TOBB EKONOMİ VE TEKNOLOJİ ÜNİVERSİTESİ

# Department of Mechanical Engineering

## MAK 206 STRENGTH OF MATERIALS

*2012- 2013 Spring Semester*
**Final**

Dr. Mehmet Ali Güler

27 Mart 2013, Çarşamba

Name Fatih Yunus KARAOĞLU

Student # 091501036

Duration of Examination: **2.5 hours** (14:30-17:00)

| QUESTION | Maximum Point | Points |
|---|---|---|
| 1 | 30 | 30 |
| 2 | 30 | 29 |
| 3 | 30 | 28 |
| 4 | 30 | 24 |
| Total | 120 | 115 |

**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.

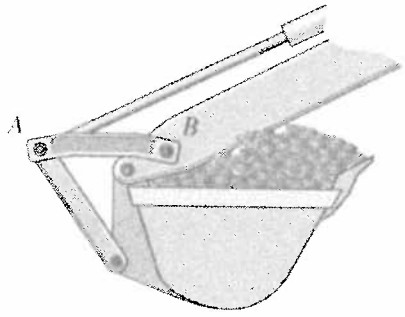
**UYARI VE KURALLARI OKUDUM.**

**Öğrencinin İmzası:**
**Adı Soyadı** : Fatih Yunus KARAOĞLU

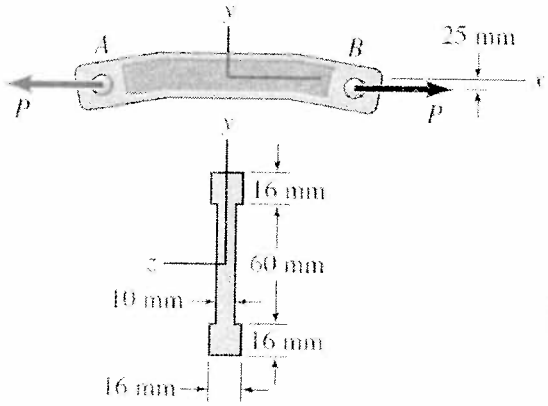
Ön sayfa dahil, bu sınav kağıdında toplam **(10)** sayfa vardır.

Student #: Fatih Yunus KARAOĞLU

**Question 1: (30 points)**




(a)

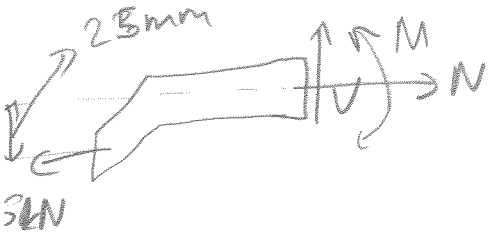



(b)

16

Pending

One part of the mechanism that controls the operation of the backhoe bucket in Fig. a is the (slightly C-shaped) two-force link AB, whose dimensions are shown in Fig. b. (a) Determine the maximum tensile stress on the cross section at the center of link AB if the force exerted on the link by the pins at A and B is P=6 kN. Show the state of stress on a differential element and draw the Mohr's circle **for maximum tensile stress point**. (b) How much would the maximum tensile stress be if the link were perfectly straight, with the same cross-sectional dimensions?


$\sum F_x = 0 \quad -6kN + N = 0$

$\boxed{N = 6kN}$

$\sum F_y = 0 \quad \boxed{V = 0}$

$\sum M = 0$

$-6kN \times 25mm + M = 0$

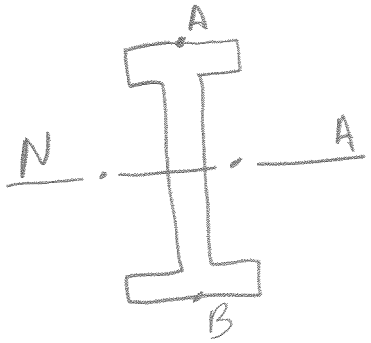
$\boxed{M = 150000 N.mm}$

$\sigma = \frac{P}{A} = \frac{6000N}{1112mm^2}$

$A = 92 \times 16 - 6 \times 60$

$A = 1112 mm^2$

$\boxed{\sigma = 5,395 MPa}$ → çekme (Tensile)




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

$I = \frac{1}{12} b h^3$

$I = \frac{1}{12} \times 16 \times 92^3 - 2 \times \left(\frac{1}{12} 3 \times 60^3\right)$

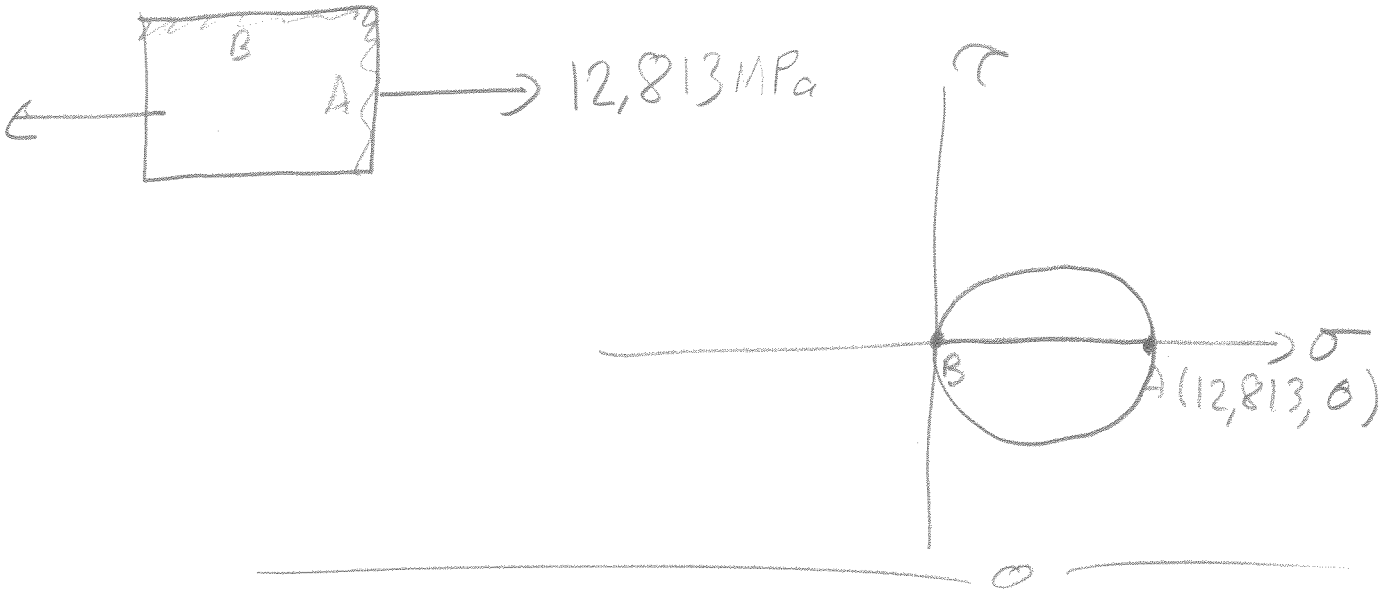
$1038250,667 - 108000$

$\Rightarrow \boxed{I = 930250,667}$

$\sigma_{max\ (B)} = \frac{150000 \times 46}{930250,667} = \boxed{7,417 MPa}$ → Bending

$\sum \sigma_{max\ (B)} = 5,396 + 7,417 = \boxed{12,813 MPa}$ B noktasında

$\sigma_{min\ (B)} = 7,417 - 5,396 = \boxed{2,021 MPa}$ Analtası




b)


$$\sum F_x = 0 \qquad N - 6000N = 0$$

$$\boxed{N = 6000N}$$

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

$$\sum F_y = 0 \qquad \boxed{V = 0}$$

$$\sum M = 0 \qquad \boxed{M = 0}$$

$$\sigma = \frac{N}{A} \Rightarrow \frac{6000}{1112} = \boxed{5,396\,MPa}$$

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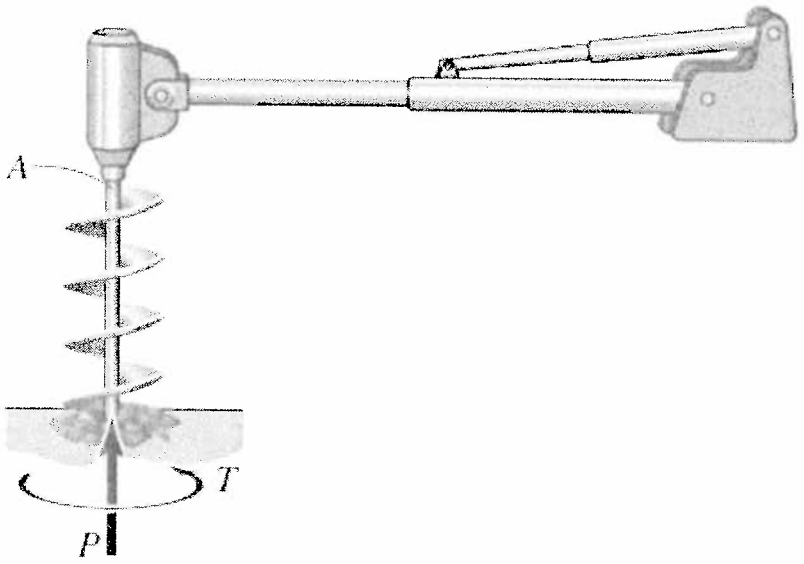
**Question 2: (30 points)**




A post-hole digger is mounted on a tractor (not shown).The power unit of the machine consume 1 kW of power while the shaft is turning at a speed of 10 RPM (revolutions per minute) and it also exerts a downward force of $P = 6$ kN on the auger. If the shaft of the auger is a solid circular rod with a diameter of 50 mm., determine the principal stresses and the maximum shear stress at a typical point A on the surface of the shaft of the auger near the power unit. Show the state of stress on a differential element and draw the Mohr's circle for point A (**at the perimeter of the circular cross-section**).

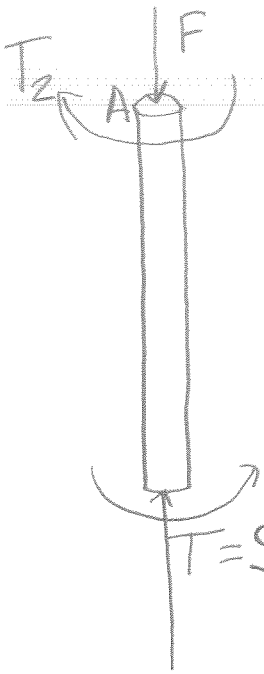
Power (N.m/s) = Torque (N.m) x Angular velocity (Rad/s)

$1\text{RPM} = \frac{2\pi}{60}\text{Rad/s}$

$$1000W = T \times 10 \times \frac{2\pi}{60}$$

$$T = \frac{6000}{2\pi}$$

$$T = 954,93\ N.m$$




$$\sum F_y = 0 \quad F - 6kN = 0$$

$$\boxed{F = 6kN}$$

$$\sum T = 0 \quad T_2 - T = 0$$

$$\boxed{T_2 = 954,93\ N.m}$$

$$\boxed{d = 50mm}$$

$$J = \frac{\pi}{2} c^4$$

$$J = \frac{\pi}{2} 25^4$$

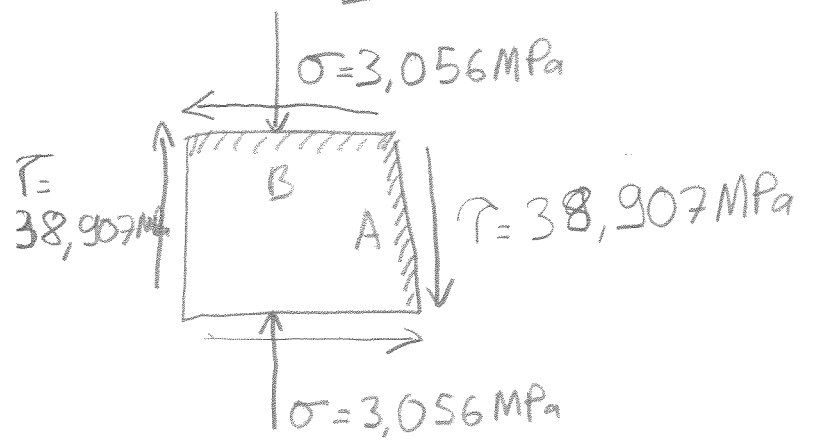
$$\boxed{J = 613592,3152}$$

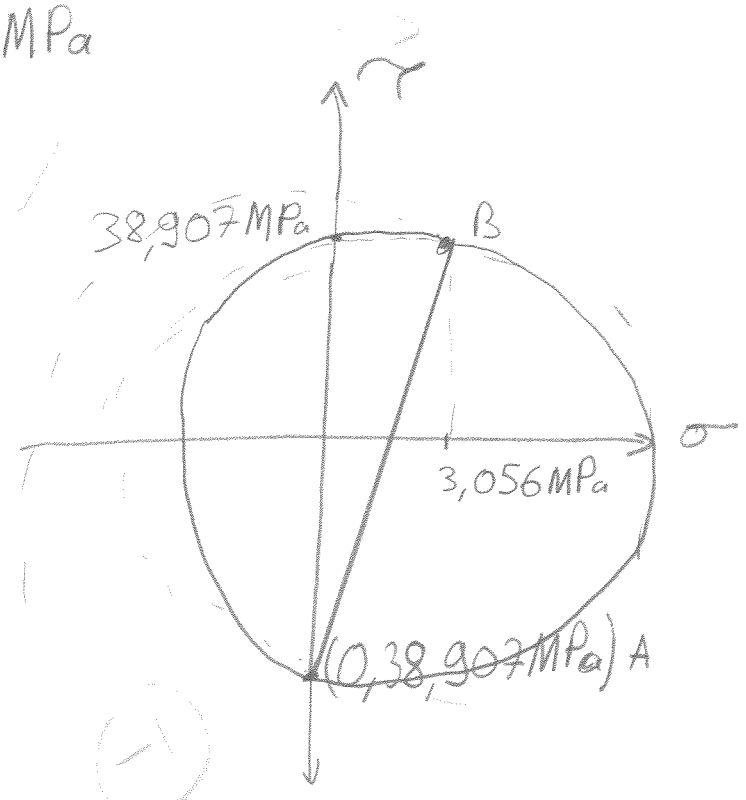
$$\tau = \frac{T c}{J} \Rightarrow \frac{954,93 \times 10^3 \times 25}{613592,3152}$$

$$\boxed{\tau = 38,907MPa}$$

$$\sigma = \frac{N}{A} \Rightarrow \frac{6000}{\pi \cdot \left(\frac{50}{2}\right)^2} = 3,056MPa$$

$$\boxed{\sigma = 3,056MPa}$$



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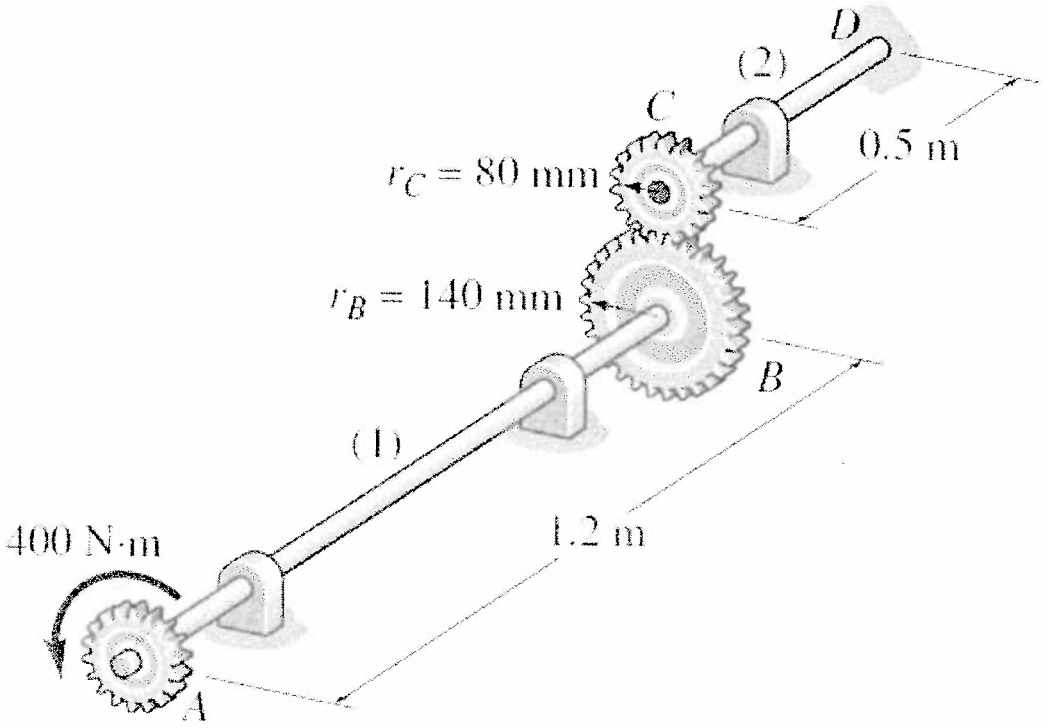
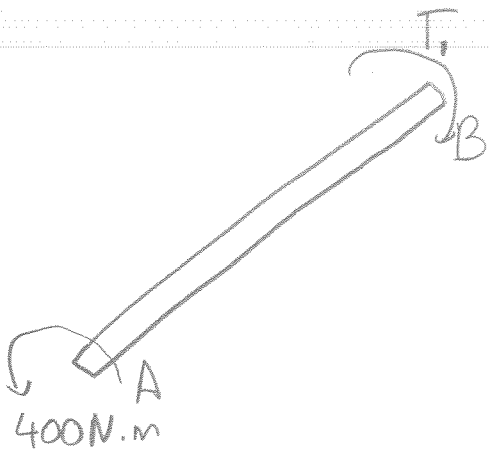
**Question 3: (30 points)**



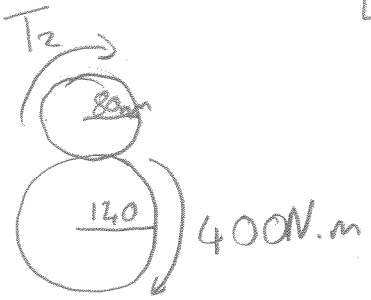

A torque is applied to gear A of a two-shaft system and is transmitted through gears at B and C to a fixed end at D. The shafts are made of steel (G = 80 GPa). Each shaft has a diameter d = 32 mm, and they are supported by frictionless bearings as shown in Figure. If the torque applied to gear A is 400 Nm, and D is restrained, (a) determine the maximum shear stress in each shaft, and (b) determine the angle of twist of the gear A relative to its no-load position. Show the state of stress on a differential element and draw the Mohr's circle for the point where maximum shear stress occurs.




$$\sum T = 0$$

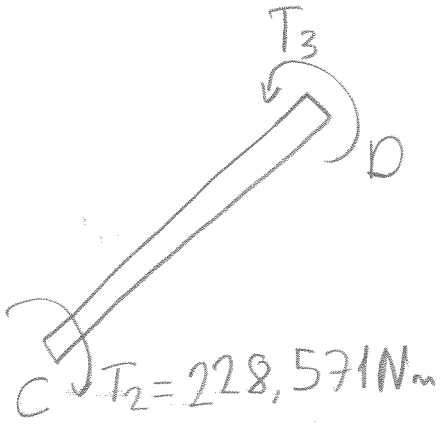
$$T_1 - 400\ N.m = 0$$

$$\boxed{T_1 = 400\ N.m}$$




$$\frac{T_2}{80} = \frac{400\ N.m}{140}$$

$$\boxed{\Rightarrow T_2 = 228,571\ N.m}$$




$$\sum T = 0$$

$$T_3 - 228,571\ N.m = 0$$

$$\boxed{T_3 = 228,571\ N.m}$$

$$\boxed{d = 32\ mm}$$

$$\tau = \frac{T.c}{J}$$

$$J = \frac{\pi}{2} c^4$$

$$\Rightarrow J = \frac{\pi}{2} 16^4$$

$$\boxed{\Rightarrow J = 102943,7081\ mm^4}$$

$$\tau_{AB\ max} = \frac{400000\ N.mm \times 16mm}{102943,7081\ mm^4}$$

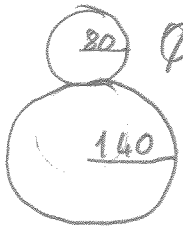
$$\boxed{\tau_{AB\ max} = 62,169\ MPa}$$

$$\tau_{CO\ max} = \frac{228571\ N.mm \times 16mm}{102943,7081\ mm^4}$$

$$\boxed{\tau_{CO\ max} = 35,526\ MPa}$$

$$\phi = \frac{T \cdot L}{J \cdot G}$$

$$\phi_{CD} = \frac{228571\,N.mm \times 500}{102943{,}7081\,mm^4 \times 80000\,MPa} = \boxed{1{,}3877 \times 10^{-2}\,rad}$$



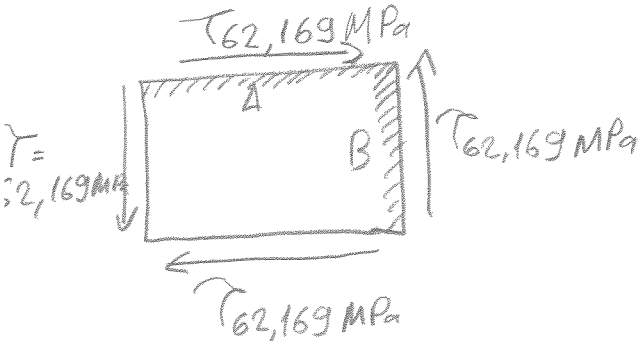

$$\phi_2 = \frac{\phi_1 \times 80}{140} = \phi_2 = \frac{4}{7}\phi_1$$

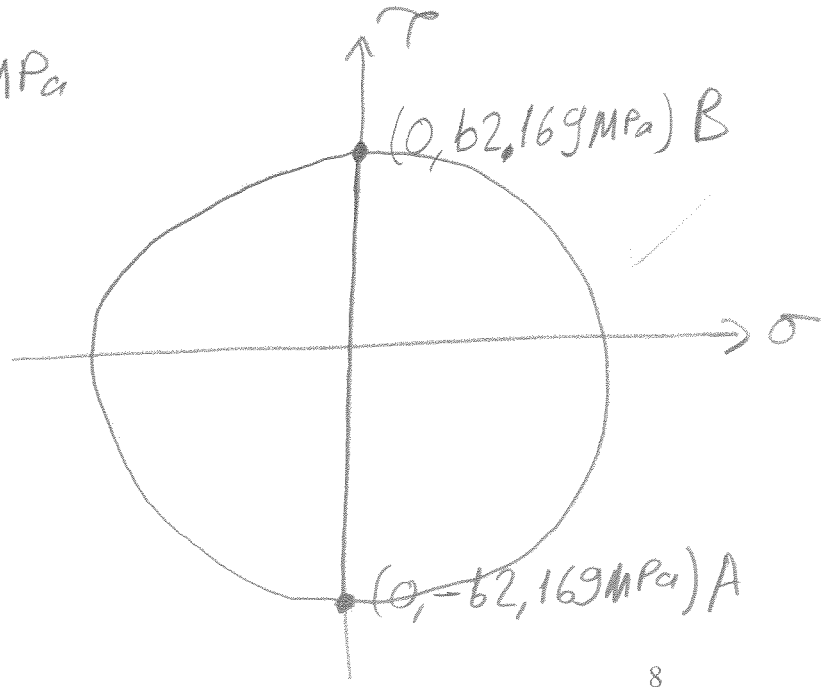
$$\boxed{\phi_2 = 0{,}79298 \times 10^{-2}\,rad}$$

$$\phi_{AB} = \frac{400000\,N.mm \times 1200}{102943{,}7081\,mm^4 \times 80000\,MPa} = \boxed{5{,}82843 \times 10^{-2}\,rad}$$

$$\boxed{\phi_A = \phi_{AB} + \phi_2 = 0{,}06621408\,rad}$$

$$\tau_{max} = \tau_{AB\,max} = 62{,}169\,MPa$$



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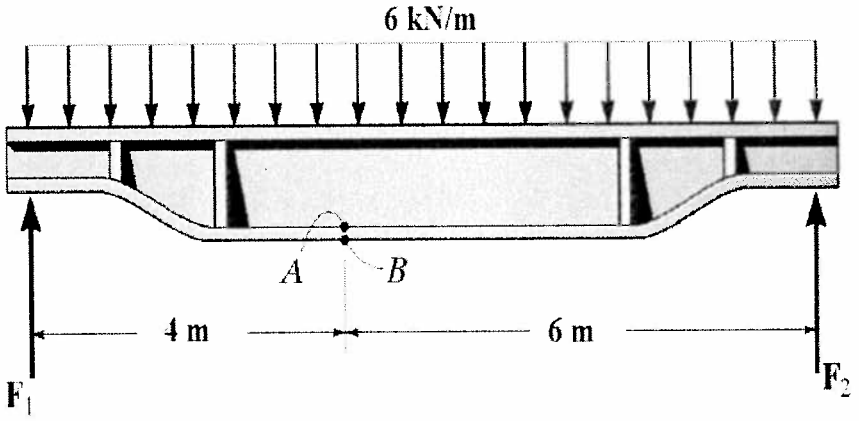
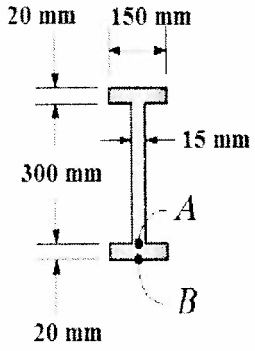
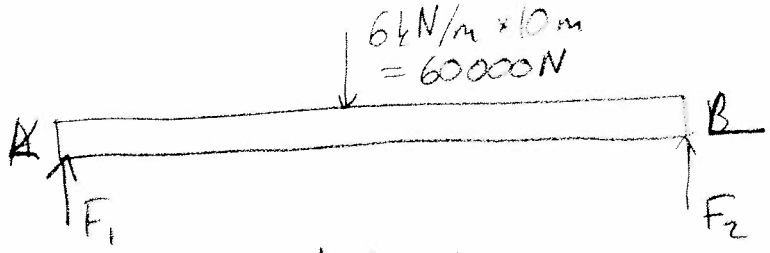
**Question 4: (30 points)**




The bolster or main supporting girder (chassis) of a truck body is subjected to the uniform distributed load. Draw the shear and moment diagrams for the bolster (chassis). Determine **the bending stress and the transverse shear stress** at points A and B. (Note: the thickness at point A is 15 mm.)



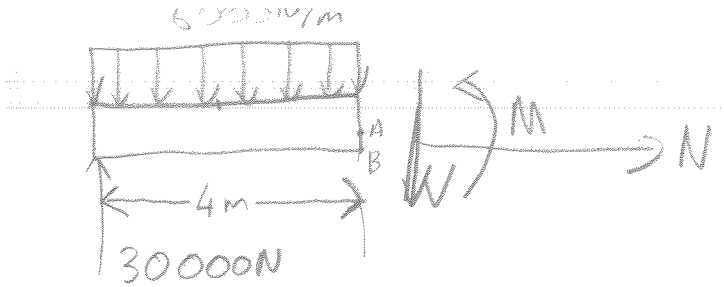

K'ya göre moment alırsak

$\sum M = 0 \quad 60000 \times 5m - F_2 \times 10m = 0$

$F_2 = 30000N$

$\sum F_y = 0 \quad 60000 - F_1 - 30000 = 0$

$F_1 = 30000N$

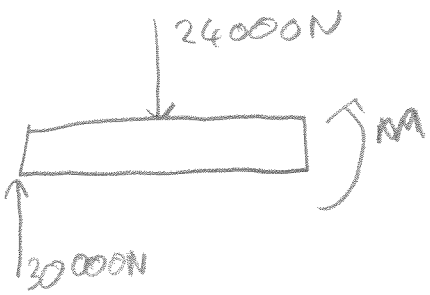



$$\sum F_x = 0 \Rightarrow \boxed{N = 0}$$

$$\sum F_y = 0$$

$$30000 - 6000 \times 4 - V = 0$$

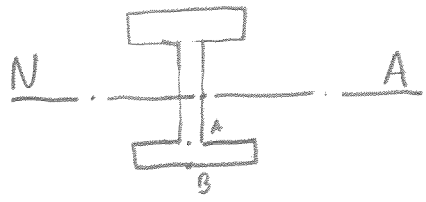
$$\boxed{V = 6000N}$$




$$\sum M = 0$$

$$M - 30000 \times 4 + 24000 \times 2 = 0$$

$$\boxed{M = +72000 N.m}$$




$$\sigma = \frac{M.c}{I} \qquad I = \frac{1}{12} bh^3$$

$$I = \frac{1}{12} \times 150 \times 340^3 - 2 \times \left( \frac{1}{12} \times 67{,}5 \times 300^3 \right)$$

$$\Rightarrow I = 491300000 - 303750000$$

$$\Rightarrow \boxed{I = 187550000 mm^4}$$

$$\sigma_A = \frac{72000000 \times 150}{187550000} = \boxed{57{,}585 MPa}$$

$$\sigma_B = \frac{72000000 \times 170}{187550000} = \boxed{65{,}263 MPa}$$

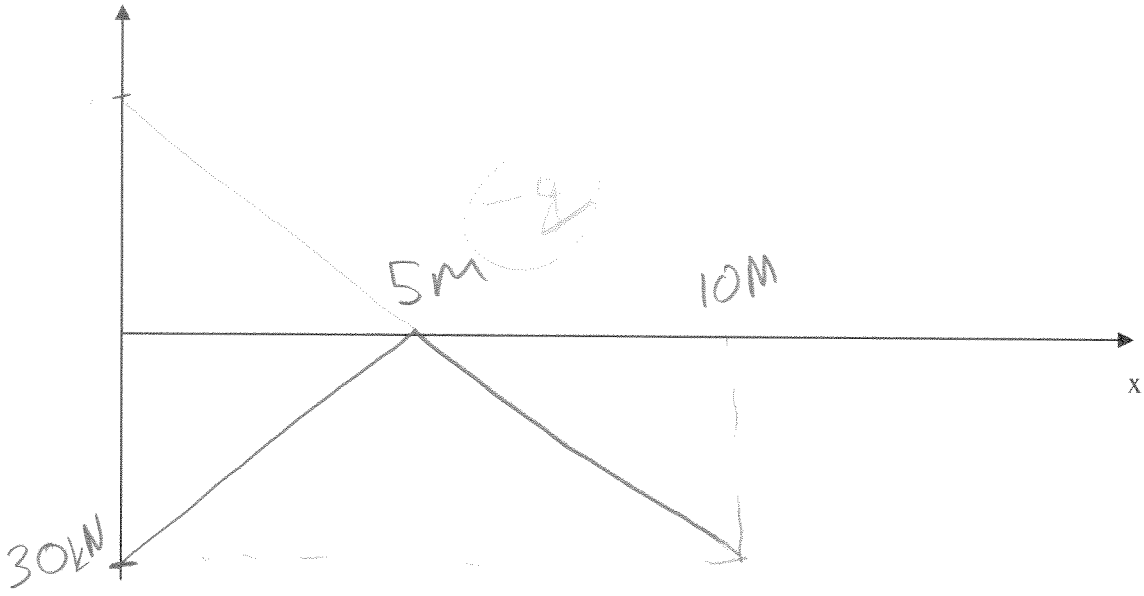
$$\tau = \frac{V.Q}{I.t} \qquad Q = A'.y' \Rightarrow Q_A = 150 \times 20 \times 160 = 480000$$

$Q_B =$ "0" (çünkü alan "0")

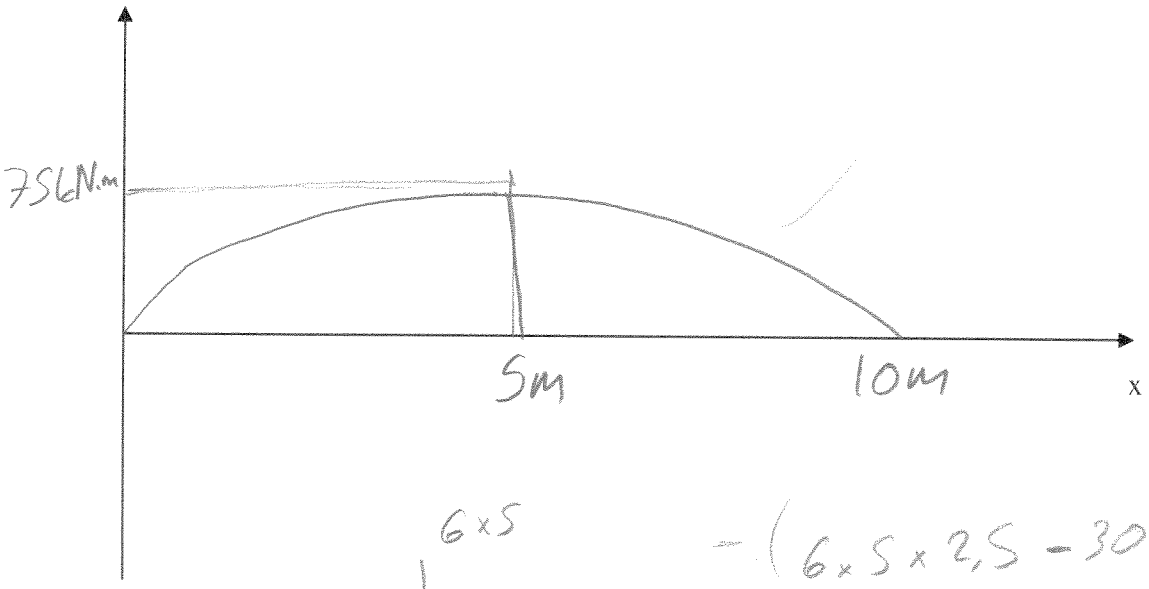
$$\tau_A = \frac{6000N \times 480000}{187550000 \times 15} = \boxed{1{,}0237 MPa}$$

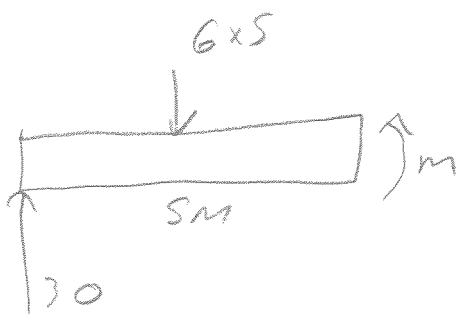
$$\tau_B = \frac{6000 \times 0}{187550000 \times 150} = 0$$

V ( Shear Force)




Moment




$-(6\times5\times2{,}5-30\times5)$

$30\times{,}25-30\times5$

$m = 75\,kNm$