt{F_n'^2 + F_n''^2 + 2 F_n' F_n'' \cos \theta}$$



$$\tau_n = \frac{F_n}{A_n}$$

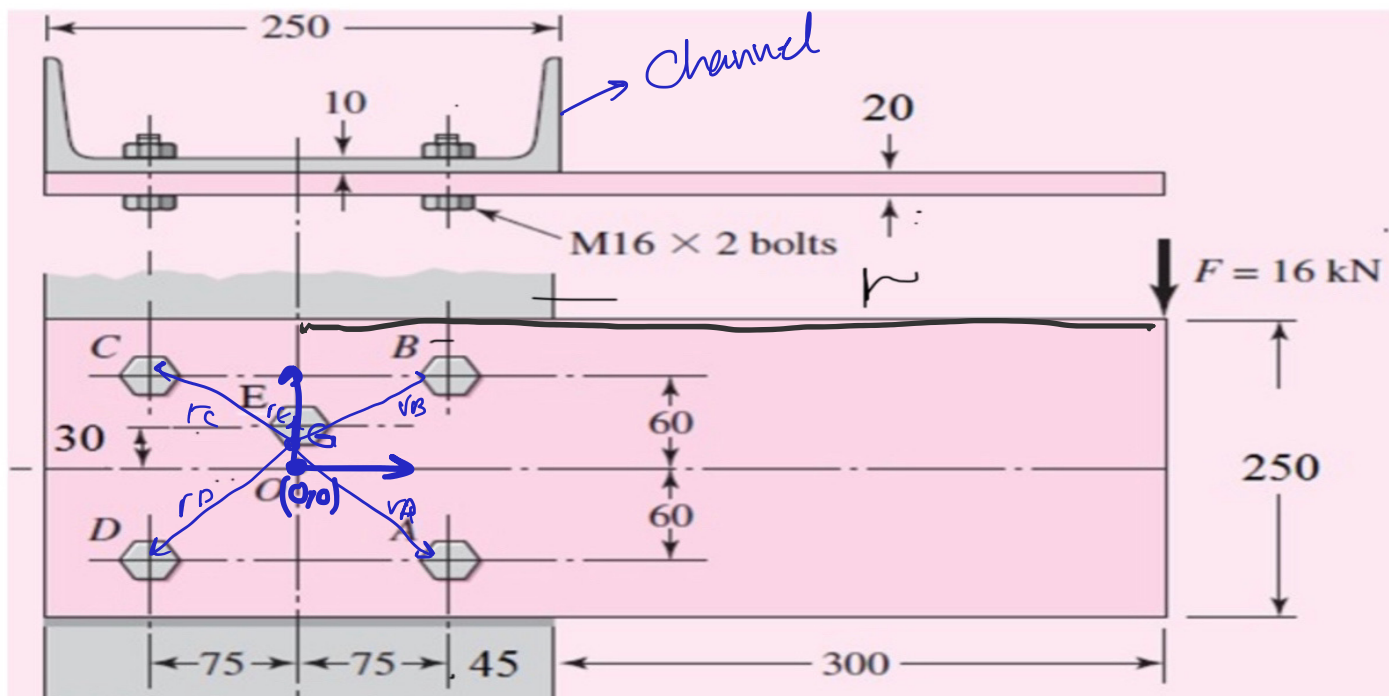
* اذا طلب ار Max value بنسوف احي

محطة ربتسجا على المساحة

Shown in the figure is a 20 by 250-mm rectangular steel bar cantilevered to a 250-mm steel channel using five tightly fitted bolts located at A, B, C, D and E. For $F = 16$ kN load find

(a) The resultant load on each bolt

(b) The maximum shear stress in each bolt



$$1) G(\bar{x}, \bar{y})$$

$$\bar{x} = \frac{A_A x_A + A_B x_B + A_C x_C + A_D x_D + A_E x_E}{A_A + A_B + A_C + A_D + A_E} = 0$$

$$\bar{y} = \frac{A_A y_A + A_B y_B + A_C y_C + A_D y_D + A_E y_E}{A_A + A_B + A_C + A_D + A_E} = \frac{30}{5} = 6$$

$$G(0, 6)$$

$$2) M = \vec{r} \times \vec{F} = (300 + 75 + 45) * 16 = 6720 \text{ N.m}$$

$$3) F' = \frac{16}{5} = 3.2 = F'_A = F'_B = F'_C = F'_D = F'_E$$

$$4) r_A = \sqrt{75^2 + 66^2} = 99.9 \quad r_B = \sqrt{75^2 + 54^2} = 92.4$$

$$r_C = \sqrt{75^2 + 54^2} = 92.4 \quad r_D = \sqrt{75^2 + 66^2} = 99.9$$

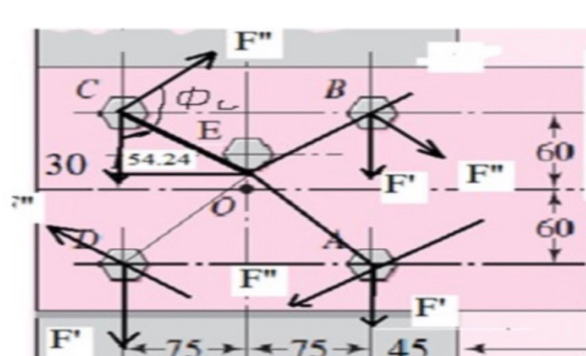
$$r_E = 24$$

$$F''_A = F''_D = \frac{6720 * 99.9}{2 * 99.9^2 + 2 * 92.4^2 + 24^2} = 17.9 \text{ kN}$$

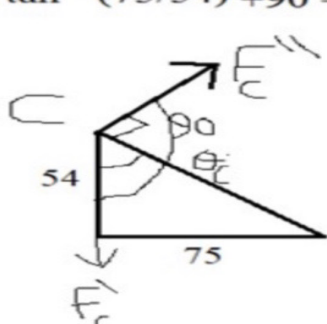
$$F''_C = F''_B = \frac{6720 * 92.4}{2 * 99.9^2 + 2 * 92.4^2 + 24^2} = 16.52 \text{ kN}$$

$$F''_E = \frac{6720 * 24}{2 * 99.9^2 + 2 * 92.4^2 + 24^2} = 4.3 \text{ kN}$$

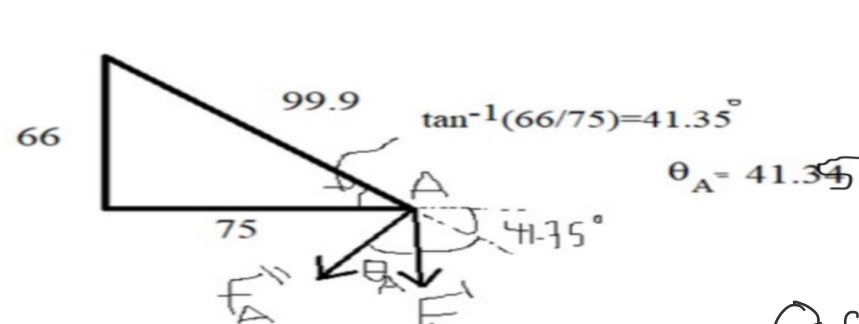
A)



$$\theta_c = \tan^{-1}(75/54) + 90 = 54.24 + 90 = 144.24$$

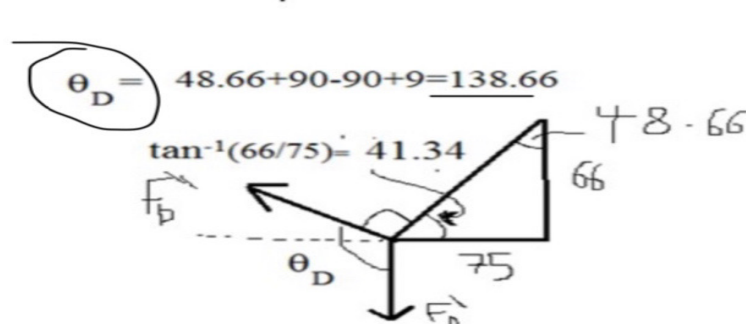


$$\theta_B = 90 - \tan^{-1}(75/54) = 35.76$$



$$\theta_A = 41.35$$

$$\theta_E = 90^\circ$$



$$\theta_D = 48.66 + 90 - 90 + 9 = 138.66$$

$$\tan^{-1}(66/75) = 41.34$$

$$F_A = \sqrt{(F'_A)^2 + (F''_A)^2 + 2 F'_A F''_A \cos \theta_A} = 20.41$$

$$F_B = 19.21$$

$$F_C = 14.05$$

$$F_D = 15.64$$

$$F_E = 5.36$$

$$dr = d - 1.226p$$

$$= 16 - 1.226 * 7$$

$$=$$

$$B) \tau = \frac{F}{A} = \frac{20.41}{\frac{\pi d r}{4}} = \frac{20.41}{141}$$

Wednesday, 2 June 2021 10:07 PM

يعني لو بنا عنا مادة عليه لصلا يتفيس القيمة مع الوقت او في الانظام المهم في تغير في
او لصلا المادة بعد فترة زح زح في تقب فبهمر فيه كسر او احتمال ان يستمر طرعا صلب
او level تبع او Stress

Fatigue can occur at stress level below yield strength

Diagram of a bolt under tension. The total length is $3 \frac{7}{16}$ in. The neck diameter is 0.30 in. The distance from the left end to the neck is $9 \frac{7}{8}$ in R. The material is labeled S.S. (Stainless Steel). A blue arrow points to the neck with the word "Failure".

○ في البداية تكون " - " بعدية " 0 " بعدية " + " بعدية " 0 "

و بعدية " - " بعدية

د اد $\epsilon = \frac{\mu r}{T}$

يعني المادة هاي بتتحلل لحد تقريباً 50 ميغا وببدا بتتكسر أقل منه 50 مارج
تتكسر يعني لو أخذنا 1 level يساوي ٩٥ عدد اللغات رح يكون "٥٥"

$$\sigma_c' = \begin{cases} 0.5 S_{ut} & , S_{ut} \leq 200 \text{ kpsi (1400 MPa)} \\ 100 \text{ kpsi} & , S_{ut} > 200 \text{ kpsi} \\ 700 \text{ MPa} & , S_{ut} > 1400 \text{ MPa} \end{cases}$$

(d) AIST 4130 steel heat-treated to tensile strength of 235 ksi

(d) $S_{ut} > 200 \text{ kpsi}$ $S_e' = 100 \text{ kpsi}$

*! اصل عن Failure بنسخت علاقات - صای العلاقات - بنا نطلع فيها ان
 # of cycle to failure او ان Load هو ان Stress ای اصل حیات Failure

$$S_f = a N^b$$

$$q = \frac{(\sum S_{ut})^2}{S_e}$$

∴ find figure 6-18

$$b = -\frac{1}{3} \log \left(\frac{f_{\text{Sut}}}{S_c} \right)$$

بعد از 200 ری تبیین شده
ار 1 ری، سکو 0.77
داخل من 70 ار 1 ری، سکو
0.9

- Completely reversed stress :- σ_{rev}

$$\sum p_i = 1$$

$$N = \left(\frac{\sigma_{rad}}{\alpha} \right)^{1/p}$$

Ex:- A steel rotating-beam test specimen has an ultimate strength of 1600 Mpa, Estimate the life of the specimen if it is tested at a completely reversed stress amplitude of 900 Mpa

$$\sum u_t = 1600$$

$$\sigma_a = \sigma_p$$

$$S_e = k_a k_b k_c \dots k_t S_e'$$

$$\sigma_c' = 700 \text{ MPa}$$

$$S_c: S_c' = 700$$

$f = 0.77.$

$$Q = \frac{(0.77 \times 1600)^2}{700} = 2168.3 \text{ MPa}$$

$$b = -1/3 \log \left(\frac{0.77 * 1600}{700} \right) = -0.081838$$

$$N = \left(\frac{900}{2168.3} \right)^{1/0.081832} = 46400 \text{ cycles}$$

Lecture24

Wednesday, 2 June 2021 11:16 PM

>10³ high cycle fatigue.

<10³ low cycle fatigue.

اد S_e بنسختهاار test specimen به اپنا في عنا actual part تعرضه لظروف مختلفة
 صاي الظروف السطح تغير مختلف يكونه في ال test sample ظلازم نظرب ب
 Factor اسو Surface finish factor وازم نظرب ب ال Size factor وازم ال Size
 بنو مختلف عن ال Size ال test specimen و نظربوا بل loading factor و نظرب
 يكونه Bending وكونه axial او Torsion او Combination نظربوا بده
 اصرار و نظربوا بل reliability factor و نظربوا باي اسني ممكنه بانن حكا ال
 endurance limit به يكونه معطى بالسؤال
 $S_e = k_a k_b k_c k_d k_e k_f S'_e$
 اذا في اهم نانن بقدر نطلع
 قيعم منه الكتاب

$$S_e = k_a k_b k_c k_d k_e k_f S'_e$$

k_a = Surface condition modification factor
 k_b = Size modification factor
 k_c = load modification factor
 k_d = temperature modification factor
 k_e = reliability factor
 k_f = miscellaneous-effects modification factor

$$k_a = \frac{1}{Q} S_{ut}^b$$

a and b from table 6-2

بقدرها في ال Surface finish

لازم نتأكد منه شغلين :- k_b

- 1- cross section Circular ,
- 2- Rotating .

اذا دققوا بقدر نستعمل ال d
 تبع ال cross section
 $d = d_{actual}$

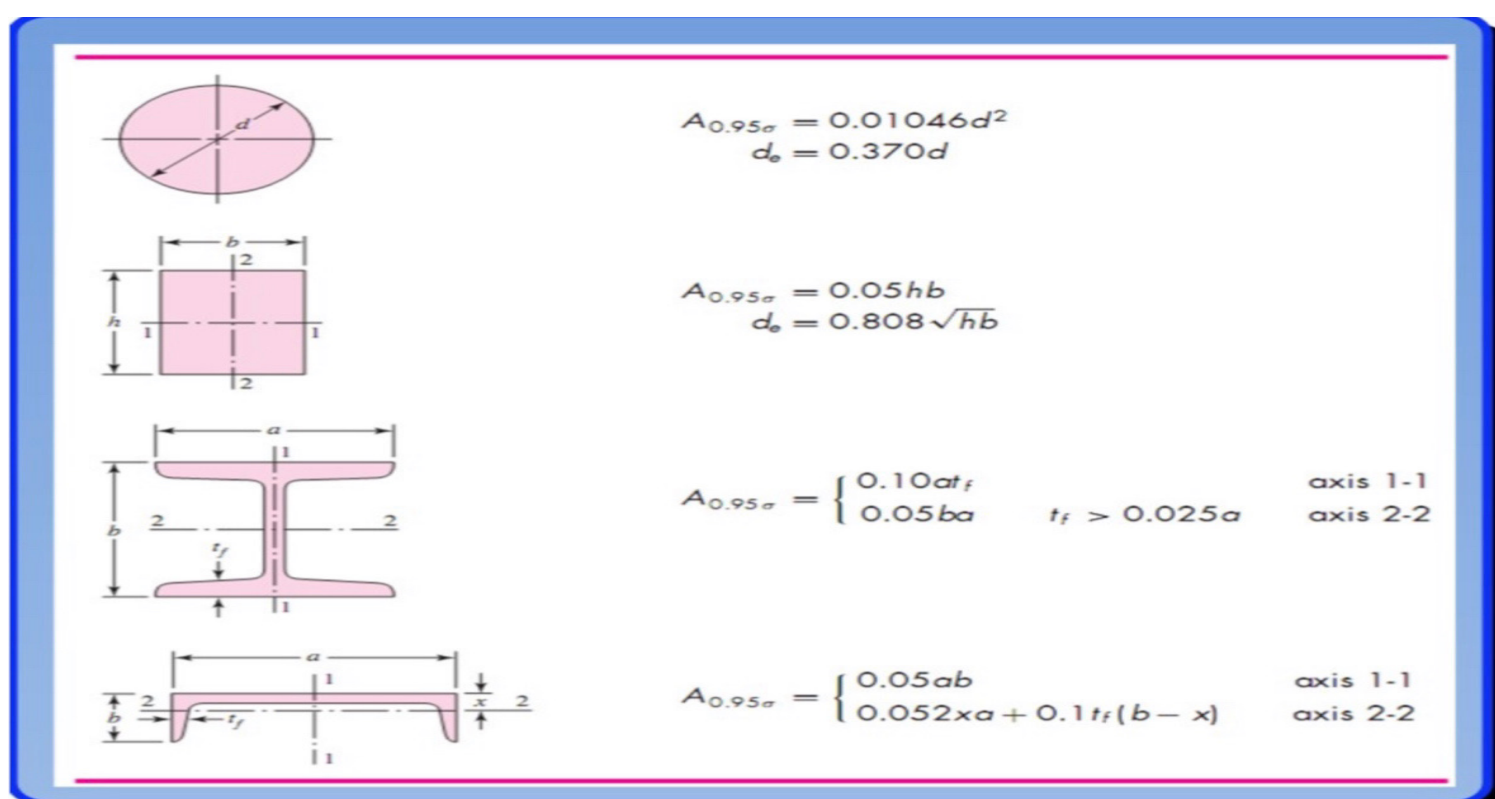
$$k_b = \begin{cases} (d/3)^{-0.107} = 0.879 d^{-0.107} & 0.11 \leq d \leq 2 \text{ in} \\ 0.91 d^{-0.157} & 2 < d \leq 10 \text{ in} \\ (d/7.62)^{-0.107} = 1.24 d^{-0.107} & 2.79 \leq d \leq 51 \text{ mm} \\ 1.51 d^{-0.157} & 51 < d \leq 254 \text{ mm} \end{cases}$$

* اذا كان non-rotating , Circular و rotating , non-circular
 او non-rotating , non-circular

لما راعد من العنود ما يتحقق بنسختهم

$$d = \frac{d_c}{2}$$

Table 6-3



بسه نطلع ال d_c بنسختهم باي range موجود و بنسختهم بواي ال d_c بتطابق

• اذا كان axial loading دانا $k_b = 1$

$$k_c = \begin{cases} 1 & \text{bending} \\ 0.85 & \text{axial} \\ 0.59 & \text{torsion} \end{cases}$$

• اذا كانت ال Temperature اعلا من ال room temperature بنسختهم علاقة

$$k_d = 0.9887 + 0.6507(10^{-3}) T_c - 0.3414(10^{-6}) T_c^2 + 0.5421(10^{-8}) T_c^3 - 6.426(10^{-11}) T_c^4$$

$$\text{For } 37 \leq T_c \leq 510^\circ\text{C}$$

ke بنا نرجع على table 6-5

Reliability, %	Transformation Variate z_d	Reliability Factor k_e
50	0	1.000
90	1.288	0.897
95	1.645	0.868
99	2.326	0.814
99.9	3.091	0.753
99.99	3.719	0.702
99.999	4.265	0.659
99.9999	4.753	0.620

* Stress Concentration and Notch

k_f normal stress

k_{fs} tension

$$k_f = \left[1 + q(k_t - 1) \right], \quad k_{fs} = \left[1 + q_{shear}(k_{ts} - 1) \right]$$

منظر كساب منو figure

منظر كساب منسختهم ال S_{ut}

Figure 6-20 , 6-21

$$\sigma = k_f \sigma_{nom}$$

• The modified Neuber equation.

$$k_f = \frac{k_t}{1 + \frac{2(k_t - 1)}{k_t} \cdot \frac{\sqrt{a}}{\sqrt{r}}}$$

بنسختهم نوح ال loading

Notch radius "given"

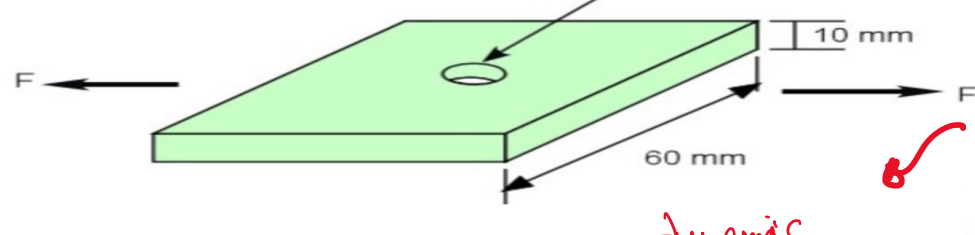
$$\text{Bending or axial: } \sqrt{a} = 0.216 - 3.08(10^{-3}) S_{ut} + 1.51(10^{-5}) S_{ut}^2 - 2.67(10^{-9}) S_{ut}^3$$

$$\text{Torsion: } \sqrt{a} = 0.190 - 2.51(10^{-3}) S_{ut} + 1.35(10^{-5}) S_{ut}^2 - 2.67(10^{-9}) S_{ut}^3$$

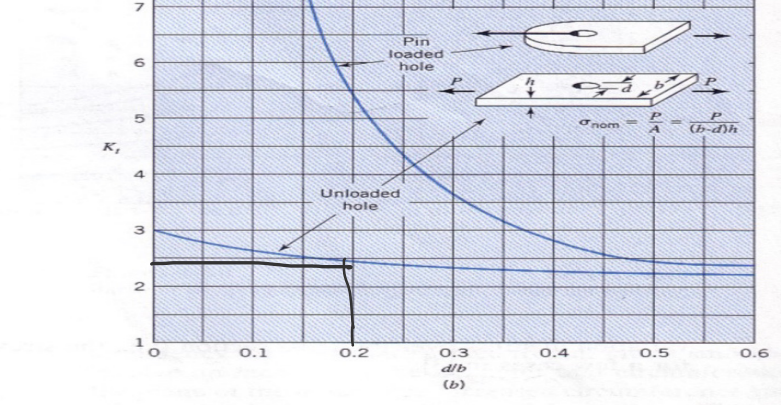
Ex:AISI 1020 as-rolled steel

Ex: Find an expression for max. stress

$$S_{ut} = 448 \text{ MPa} = 65.0 \text{ ksi}$$



dynamic loading
"متغير"



$$k_f = 1 + q(k_t - 1)$$

$$d/b = 12/60 = 1/5 = 0.2$$

$$k_t = 2.5$$

$$q \approx 0.8$$

$$r = 6 \text{ mm}$$

$$k_f = 1 + 0.8(2.5 - 1)$$

$$=$$

$$\sigma_{nom} = \frac{F}{A} = \frac{F}{(b-d)h} = \frac{F}{(60-12)10}$$

$$\sigma_{max} = k_f \sigma_{nom}$$

$$= [1 + 0.8(2.5 - 1)] 2083 F$$

$$= 4583(F)$$