Fayoum University
Faculty of Engineering
Industrial Engineering Department

Term Exam 2nd year
Stress Analysis
Time: 3 Hrs

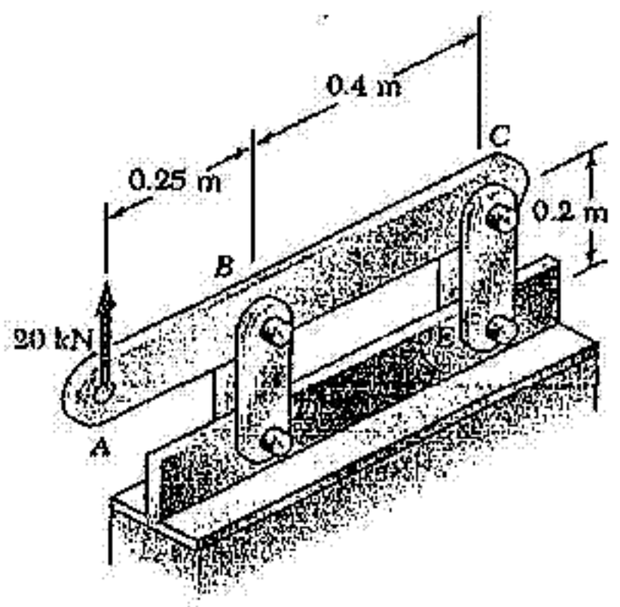
امتحان طلاب نظامى + تخلفات

Answer as much as you can. Maximum points are 100 points

Question No. (1): **(20 points)**

Each of the four vertical links has an 8 x 36 mm uniform rectangular cross section and each of the four pins has a 16 mm diameter, determine:

a. The force in each link.
b. The maximum value of the average normal stress in the links connecting points B and D, points C and E.
c. The average shearing stress in the pin at B.
d. The average bearing stress at B in link BD.
e. The average bearing stress at B in member ABC, knowing that this member has a 10 x 50 mm uniform rectangular cross section.



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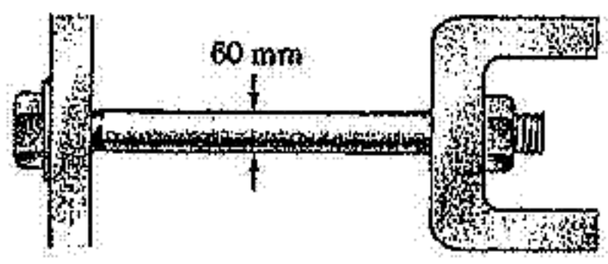
Question No. (2): **(20 points; (5+15))**

(A) The change in diameter of a large steel bolt is carefully measured as the nut is tightened. Knowing that E = 200 GPa and $\upsilon = 0.29$, determine the internal force in the bolt if the diameter is observed to decrease by 13 μm.



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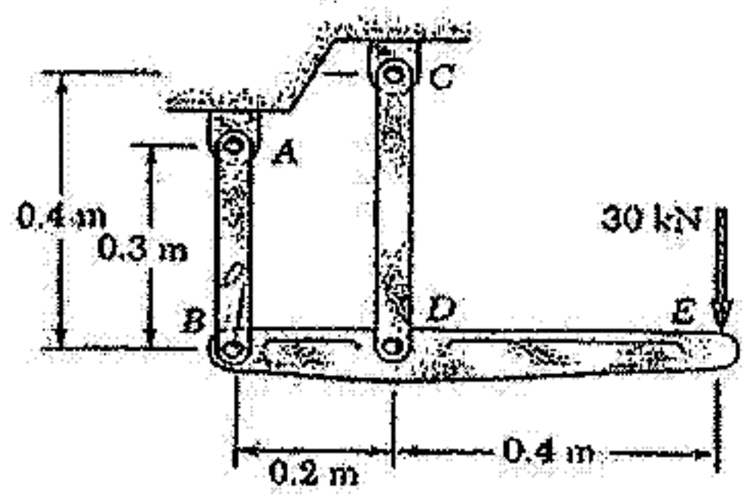
(B) The rigid bar BDE is supported by two links AB and CD. Link AB is made of aluminum (E = 70 GPa) and has a cross sectional area of 500 mm^2, link CD is made of steel (E = 200 GPa) and has a cross sectional area of 600 mm^2. For the 30 KN force shown, determine:

a. The deflection at point B and point D.
b. The deflection at point E.
c. The deflection at point C if it is become free to move and deflection at point D = 0.4 mm.



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Question No. (3): **(20 points; (5+15))**

(A) Design a solid shaft for allowable shearing stress 70 MPa and subjected to a torque of magnitude 600 N.m.

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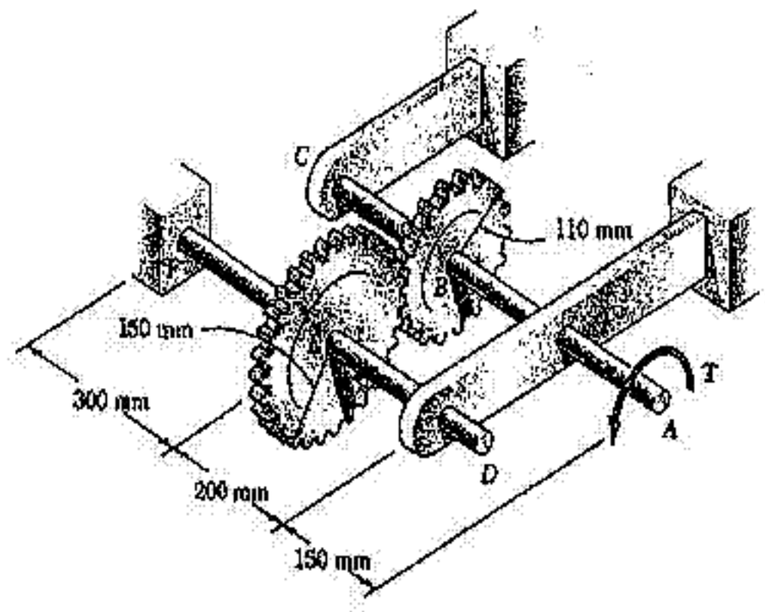
(B) Two shafts, each with 22 mm diameter are connected by the gears shown. Knowing that G = 77 GPa, the shaft at is fixed at F, the torque at point A is equal to 130 N.m, determine:

(i) The torque at shaft FE.

(ii) The maximum shearing stress at shaft AB and shaft FE.

(iii) The twist angle at end A.



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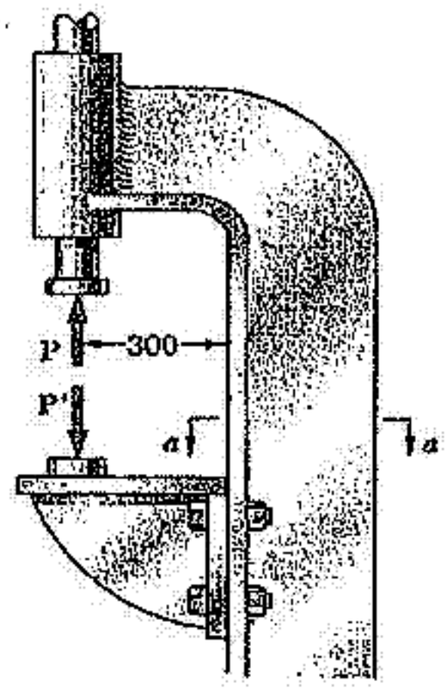
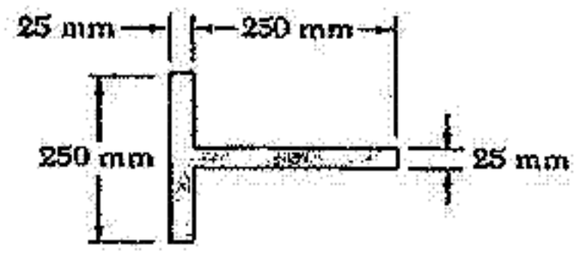
Question No. (4): **(15 points)**

Knowing that the allowable stress in section a-a of the hydraulic press shown is 40 MP in tension and 80 MPa in compression, determine:

a. The largest force P that can be exerted by the press.

b. The location of the neutral axis.





Section a-a

Dimensions in mm

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Question No. (5): **(15 points)**

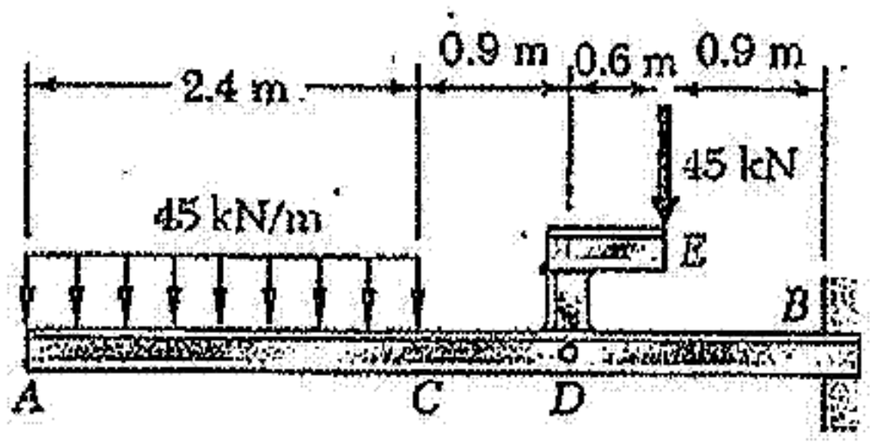
The structure shown consists of a rolled steel beam AB and of two short members welded together and to the beam. Required:

(a) Write down the shear and bending moment equations.

(b) Draw the shear and bending moment diagrams.

(c) Determine the maximum normal stress in sections just to the left and just to the right of point D.

Knowing that the elastic section modulus S has a value of $2.08 \times 10^6 mm^3$ about the x-axis.



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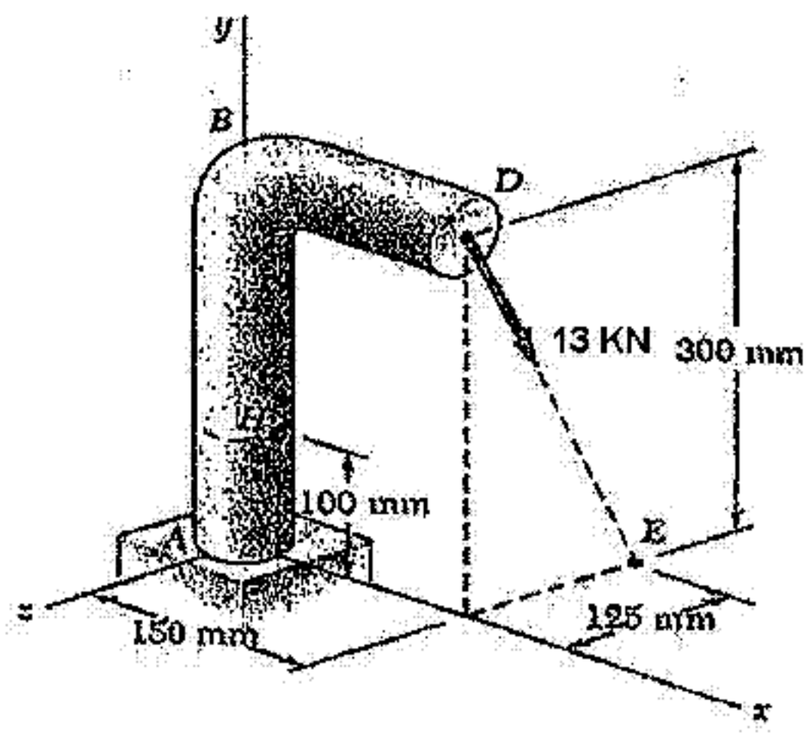
Question No. (6): **(20 points)**

A 13 KN force is applied as shown to the 60 mm diameter cast iron post ABD. At point H, determine:

a. The principle planes.

b. The principle stresses.

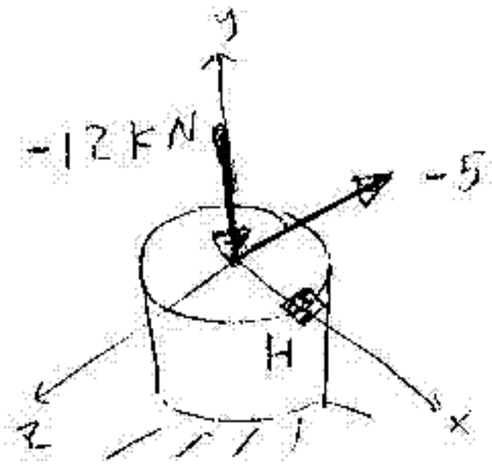
c. The maximum shearing stress

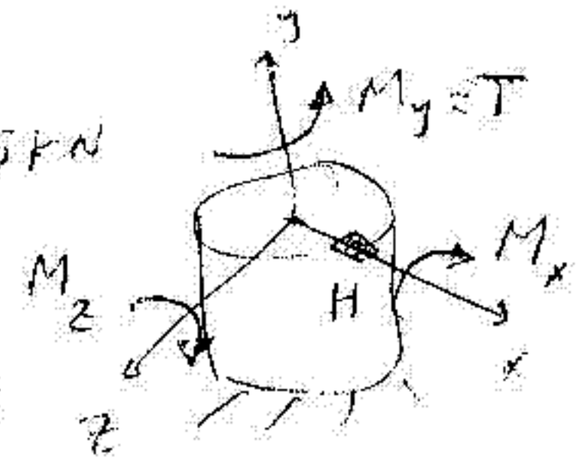


Good Luck

Q[6] (20 points) (9 points)

(11 points) $DE = \sqrt{125^2 + 300^2} = 325$ mm





* $V_x = 0$, $V_y = -13\left(\frac{300}{325}\right) = -12$ KN

$V_z = -13\left(\frac{125}{300}\right) = -5$ KN

* $M_x = -5(0.2) = -1$ KN.m

$M_y = 5(0.15) = 0.75$ KN.m, $M_z = -12(0.15) = -1.8$ KN.m

* $A = \pi c^2 = \pi (0.03)^2 = 2.8274 * 10^{-3}$ mm^2

$I = \frac{\pi}{4} c^4 = \frac{\pi}{4}(0.03)^4 = 636.17 * 10^{-9}$ mm^4

$J = \frac{\pi}{2} c^4 = \frac{\pi}{2}(0.03)^4 = 1.2723 * 10^{-6}$ mm^4

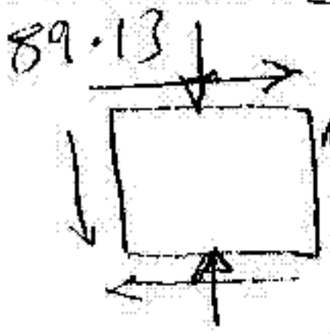
$Q = A\bar{y} = \frac{1}{2}\pi c^2 * \frac{4c}{3\pi} = \frac{2}{3}c^3 = \frac{2}{3}(0.03)^3 = 18 * 10^{-3}$ mm^3

↳ at point H

$$\sigma_y = -\frac{P}{A} - \frac{My}{I} = \frac{-12 * 10^3}{2.8274 * 10^{-3}} - \frac{(1.8 * 10^3)(0.03)}{636.17 * 10^{-9}} = -89.13 \text{ Mpa}$$

$$\tau_{xy} = \frac{QV}{It} + \frac{Tc}{J} = \frac{(18 * 10^{-6})(-5000)}{636.17 * 10^{-9}(0.006)} + \frac{(0.75 * 10^3)(0.03)}{1.2723 * 10^{-6}} = 15.3 \text{ Mpa}$$

* State of Stress at element H is



$\sigma_x = 0$, $\sigma_y = -89.13$ Mpa, $\tau_{xy} = 15.3$ Mpa

↳ using Mohr's Circle

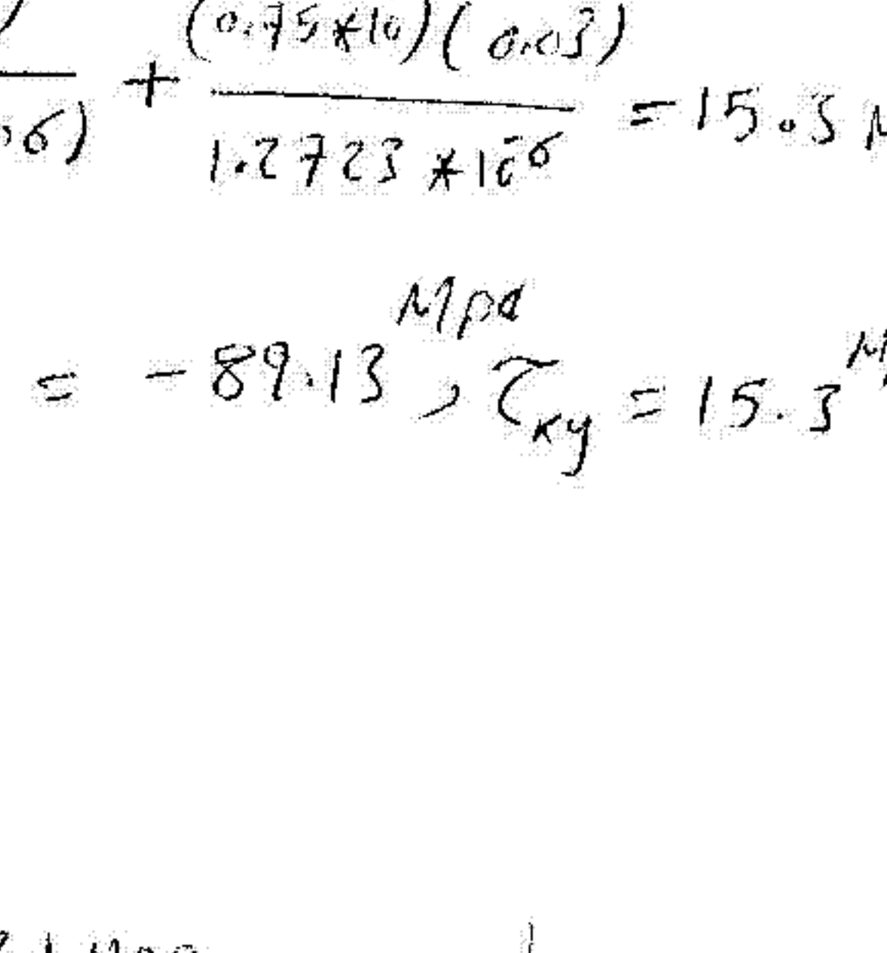
$$\sigma_{av} = \frac{\sigma_x + \sigma_y}{2} = \frac{-89.13}{2} = -44.565 \text{ Mpa}$$

$$R = \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2} = \sqrt{\left(\frac{89.13}{2}\right)^2 + (15.3)^2} = 47.1 \text{ Mpa}$$

[a] 3 points $\tan 2\theta_p = \frac{\tau_{xy}}{\frac{\sigma_x - \sigma_y}{2}} = \frac{2(15.3)}{89.13}$

$\theta_p = 9.5^\circ, 99.5^\circ$

[b] 3 points $\sigma_{max,min} = \sigma_{av} \pm R = -44.565 \pm 47.1$



$\sigma_{max} = 2.535$ MPa

$\sigma_{min} = -91.665$ MPa

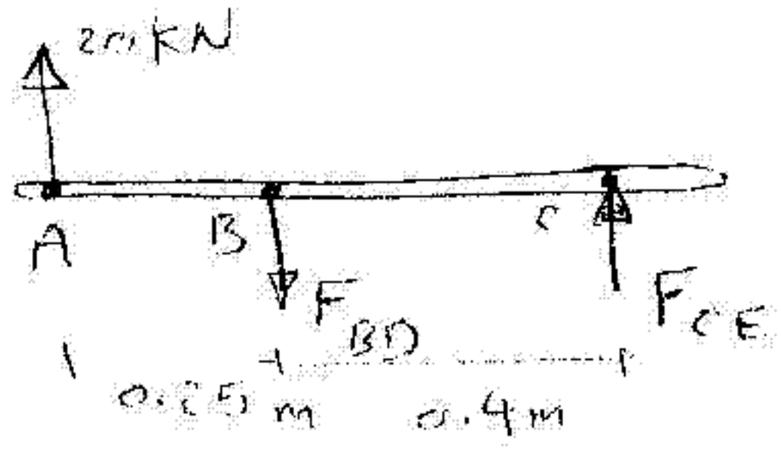
[c] 3 points $\tau_{max} = R = 47.1$ Mpa

2nd year
1st term
Stress Analysis

Model Answer
Term Exam 2009/2010

Q.(1) (20) points

(a) $\curvearrowleft \Sigma M_C = 0$ (3 points)



$$-20(0.25+0.4) + F_{BD}(0.4) = 0$$

$$\{F_{BD} = 32.5 \text{ KN Tension}\}$$

$$\{F_{BD} \text{ at one link} = \frac{32.5}{2} = 16.25 \text{ KN Tension}\}$$

$$\Sigma F_y \uparrow = 0$$

$$20 - F_{BD} + F_{CE} = 0 \longrightarrow 20 - 32.5 + F_{CE} = 0$$

$$\{F_{CE} = 12.5 \text{ KN Compression}\}$$

$$\{F_{CE} \text{ at one link} = \frac{12.5}{2} = 6.25 \text{ KN Compression}\}$$

(4 points)

(b) → link BD at Tension ⟶ max. stress value will be at smallest area (hole)

$$\sigma_{BD} = \frac{F_{BD} \text{ for one link}}{A \text{ at hole}} = \frac{16.25 * 10^3}{(0.036 - 0.016)(0.008)} = 101.6 \text{ Mpa}$$

→ link CE at Compression ⟶ max. stress will be at the origin area

$$\sigma_{CE} = \frac{F_{CE} \text{ one link}}{A \text{ at origin}} = \frac{-6.25 * 10^3}{(0.036 * 0.008)} = -21.7 \text{ Mpa}$$

(4 points)

(c) Shear stress at pin B

$$\tau = \frac{F_{BD} \text{ for one link}}{A_P} = \frac{16.25 * 10^3}{\frac{\pi}{4}(0.016)^2} = 80.8 \text{ MPa}$$

(4 points)

(d) Bearing stress at B in link BD

$$\sigma_b = \frac{F_{BD} \text{ for one link}}{A} = \frac{16.25 * 10^3}{(0.016 * 0.008)} = 126.9 \text{ Mpa}$$

(4 points)

(e) Bearing stress at B in ABC

$$\sigma_b = \frac{F_{BD}}{A} = \frac{32.5 * 10^3}{(0.016 * 0.01)} = 203.1 \text{ Mpa}$$

Q[2] 20 points (5+15)

(A) 5 points:

$$\delta_y = -13*10^{-6}\ m \longrightarrow \varepsilon_y = \frac{\delta_y}{d} = \frac{-13*10^{-6}}{60*10^{-3}} = -2.17*10^{-4}$$

$$\nu = -\frac{\varepsilon_y}{\varepsilon_x} \longrightarrow \varepsilon_x = \frac{-\varepsilon_y}{\nu} = \frac{2.17*10^{-4}}{0.29} = 7.47*10^{-4}$$

$$\hookrightarrow \sigma_x = E\varepsilon_x = 200*10^9 * 7.47*10^{-4} = 149.4\ MPa$$

$$A = \frac{\pi}{4}d^2 = \frac{\pi}{4}(0.06)^2 = 2.83*10^{-3}\ m^2$$

$$\hookrightarrow \sigma_x = \frac{F_x}{A} \longrightarrow F_x = \sigma_x A = 149.4*10^6 * 2.83*10^{-3}$$

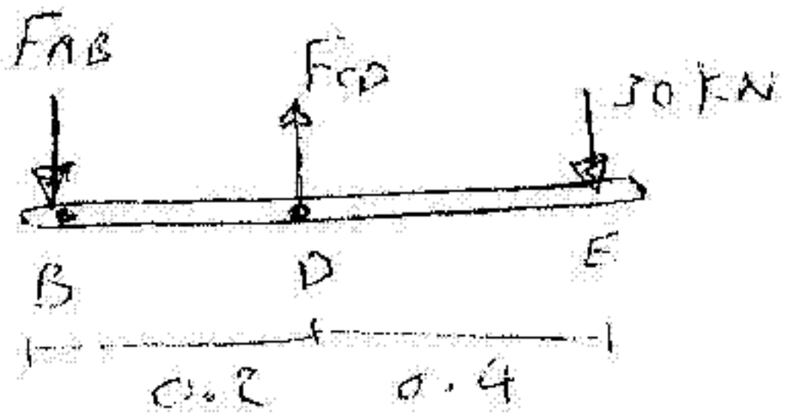
$$= 422.4\ kN$$

$$\therefore \boxed{F_x = 422.4\ N}$$

(B) (15 points)

$$\Sigma M_B \circlearrowleft = 0 \longrightarrow F_{CD}(0.2) - 30(0.6) = 0$$

$$\boxed{F_{CD} = 90\ kN\ \text{Tension}}$$



$$\Sigma M_D \circlearrowleft = 0 \longrightarrow F_{AB}(0.2) - 30(0.4) = 0$$

$$\boxed{F_{AB} = 60\ kN\ \text{Compression}}$$

(5 Points)

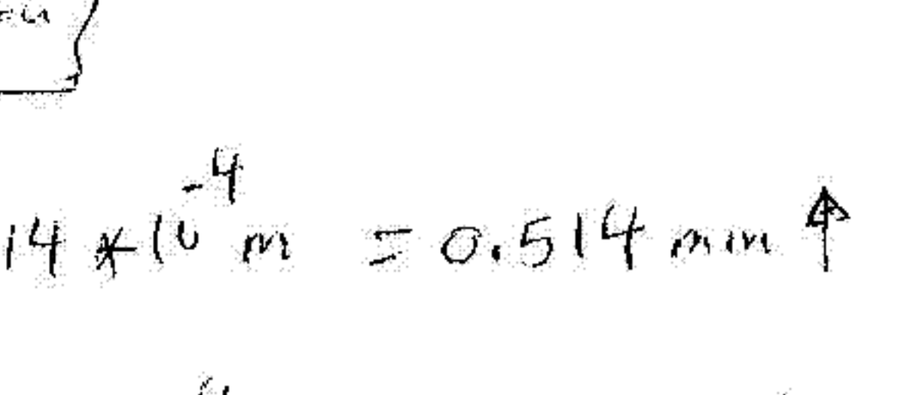
(a) $$\delta_B = \frac{F_{AB}L_a}{A_a E_a} = \frac{-60*10^3 * 0.3}{500*10^{-6} * 70*10^9} = -5.14*10^{-4}\ m = 0.514\ mm \uparrow$$

(5 points)

(b) $$\delta_D = \frac{F_{CD}L_s}{A_s E_s} = \frac{90*10^3 * 0.4}{600*10^{-6} * 200*10^9} = 3*10^{-4}\ m = 0.3\ mm \downarrow$$

$$\frac{\delta_B}{\delta_D} = \frac{200-X}{X} \Rightarrow \frac{0.514}{0.3} = \frac{200-X}{X}$$

$$\boxed{X = 73.7\ mm}$$



$$\frac{\delta_E}{\delta_D} = \frac{0.4+X}{X} = \frac{0.4+(73.7*10^{-3})}{(73.7*10^{-3})} = \frac{\delta_E}{0.3}$$

(5 points)

$$\boxed{\delta_E = 1.93\ mm}$$

(c) In This Case $\delta_{Dr} = \delta_D - \delta_c = 0.3$

$$\therefore \delta_c = \delta_D - \delta_{Dr} = 0.4 - 0.3 = 0.1\ mm$$

P(3) 20 points (5+15)

(A) 5 points $\tau_{all} = 70\ MPa$, $T = 600\ N.m$

$$\tau_{max} = \frac{T.c}{J} = \frac{T.c}{\frac{\pi}{2}c^4} = \frac{2T}{\pi c^3} \Rightarrow c^3 = \frac{2T}{\tau_{max}\pi}$$

$$c^3 = \frac{2(600)}{70*10^6*\pi} = 5.46*10^{-6}\ m^3 \Rightarrow c = 0.018\ m$$

$$\therefore \boxed{c = 18\ mm \longrightarrow d = 2c = 36\ mm}$$

(B) (15 points)

a. (5 points) $\frac{T_{FE}}{r_E} = \frac{T_{AB}}{r_B} \rightarrow T_{FE} = r_E\frac{T_{AB}}{r_B} = 0.15*\frac{130}{0.11}$

$$\therefore \boxed{T_{FE} = 177.3\ N.m}$$

b. (5 points) $\tau_{max})_{AB} = \frac{T_{AB}.c}{J} = \frac{130(0.011)}{\frac{\pi}{2}(0.011)^4} = 62.2\ MPa$

$$\tau_{max})_{FE} = \frac{T_{FE}.c}{J} = \frac{177.3(0.011)}{\frac{\pi}{2}(0.011)^4} = 89.8\ MPa$$

c. (5 points)

$$\phi_E = \phi_{FE} = \frac{T_{FE}L_{FE}}{G\ J_{FE}} = \frac{177.3*0.3}{77*10^9*\frac{\pi}{2}(0.011)^4} = 0.03\ rad = 1.72^\circ$$

$$\phi_E r_E = \phi_B r_B \rightarrow \phi_B = \frac{\phi_E r_E}{r_B} = \frac{0.03*0.15}{0.11} = 0.041\ rad = 2.34^\circ$$

$$\phi_{AB} = \frac{T_{AB}L_{AB}}{G\ J_{AB}} = \frac{130*0.35}{77*10^9*\frac{\pi}{2}(0.011)^4} = 0.026\ rad = 1.47^\circ$$

$$\phi_{AB} = \phi_A - \phi_B$$

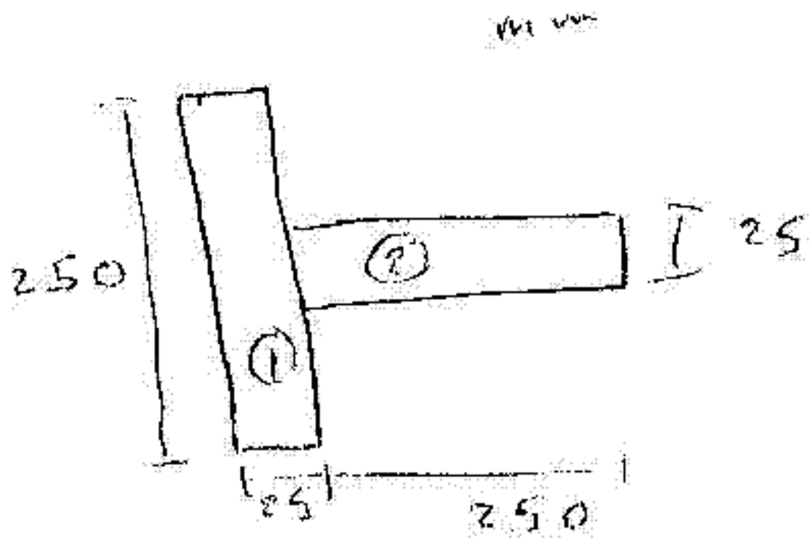
$$\phi_A = \phi_{AB} + \phi_B$$

$$= 1.47^\circ + 2.34^\circ$$

$$= 3.81^\circ$$

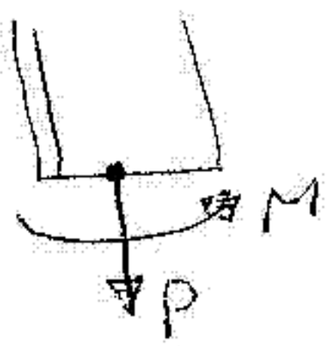
Q [4] (15 points) (10+5)

(a) (10 points)



	A_{mm^2}	$\bar{y}_{mm}$	$A\bar{y}_{mm^3}$
(1)	6250	12.5	78125
(2)	6250	150	937500
Σ	12500		1015625

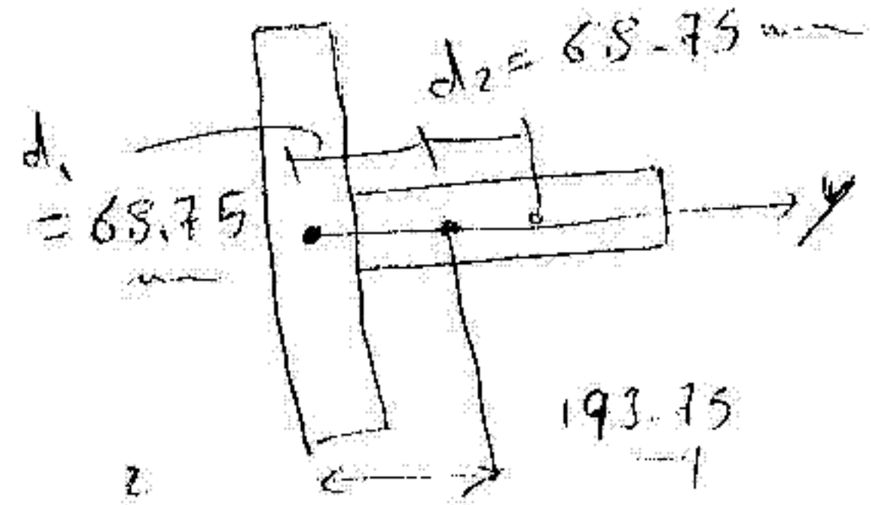
$$\bar{y} = \frac{\Sigma A\bar{y}}{\Sigma A} = \frac{1015625}{12500} = 81.25 \text{ mm}$$



$M = P(300 + \bar{y})$

$= P(381.25)$

$= 0.38125P$ N.m



$$I_1 = \frac{bh^3}{12} + A_1 d_1^2 = \frac{250(25)^3}{12} + 6250(68.75)^2$$

$$= 29.9 * 10^{6} \text{ mm}^4 = 29.9 * 10^{-6} \text{ m}^4$$

$$I_2 = \frac{bh^3}{12} + A_2 d_2^2 = \frac{25(250)^3}{12} + 6250(68.75)^2$$

$$= 62.1 * 10^{6} \text{ mm}^4 = 62.1 * 10^{-6} \text{ m}^4$$

$$I = I_1 + I_2 = 92 * 10^{-6} \text{ m}^4$$

* at tension $y = 81.25$ mm, $\sigma_{Ten} = \frac{P}{A} + \frac{My}{I} \Rightarrow 40 * 10^{6} = \frac{P}{12500 * 10^{-6}} + \frac{0.38125P(0.8}{92 * 10^{-6}}$

$$40 * 10^{6} = P(80 + 335.7) \rightarrow \boxed{P = 96.22 \text{ kN}}$$

* at Compression $y = 193.75$ mm, $\sigma_{Com} = \frac{P}{A} - \frac{My}{I} \Rightarrow -80 * 10^{6} = \frac{P}{12500 * 10^{-6}} + \frac{0.38125P(0.193}{92 * 10^{-6}}$

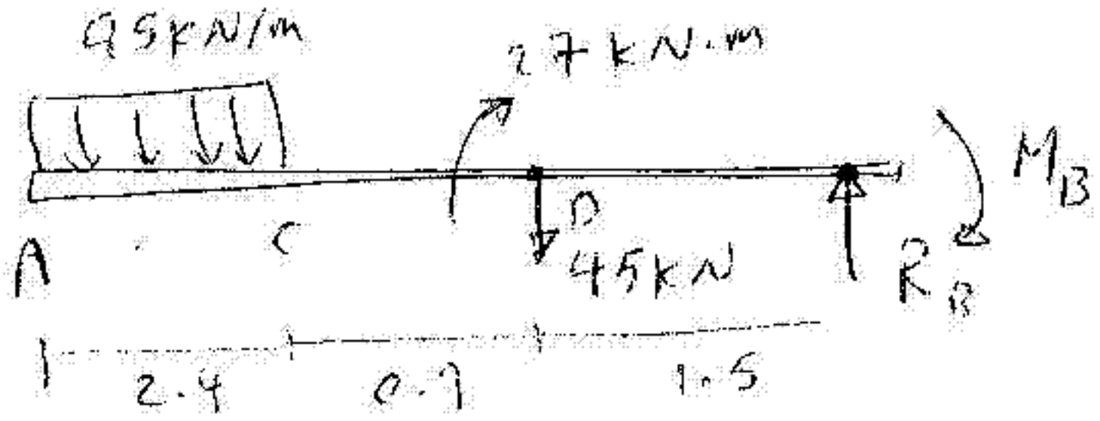
$$-80 * 10^{6} = P(80 - 799.8) \rightarrow \boxed{P = 111 \text{ kN}}$$

Smallest P that can be applied is 96.22 kN

(b) at neutral axis $\sigma = 0 \rightarrow \frac{P}{A} - \frac{My}{I} = 0 \Rightarrow \frac{P}{A} = \frac{My}{I}$

$$y = \frac{PI}{MA} = \frac{92 * 10^{-6}}{0.38125 * 12500 * 10^{-6}} = 0.019 \text{ m} = 19 \text{ mm}$$

Q5 (15 points)



(a) 5points

free body diagram

$\Sigma F_y \uparrow = 0$

$-45(2.4) - 45 + R_B = 0$

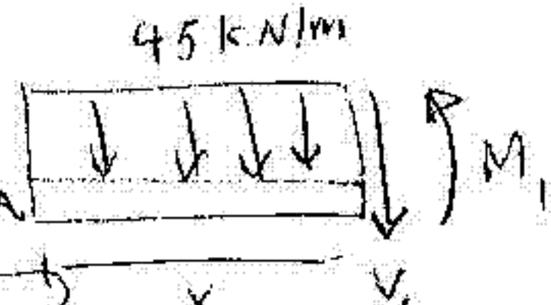
$\boxed{R_B = 153\ KN}$

$\Sigma M_D \circlearrowleft = 0$

$45 * 2.4(1.2+0.9) - 27 - M_B + 153(1.5) = 0$

$\boxed{M_B = 429.3\ KN.m}$

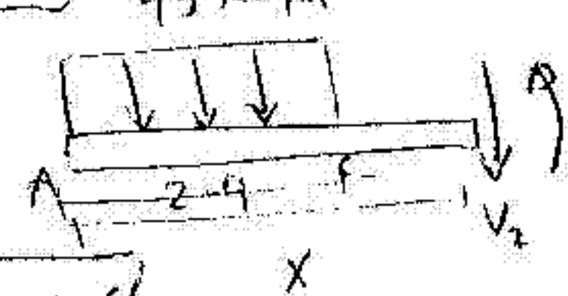
(a) $0 \le X \le 2.4$



$\Sigma F_y = 0 \rightarrow -45X - V_1 = 0 \Rightarrow \boxed{V_1 = -45X}$

$\Sigma M = 0 \rightarrow 45X(\frac{X}{2}) + M_1 = 0 \Rightarrow \boxed{M_1 = -22.5X^2}$

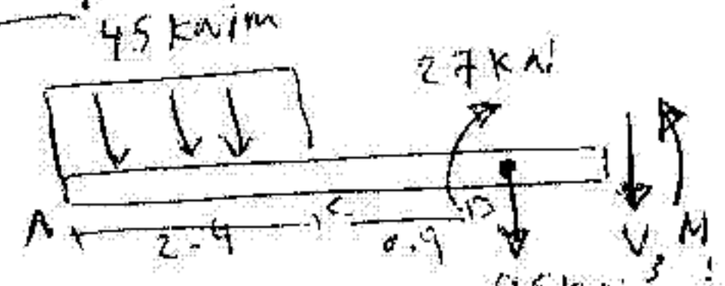
$2.4 \le X \le 3.3$



$\Sigma F_y \uparrow = 0 \Rightarrow -45(2.4) - V_2 = 0 \ \boxed{V_2 = -108KN}$

$\Sigma M \circlearrowleft = 0 \Rightarrow 45(2.4)(X-1.2) + M_2 = 0 \ \boxed{M_2 = -108X + 129.6}$

$3.3 \le X \le 4.5$



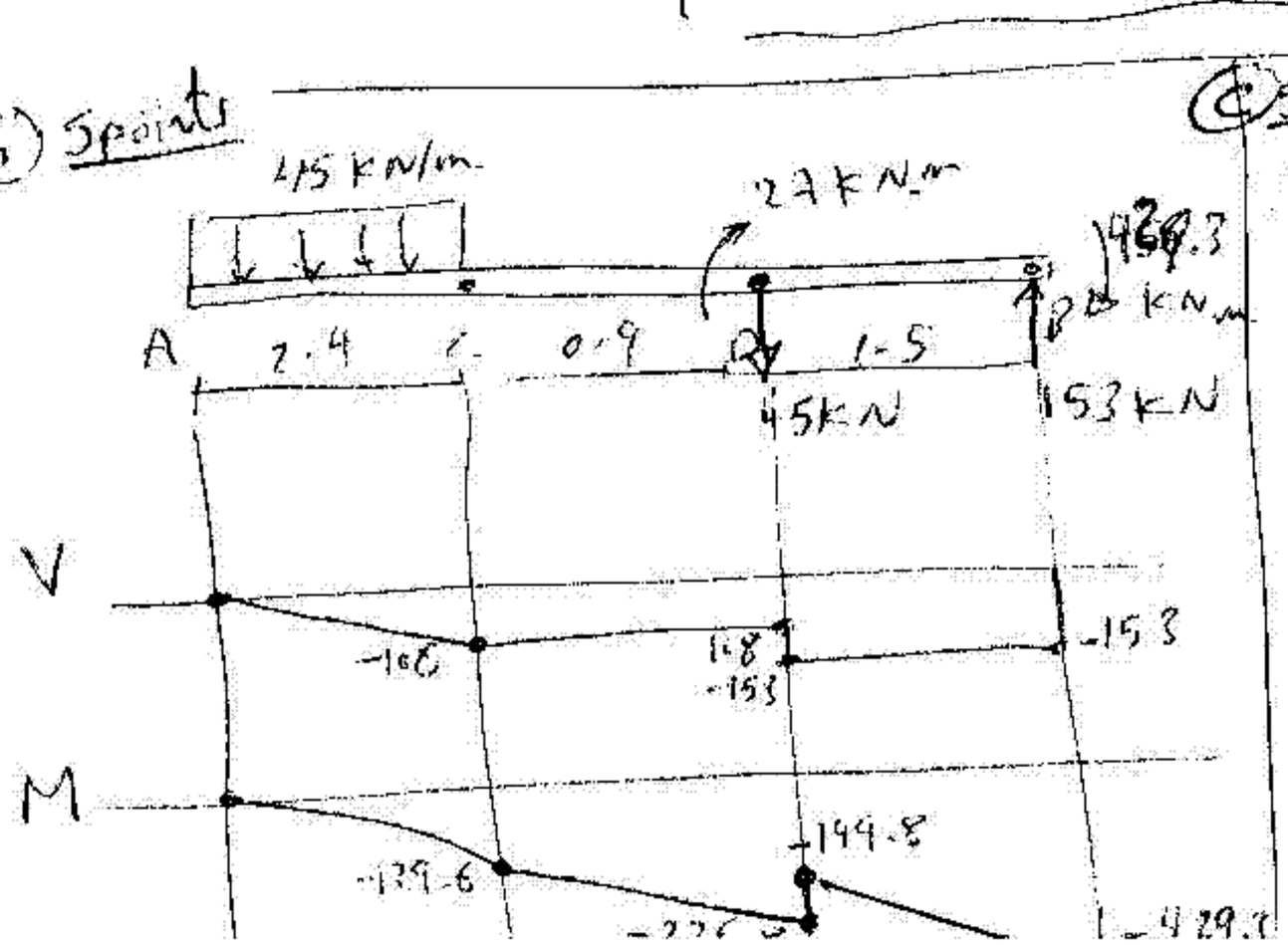
$\Sigma F_y \uparrow = 0 \Rightarrow -45(2.4) - 45 - V_3 = 0 \ \boxed{V_3 = -153KN}$

$\Sigma M_y \circlearrowleft = 0 \Rightarrow 45(2.4)(X-1.2) + 45(X-3.3) - 27 + M_3 = 0$

$108X - 129.6 + 45X - 148.5 - 27 + M_3 = 0$

$\boxed{M_3 = -153X + 305.1\ KN.m}$

(b) 5points



(c) 5points

at left of point D $\rightarrow M = -226.8\ KN.m$

$\sigma_m = \frac{|M|}{S} = \frac{226.8}{2.08 * 10^{-3}} = 109\ MPa$

at right of point D $\rightarrow M = -199.8\ KN.m$

$\sigma_m = \frac{|M|}{S} = \frac{199.8}{2.08 * 10^{-3}} = 96\ MPa$

أعمال السنة
المادة: تحليل الاجهادات
السنة: ثانية صناعية

الاسم	HW; AT.; Q. (25)	Med Term (25)	Final (50)
اسراء عبد اللطيف محمود	23	11	34
أحمد على عبد الجيد	25	20	45
أمنية عبد الفتاح جودة	1	0	1
حمدية عوض منصور	23	17	40
زينب عبد الستار محمد	21	6	27
سمر عصام أحمد سالم	22	15	37
علا موسى محمد	21	10	31
غادة رمضان عبد الباقى	22	13	35
محمد مصطفى مصطفى	21	16	37
مريم نبيل ظريف	22	12	34
ناهد سمير ميهوب أحمد	21	10	31
نورا سالم عويس	20	5	25
هويدا محمد	25	18	43
هيثم صبخى سلامة	11	14	25