YAKIN DOĞU ÜNİVERSİTESİ — NEAR EAST UNIVERSITY

Makine Mühendisliği Bölümü — Department of Mechanical Engineering

MAK 303 MAKİNE TASARIMI I – ME 303 MACHINE DESIGN I

2014- 2015 *Güz Dönemi* - 2014- 2015 Fall Semester

Ara Sınav - Midterm

Dr. Mehmet Ali Güler — Ad, Soyad: Ahmad Chanaa

30 Kasım 2014, Pazar — Öğrenci No: 20143753

Verilen Zaman: 2 saat (18:30-20:30) Time allowed: 2 hours (14:00-16:00)

Soru No	Maksimum Puan	Puan
1	40	30
2	40	40
3	40	40
Toplam	120	110

ÖNEMLİ UYARI !!!

Yükseköğretim Kurumları Öğrenci Disiplin Yönetmeliği Madde 9-m'ye göre "sınavlarda kopya yapmak veya yaptırmak veya bunlara teşebbüs etmek" fiilinin suçu YÜKSEKÖĞRETİM KURUMUNDAN BİR VEYA İKİ YARIYIL İÇİN UZAKLAŞTIRMA cezasıdır.

Özel Sınav Kuralları:
Sınav süresince cep telefonları kapalı konumda olmak suretiyle sıra üzerine konulmalıdır.

UYARI VE KURALLARI OKUDUM.

Öğrencinin İmzası:
Adı Soyadı :...Ahmad...

Ön sayfa dahil, bu sınav kağıdında toplam **(9)** sayfa vardır.
There are (9) pages including the cover page

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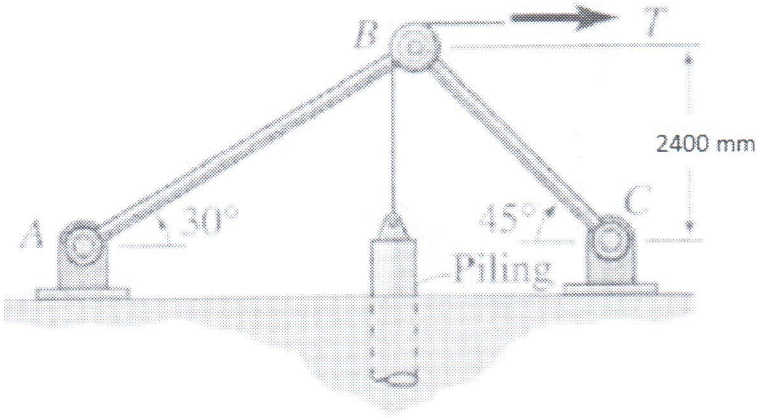
Soru 1: (40 puan)



Şekil.1: [Kaynak: Problem 10.2-15 Sayfa 649 Roy R. Craig, Jr. Mechanics of Materials, 2nd Edition]

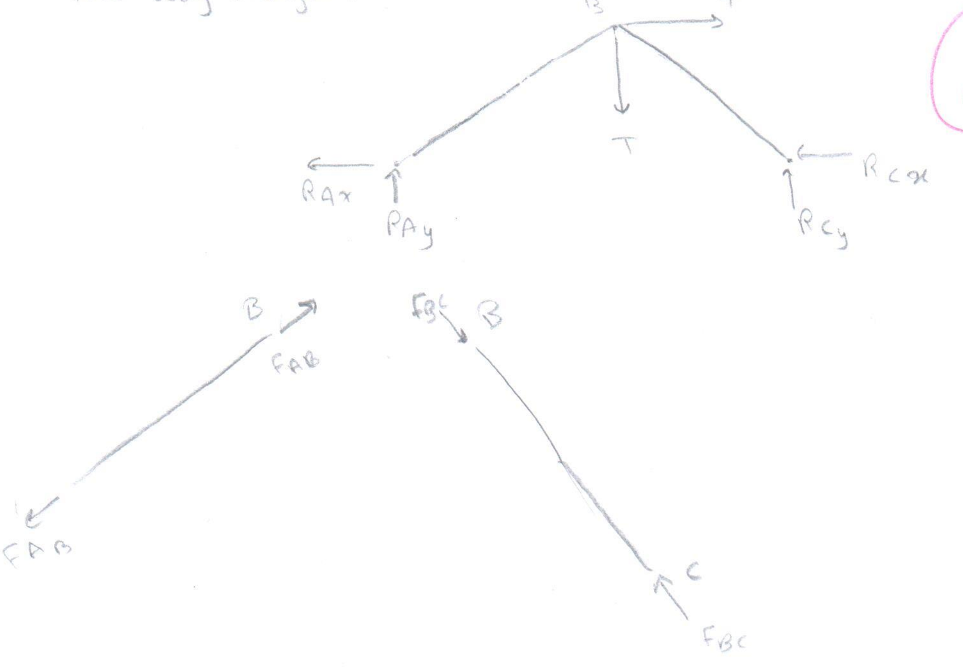
Şekil 1'de gösterilen sistem, kazıkları çekmek için kullanılan bir teçhizat parçasıdır. AB ve BC kolları çelikten yapılan bu sistemin, dış kesit çapı d_0 ve et kalınlığı t'dir. Sistemin herhangi bir elemanında elastik bel verme meydana gelmeden kazık üzerinde oluşturulabilecek en büyük çekme kuvvetini hesaplayınız. (T çekme kuvvetini taşıyan halat AB ve BC elemanlarının birleştiği B noktasına pimle bağlanmış olan dönüşü serbest bir makaraya sarılıdır)

Verilenler: $d_0 = 75\ mm$, $t = 7\ mm$, $E_{st}=200\ GPa$, $\sigma_Y = 250\ MPa$

The truss is used as part of a rig to pull pilings out of the ground. If the two truss members are steel pipes with outer diameter of d_0 and wall thickness of t, determine the largest tension that can be exerted on the piling without causing elastic buckling of a truss member. (The cable that exerts tension T on the piling passes over a pulley that is free to rotate about the same pin that connects the two truss members together at B.)

Given: $d_0 = 75\ mm$, $t = 7\ mm$, $E_{st}=200\ GPa$, $\sigma_Y = 250\ MPa$

free body - diagram:



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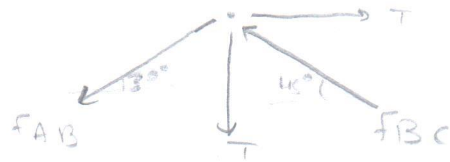
at pin B



$\xrightarrow{+} \Sigma F_x = 0 \Rightarrow -F_{AB}\cos 30 + T - F_{BC}\cos 45 = 0$

$\Rightarrow T = F_{BC}\cos 45 + F_{AB}\cos 30 \quad \text{--- (1)}$

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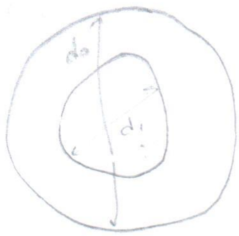

$d_o = 75\,mm$

$d_i = d_o - 2t = 75 - 2(7)$
$= 61\,mm$

$I = \frac{\pi}{64}(d_o^4 - d_i^4)$

$\Rightarrow I = \frac{\pi}{64}(75^4 - 61^4) = 873056.6\,mm^4$

for column BC : $(P_{crit})^{BC} = \frac{\pi^2 E I}{L^2} = \frac{\pi^2 \cdot (200\times10^3)\cdot(873056.6)}{(2400 \sin 45)^2}$

$= 598383.56\,N$ X 5

for BC not to buckle the force should be less, $F_{BC} = 598383.56\,N$

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* for AB: $n\sigma_y = \frac{F_{AB}}{A} = \frac{F_{AB}}{\frac{\pi}{4}(d_o^2 - d_i^2)}$

the factor of safety is $n = 1$

$\Rightarrow 250 = \frac{F_{AB}}{\frac{\pi}{4}(75^2 - 61^2)} \Rightarrow F_{AB} = 373849.5 \, N$

the force applied on AB should be less than $F_{AB} = 373849.5$ so that no failure occurs

from eq(1): $T = F_{BC} \cos 45 + F_{AB} \cos 30$

$= (598383.56) \cos 45 + (373849.5) \cos 30$

$\Rightarrow T = 746884.23 \, N$

$\Rightarrow$ T should be less than 746884.23 N

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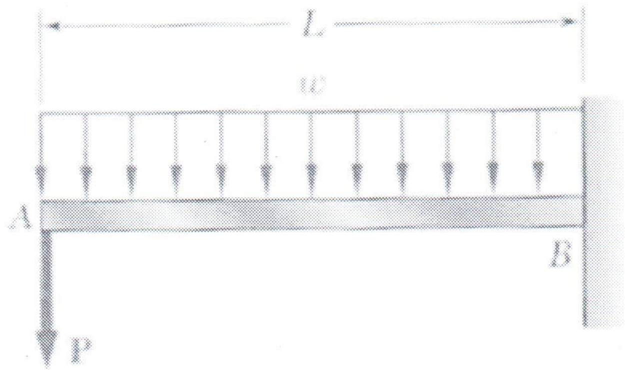
Soru 2: (40 puan)



Şekil.2 :[Kaynak: Example 11.12 , Sayfa 713, Ferdinand P. Beer, E. Russell Johnston, Jr. ,John T. Dewolf, Mechanics of Materials, 4th Edition]

Şekil 2'de verilen AB ankastre kirişine w yayılı yükü ve P kuvveti uygulanmıştır.

a) A noktasındaki sehimi Castigliano teoremi kullanarak hesaplayınız.
b) A noktasındaki eğimi hesaplayınız.
c) Kesme kuvveti ve Moment diyagramlarını çiziniz.

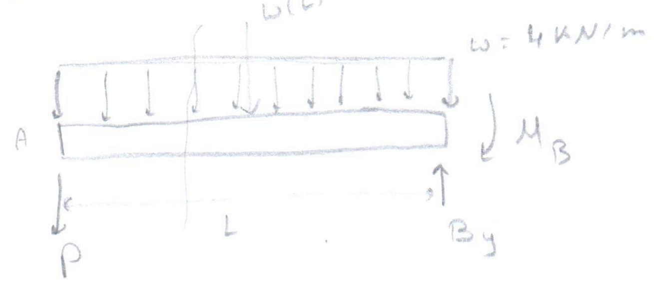
Verilenler: $L = 2\ m,\ w = 4\ kN/m,\ P = 6\ kN,\ EI = 5\ MN.m^2$

The cantilever beam AB supports a uniformly distributed load w and a concentrated load P.

a) Determine the deflection at A using Castigliano's theorem.
b) Determine the slope at A.
c) Draw the Shear and Moment diagrams.

Given: $L = 2\ m,\ w = 4\ kN/m,\ P = 6\ kN,\ EI = 5\ MN.m^2$

Free body diagram



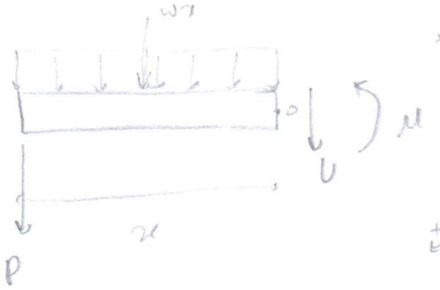
$$\circlearrowleft \Sigma M_B = 0 \Rightarrow M_B - P(L) - w(L)\cdot\frac{L}{2} \Rightarrow M_B = PL + \frac{wL^2}{2} = 6(2) + \frac{4(2)^2}{2}$$

$$\Rightarrow M_B = 20\ kN.m$$

$$\uparrow \Sigma F_y = 0 \Rightarrow B_y - P - wL = 0 \Rightarrow B_y = P + wL = 6 + 4(2)$$

$$= 14\ kN$$

a) section: $0 \le x \le L$



$+\uparrow \sum F_y = 0 \Rightarrow -V - wx - P = 0$

$\Rightarrow \boxed{V_1 = -wx - P} \Rightarrow V = -4x - 6$ kN

$\circlearrowleft \sum M_o = 0 \Rightarrow -M - wx\left(\frac{x}{2}\right) - P(x) = 0$

$\Rightarrow \boxed{M_1 = -\frac{wx^2}{2} - Px} \Rightarrow M_1 = -2x^2 - 6x$

$\boxed{\frac{\partial M_1}{\partial P} = -x}$

$U = U_b$ (No torsion and axial)

$$\Rightarrow U = \int_0^L \frac{M^2}{2EI}\,dx$$

$$\delta_A = \frac{\partial U}{\partial P} = \frac{\partial}{\partial P}\int_0^L \frac{M_1^2}{2EI}\,dx, \quad \frac{\partial M_1^2}{\partial P} = \frac{\partial M_1^2}{\partial M_1}\cdot\frac{\partial M_1}{\partial P} = 2M_1 \cdot \frac{\partial M_1}{\partial P}$$

$$\Rightarrow \delta_A = \frac{1}{2EI}\int_0^L 2M_1 \cdot \frac{\partial M_1}{\partial P}\cdot dx = \frac{1}{EI}\int_0^L \left(-\frac{wx^2}{2} - Px\right)(-x)\cdot dx$$

$$= \frac{1}{EI}\int_0^L \left(\frac{wx^3}{2} + Px^2\right)dx = \frac{1}{EI}\left[\frac{wx^4}{8} + \frac{Px^3}{3}\right]_0^L$$

$$\Rightarrow \delta_A = \frac{1}{EI}\left[\frac{wL^4}{8} + \frac{PL^3}{3}\right] = \frac{1}{5\times10^6}\left[\frac{(4\times10^3)\times 2^4}{8} + \frac{(6\times10^3)\times 2^3}{3}\right]$$

$= 4.8 \times 10^{-3}$ m

$\Rightarrow \boxed{\delta_A = 4.8 \text{ mm}}$

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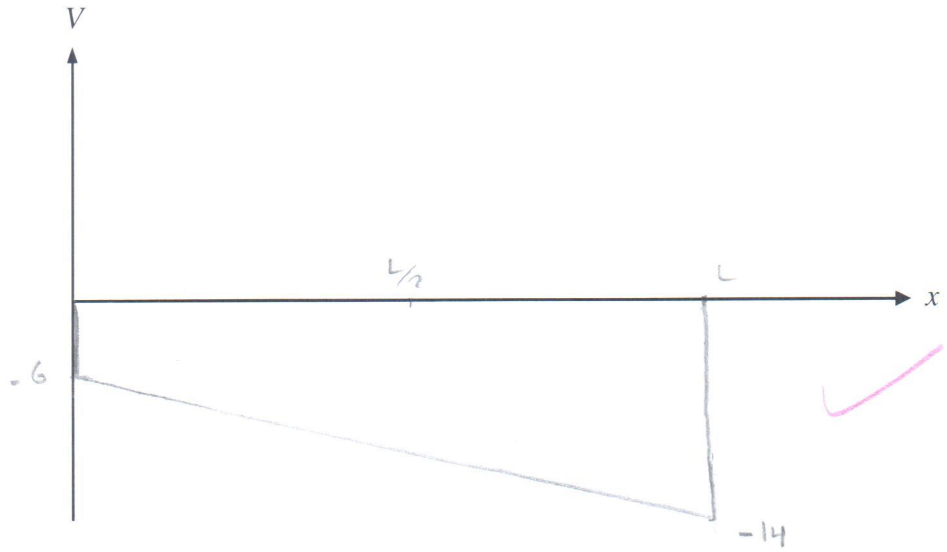
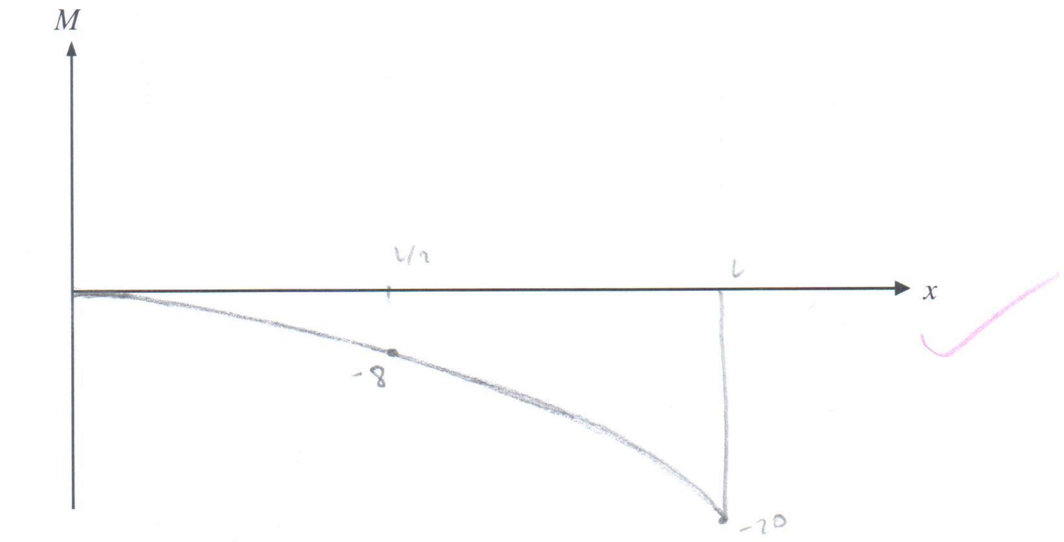
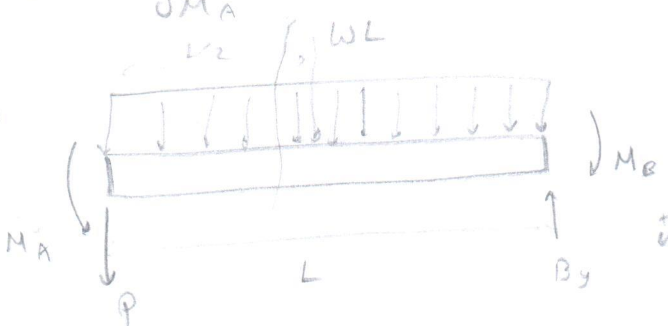
c)





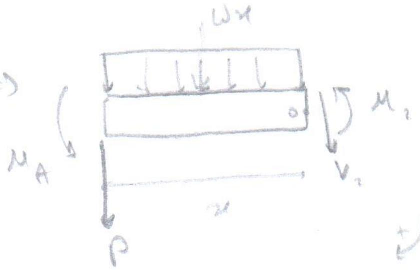
b) $\phi_A = \dfrac{\partial U}{\partial M_A} \Rightarrow$ add an imaginary moment M_A at A

$\Rightarrow$ 

$\Sigma F_y = 0 \Rightarrow B_y = P + wL$
$= 14\,kN$

$\circlearrowleft \Sigma M_B = 0 \Rightarrow M_B - M_A - PL - \dfrac{wL^2}{2}$

$\Rightarrow M_B = M_A + PL + \dfrac{wL^2}{2} = M_A + 20\,kN.m$

section: $0 \leq x \leq L \Rightarrow$ 

$+\uparrow \Sigma F_y = 0 \Rightarrow -V_2 - Wx - P = 0$
$\Rightarrow V_2 = -Wx - P$

$\circlearrowleft \Sigma M_o = 0 \Rightarrow -M_2 - \dfrac{Wx^2}{2} - Px - M_A = 0$

$$\Rightarrow \boxed{M_2 = -\frac{Wx^2}{2} - Px - M_A}$$

$$\boxed{\frac{\partial M_x}{\partial M_A} = -1}$$

$$U = U_b = \int_0^L \frac{M_2^2}{2EI}\,dx$$

$$\phi_A = \frac{\partial U}{\partial M_A} = \frac{\partial}{\partial M_A}\int_0^L \frac{M_2^2}{2EI}\,dx \quad , \quad \frac{\partial M_2^2}{\partial M_A} = \frac{\partial M_2^2}{\partial M_2}\cdot\frac{\partial M_2}{\partial M_A}$$

$$= 2M_2 \cdot \frac{\partial M_2}{\partial M_A}$$

$$\Rightarrow \phi_A = \frac{1}{2EI}\int_0^L 2M_2 \cdot \frac{\partial M_2}{\partial M_A}\,dx = \frac{1}{EI}\int_0^L \left(-\frac{Wx^2}{2} - Px - M_A\right)(-1)\,dx$$

$$= \frac{1}{EI}\int_0^L \left(\frac{Wx^2}{2} + Px + M_A\right)dx = \frac{1}{EI}\left[\frac{wx^3}{6} + \frac{Px^2}{2} + M_A\cdot x\right]_0^L$$

$$= \frac{1}{EI}\left[\frac{wL^3}{6} + \frac{PL^2}{2} + M_A\cdot L\right]_{M_A=0} \quad , \text{ set } M_A = 0$$

$$\Rightarrow \phi_A = \frac{1}{EI}\left[\frac{wL^3}{6} + \frac{PL^2}{2}\right] = \frac{1}{5\times10^6}\left[\frac{(4000)(2^3)}{6} + \frac{(6000)(2^2)}{2}\right]$$

$$\Rightarrow \boxed{\phi_A = 3.46\times10^{-3}}$$

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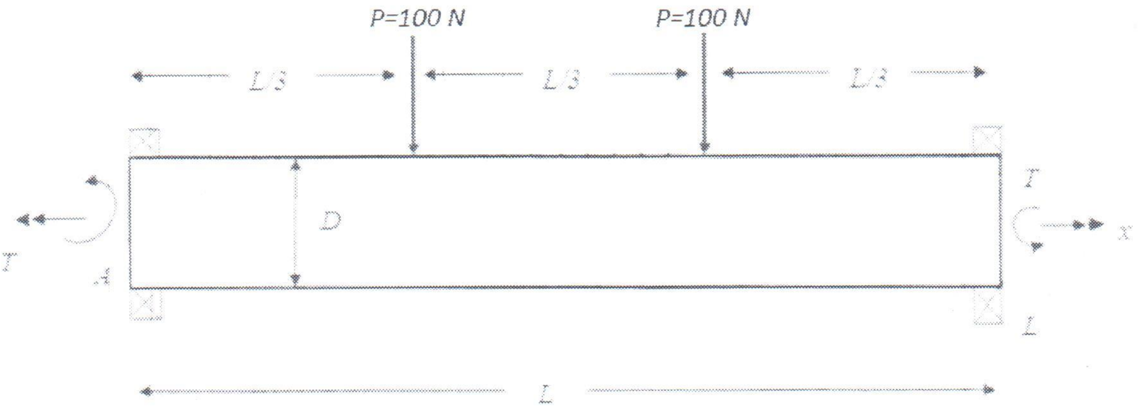
Soru 3: (40 puan)



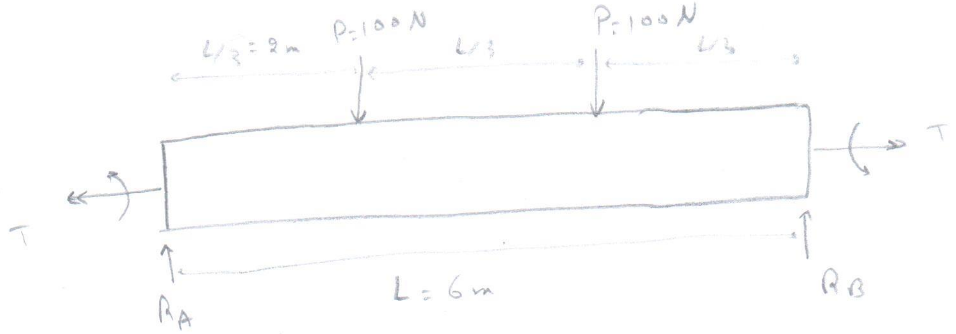
Şekil 3

Şekil 3'de gösterilen L uzunluğuna ve D çapına sahip çelik (ASTM – A36) mil, T torkuna ve şekilde uygulama noktaları gösterilen iki adet P yüküne maruz bırakılmıştır. Maksimum kayma gerilmesi (Tresca) ve maksimum şekil değiştirme enerjisi (von Mises) teoremlerine göre emniyet katsayıları belirleyiniz. Tresca heksagonunu ve Mises elipsini çizerek, yükleme doğrusunu grafik üzerinde gösteriniz.

Verilenler: $L = 6$ m, $T = 300$ Nm, $P = 100$ N, $D = 30$ mm

An ASTM-A36 steel shaft of length L carries a torque T and two concentrated forces P. Determine the safety factors in accordance with the Max. shear stress theory (Tresca) and Max. distortion energy theory (von Mises). Draw the loading line on the graphs by drawing Tresca hexagon and Mises elips.

Given: $L = 6$ m, $T = 300$ Nm, $P = 100$ N, $D = 30$ mm

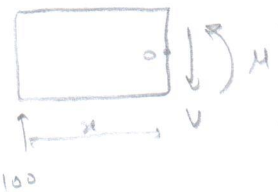


$\uparrow \sum F_y = 0 \Rightarrow R_A + R_B = 100 + 100 = 200\ N$

$+\circlearrowleft \sum M_A = 0 \Rightarrow 100 \times 2 + 100 \times 4 - R_B \times 6 = 0 \Rightarrow \boxed{R_B = 100\ N}$

$\Rightarrow \boxed{R_A = 100\ N}$

section 1 $0 \le x \le L/3$

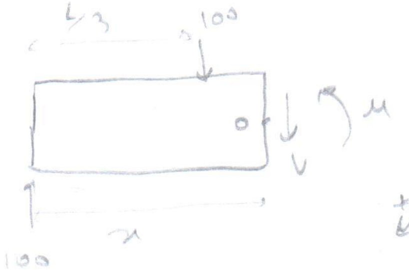


$+\uparrow \sum F_y = 0 \Rightarrow \boxed{V = 100\,N}$

$\circlearrowleft \sum M_o = 0 \Rightarrow -M + 100x = 0$

$\Rightarrow \boxed{M = 100x}$

section 2 : $L/3 \le x \le 2L/3$



$+\uparrow \sum F_y = 0 \Rightarrow -V - 100 + 100 = 0$

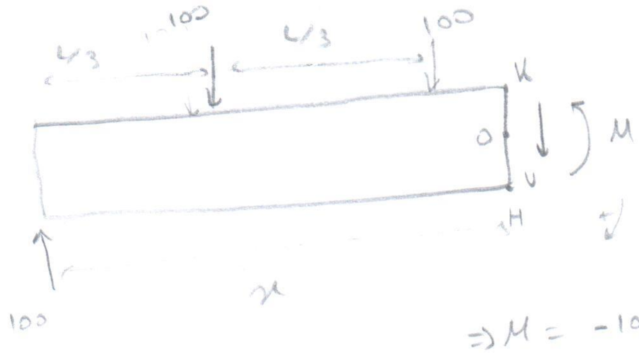
$\Rightarrow \boxed{V = 0}$

$\circlearrowleft \sum M_o = 0 \Rightarrow -M + 100x - 100\left(x - \frac{L}{3}\right) = 0$

$\Rightarrow M = 100x - 100x + 100\left(\frac{6}{3}\right)$

$\Rightarrow \boxed{M = 200\,N.m}$

section 3 : $2L/3 \le x \le L$



$+\uparrow \sum F_y = 0 \Rightarrow -V - 100 - 100 + 100 = 0$

$\Rightarrow \boxed{V = -100\,N}$

$\circlearrowleft \sum M_o = 0 \Rightarrow -M - 100\left(x - 2\frac{L}{3}\right) - 100\left(x - \frac{L}{3}\right) + 100x = 0$

$\Rightarrow M = -100x + 100\left(\frac{2L}{3}\right) - 100x + 100\frac{L}{3} + 100x = 0$

$\Rightarrow M = -100x + 100\left(\frac{2 \times 6}{3}\right) + 100\left(\frac{6}{3}\right)$

$\Rightarrow \boxed{M = -100x + 600}$

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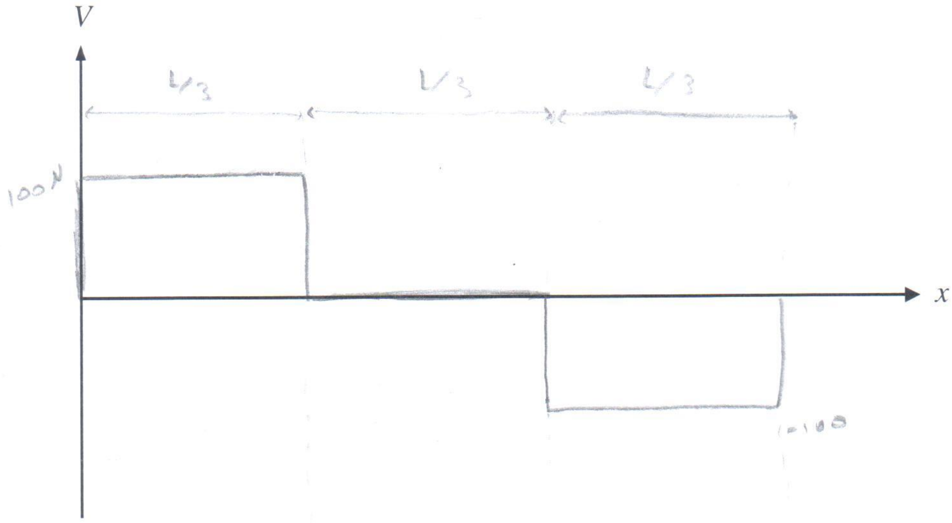
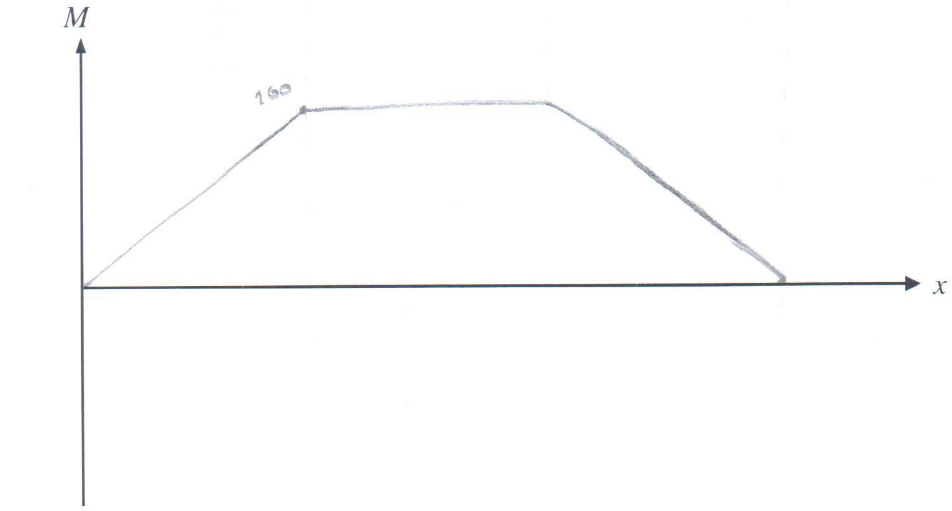
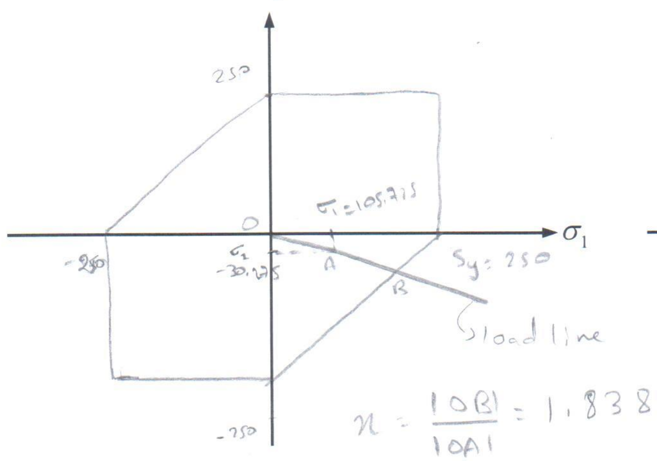
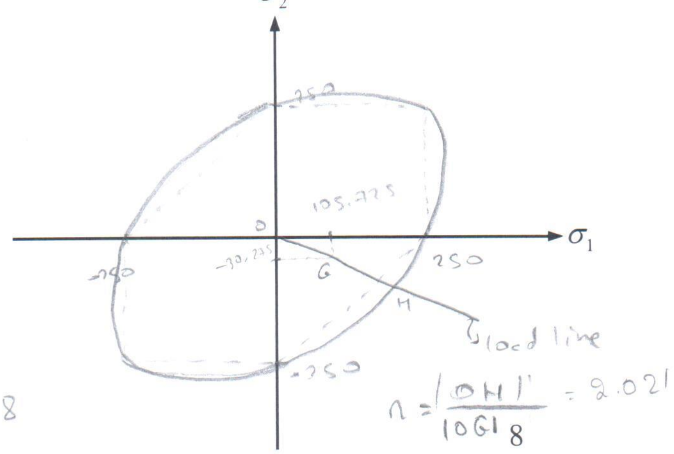




Tresca



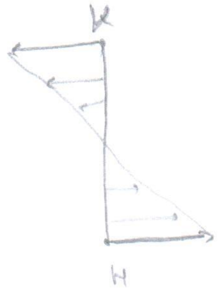
von Mises



$M_{max} = 200\ N.m$

$$\sigma_{xx} = \sigma_b = \frac{M.c}{I} = \frac{(200\times10^3)\cdot D/2}{\frac{\pi D^4}{64}} = \frac{(32)(200\times10^3)}{\pi D^3}$$

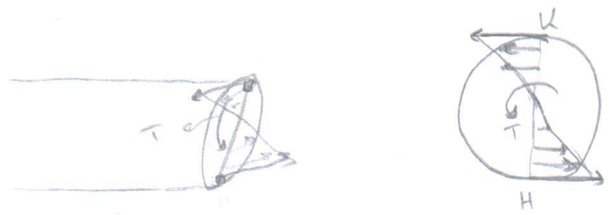
$$\sigma_{xx} = \frac{(32)(200\times10^3)}{(\pi)(30)^3} = 75.45\ MPa$$



* Torque is constant along the shaft which is $T = 300\ N.m$

$$\Rightarrow \tau = \frac{T\,c}{J} = \frac{(300\times10^3)(D/2)}{\frac{\pi}{32} D^4} = \frac{(16)(300\times10^3)}{\pi D^3}$$

$$= \frac{(16)(300\times10^3)}{\pi(30)^3} = 56.58\ MPa$$



* We take point H since it have tension

point H

(a) : (75.45, 56.58 ccw)

(b) : (0, 56.58 cw)

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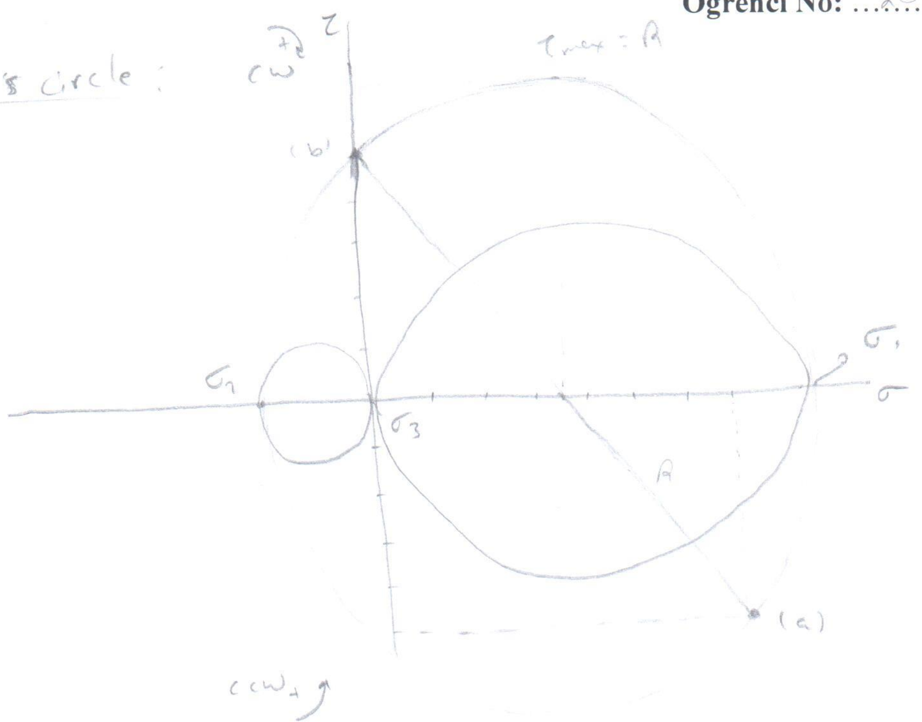
Mohr's circle :



$$R = \sqrt{\left(\frac{75.45}{2}\right)^2 + (56.58)^2} = 68$$

$$\sigma_1 = \frac{75.45}{2} + R = \frac{75.45}{2} + 68$$

$$\Rightarrow \boxed{\sigma_1 = 105.725 \text{ MPa}}$$

$$\sigma_2 = \frac{75.45}{2} - R = \frac{75.45}{2} - 68$$

$$\Rightarrow \boxed{\sigma_2 = -30.275 \text{ MPa}}$$

$$\tau_{max} = R = 68 \text{ MPa}$$

for Tresca: $n = \dfrac{\frac{S_y}{2}}{\tau_{max}} = \dfrac{S_y}{2 \times \tau_{max}} = \dfrac{250}{2 \times 68} = 1.838$

$$\Rightarrow \boxed{n_{Tresca} = 1.838}$$

+ for von-misses: $\sigma_{eq} = \sqrt{\sigma_1^2 - \sigma_1\sigma_2 + \sigma_2^2}$

$$= \sqrt{(105.725)^2 - (105.725)(-30.275) + (-30.275)^2}$$

$$\Rightarrow \sigma_{eq} = 123.673 \text{ MPa}$$

$$n_{Von\text{-}missen} = \frac{S_y}{\sigma_e} = \frac{250}{123.673} = 2.021$$

$$\boxed{n_{Von\text{-}misses} = 2.021}$$