TOBB EKONOMİ VE TEKNOLOJİ ÜNİVERSİTESİ

Makine Mühendisliği Bölümü

MAK 206 STRENGT OF MATERIALS (MUKAVEMET)

2012- 2013 Spring Semester (Bahar Dönemi)
Midterm (Ara Sınav)

Dr. Mehmet Ali Güler

24 Şubat 2013, Pazar

Ad, Soyad _____

Öğrenci No _____

Verilen Zaman: **2 saat** (16:00-18:00)

Soru No	Maksimum Puan	Puan
1	15	
2	25	
3	25	
4	25	
5	30	
Toplam	120	

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.

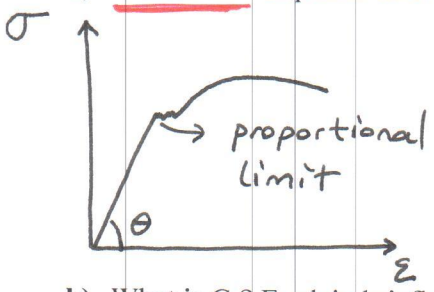
Öğrencinin İmzası:
Adı Soyadı :.....

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

Öğrenci No: .....

Soru 1: (10 puan)

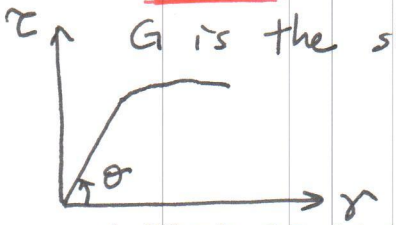
a) What is E ? Expalain briefly. Also show it on a figure.



E is the modulus of elasticity or Young's Modulus. Modulus of elasticity is a mechanical property that indicates the stiffness of a material. It is the slope of σ-ε diagram's linear part

$\sigma = E \cdot \varepsilon$, $\tan\theta = E$

b) What is G ? Explain briefly. Also show it on a figure.



G is the shear modulus of elasticity or modulus of rigidity. slope of τ-γ diagram's linear part

$\tan\theta = G$, $\tau = G \cdot \gamma$

c) What is ν ? Explain briefly. ν is the Poisson's ratio. It is the negative ratio of transverse to axial strain. when a sample is stretched to an extension in the direction of applied load, it corresponds to a contraction in the direction perpendicular to the applied load.

$$\nu = -\frac{\varepsilon_{lateral}}{\varepsilon_{longitudinal}}$$

d) Write the Hooke's Law and explain it briefly.

The linear relationship between stress and strain within the elastic region

$$\sigma = E \cdot \varepsilon$$

e) Write the relation between E and G ?

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

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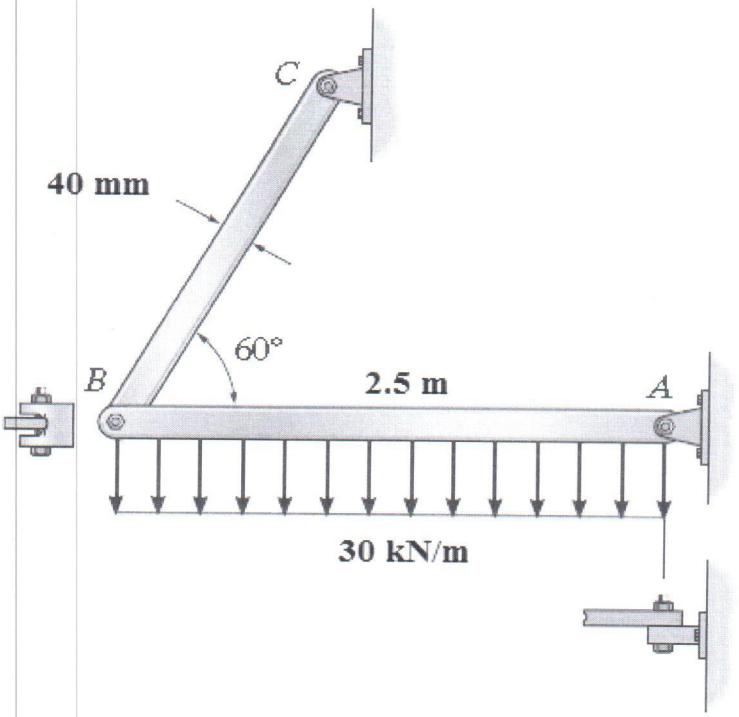
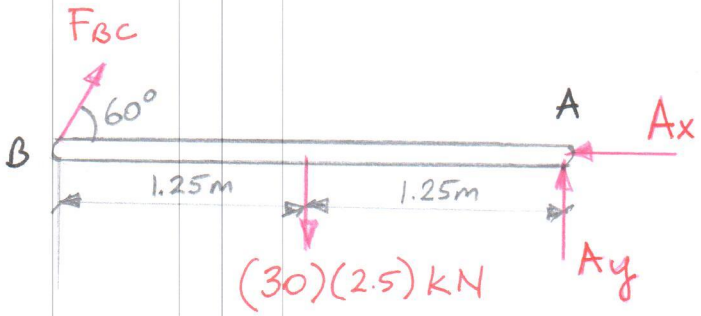
Soru 2: (25 puan)

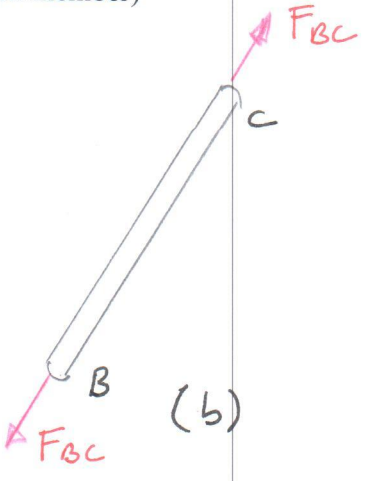


Determine the required thickness of member BC and the diameter of the pins at A and B if the allowable normal stress for member BC is σ_{allow}=200 MPa and the allowable shear stress for the pins is τ_{allow}=70 MPa. (Sketch the free body diagram for each member)

(FBD)



(a)



(b)

Referring to the FBD of member AB, Fig. (a)

$+\circlearrowright \Sigma M_A = 0$ $\quad F_{BC}.\sin(60)(2.5) - (30)(2.5)(1.25) = 0$

$F_{BC} = 43.301$ kN

$\pm\rightarrow \Sigma F_x = 0$: $F_{BC}\cdot\cos(60) - A_x = 0 \Rightarrow A_x = 21.650$ kN

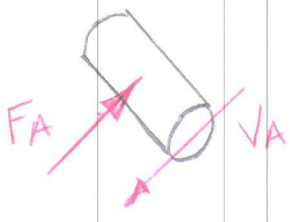
$+\uparrow \Sigma F_y = 0$: $F_{BC}\cdot\sin(60) - (30)(2.5) + A_y = 0 \Rightarrow A_y = 37.5$ kN

Thus the total force acting on the pin A

$$F_A = \sqrt{A_x^2 + A_y^2} = \sqrt{(21.650)^2 + (37.5)^2} = 43.3 \text{ kN}$$

Pin A is subjected to single shear

$$V_A = F_A = 43300 \text{ N}$$

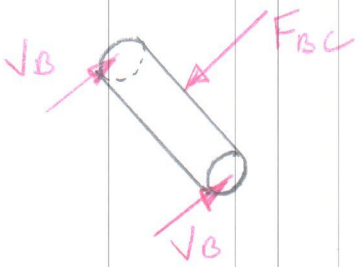


$$\tau_{allow} = \frac{V_A}{\frac{\pi d_A^2}{4}} = 70 \text{ MPa}$$

$$d_A = \sqrt{\frac{4 \cdot V_A}{\pi \cdot (70)}} = 28.064 \text{ mm}$$

Pin B is subjected to double shear

$$2V_B = F_{BC} \Rightarrow V_B = \frac{F_{BC}}{2} = 21650.5 \text{ N}$$



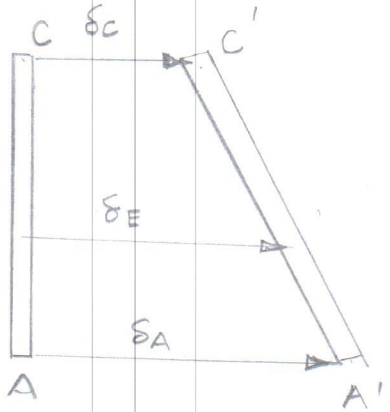
$$\tau_{allow} = \frac{V_B}{\frac{\pi d_B^2}{4}}$$

$$d_B = \sqrt{\frac{4 \cdot V_B}{\pi (70)}} = 19.844 \text{ mm}$$

For member BC

$$\tau_{allow} = \frac{F_{BC}}{40 \cdot t} = 200 \text{ MPa}$$

$$t = \frac{F_{BC}}{(40)(200)} = \frac{43301}{(40)(200)} = 5.412 \text{ mm}$$



$$\delta_C = \frac{F_{CD} \cdot L_{CD}}{A_{CD} \cdot E} = \frac{(10000)(2000)}{(600)(44700)} = 0.746 \text{ mm}$$

$$\delta_A = \frac{F_{AB} \cdot L_{AB}}{A_{AB} \cdot E} = \frac{(20000)(3000)}{(900)(44700)} = 1.492 \text{ mm}$$

From the similar triangles

$$\frac{\delta_E - \delta_C}{0.6} = \frac{\delta_A - \delta_C}{0.9}$$

$$\frac{\delta_E - 0.746}{0.6} = \frac{1.492 - 0.746}{0.9}$$

$$\delta_E = 1.243 \text{ mm}$$

$$\delta_{F/E} = \frac{F_{EF} \cdot L_{EF}}{A_{EF} \cdot E} = \frac{(30000)(500)}{(1200)(44700)} = 0.280 \text{ mm}$$

$$\delta_F = \delta_E + \delta_{F/E} = 1.243 + 0.280 = 1.523 \text{ mm}$$

Note: $\delta_E - \delta_C = 0.497$

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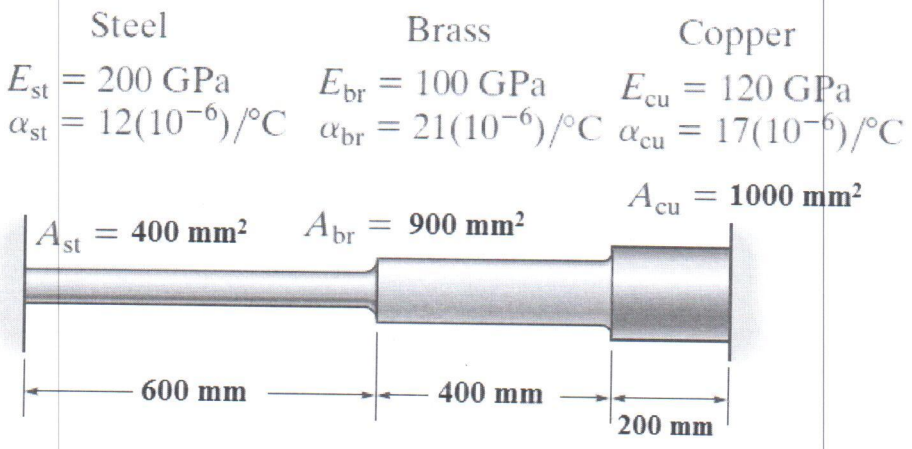
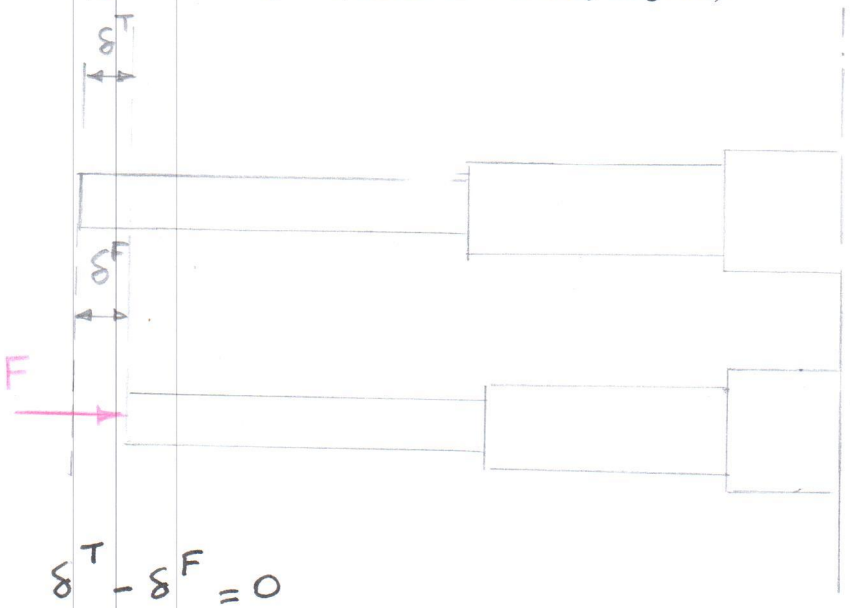
Soru 4: (25 puan)



Three bars each made of different materials are connected together and placed between two walls when the temperature is $T_1 = 12°C$. Determine the force exerted on the (rigid) supports when the temperature becomes $T_2 = 18°C$. The material properties and cross-sectional area of each bar are given in the figure. (Sketch the free body diagram.)



$$\delta^T - \delta^F = 0$$

$$\delta^T = \alpha_{st} \cdot L_{st} \cdot \Delta T + \alpha_{br} \cdot L_{br} \cdot \Delta T + \alpha_{cu} \cdot L_{cu} \cdot \Delta T$$

$$= (12)(10^{-6}) \cdot (600)(6) + (21)(10^{-6})(400) \cdot (6) + (17)(10^{-6})(200)(6)$$

$$= 0.0432 + 0.0504 + 0.0204$$

$$= 0.114 \text{ mm}$$

$$\delta^F = \delta_{st}^F + \delta_{br}^F + \delta_{cu}^F$$

$$= \frac{F.L_{st}}{A_{st}.E_{st}} + \frac{F.L_{br}}{A_{br}.E_{br}} + \frac{F.L_{cu}}{A_{cu}.E_{cu}}$$

$$= \frac{F.600}{(400)(200)(10^3)} + \frac{F.(400)}{(900).(100)(10^3)} + \frac{F.(200)}{(1000)(120)(10^3)}$$

$$= (7.5)(10^{-6})F + (4.444)(10^{-6})F + (1.667)(10^{-6})F$$

$$= (13.611)(10^{-6})F$$

$$\delta^T - \delta^F = 0$$

$$0.114 - (13.611)(10^{-6})F = 0$$

$$F = 8375.56\ N$$

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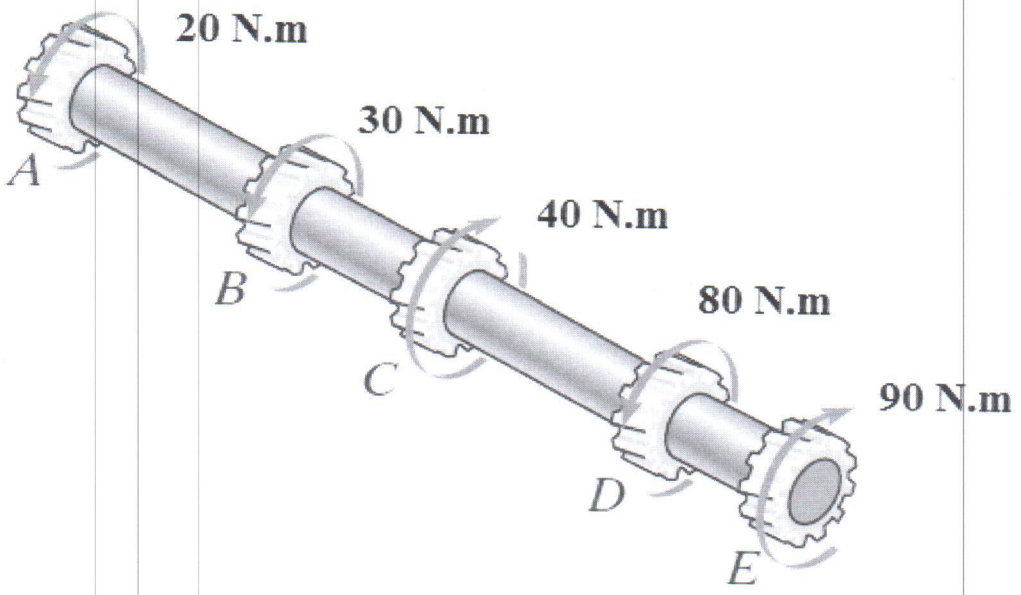
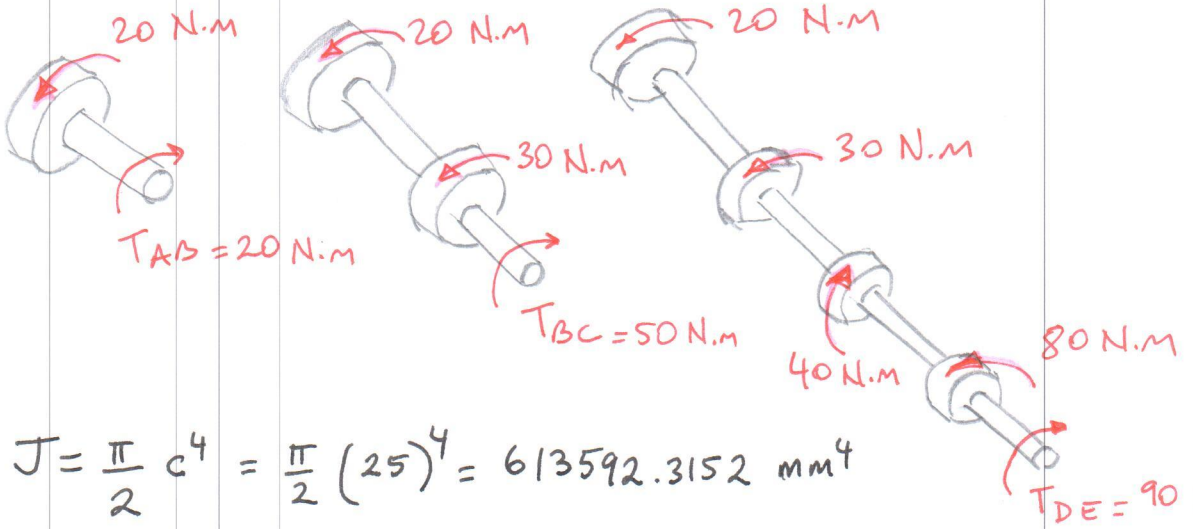
Soru 5: (30 puan)

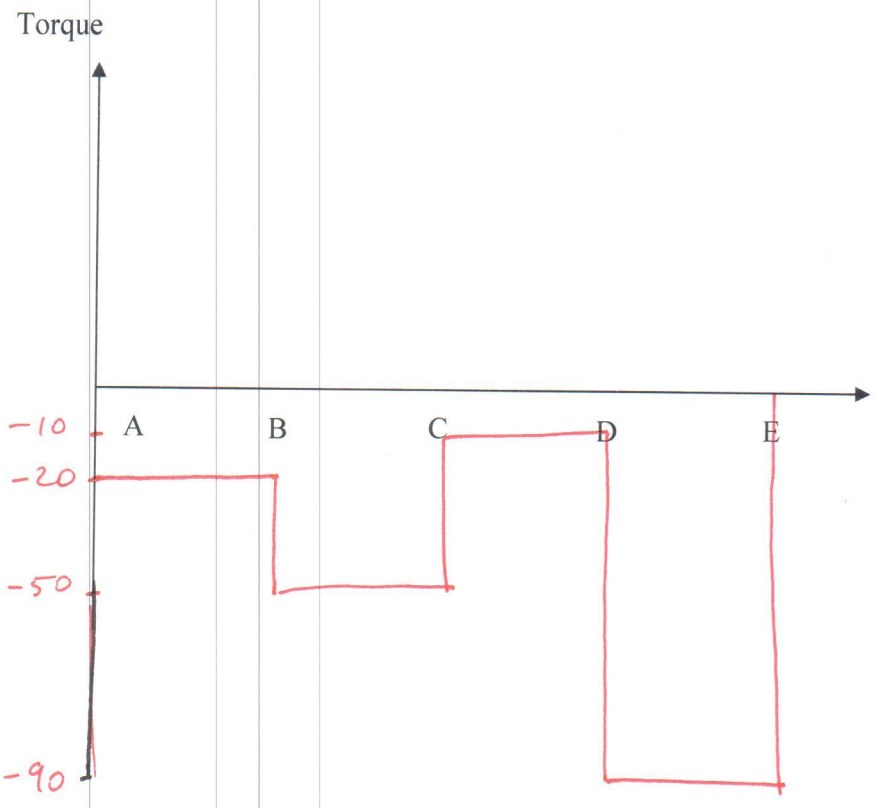


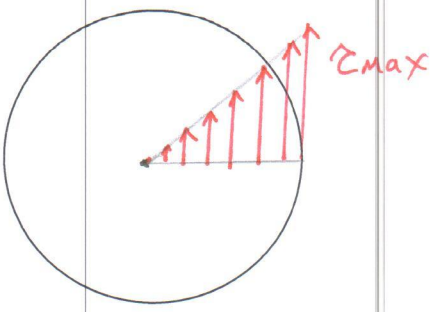
The solid shaft has a diameter of 50 mm and made of A-36 steel.. Determine the absolute maximum shear stress in the shaft and sketch the shear-stress distribution along a radial line of the shaft where the shear stress is maximum. Determine the torque values at each section between AB, BC, CD, and DE. Draw also the torque diagram for the shaft AE. Determine the angle of twist at B with respect to A, C with respect to B, D with respect to C, and E with respect to D. L_{AB}=200 mm , L_{BC}= 150 mm , L_{CD}= 250 mm , L_{DE}= 100 mm. (G_{St}=75 Gpa)



$$J = \frac{\pi}{2} c^4 = \frac{\pi}{2} (25)^4 = 613592.3152 \text{ mm}^4$$

$$\phi_{B/A} = \frac{T_{AB} \cdot L_{AB}}{J \cdot G} = \frac{(-20000) \cdot (200)}{(613592.3152) \cdot (75000)} = -86.92 \times 10^{-6} \text{ rad}$$





$$\phi_{C/B} = \frac{T_{BC} \cdot L_{BC}}{J\,G} = \frac{(-50000).(150)}{(613592.3152)(75000)} = -162.97 * 10^{-6}\ rad$$

$$\phi_{D/C} = \frac{T_{CD} \cdot L_{CD}}{J\,G} = \frac{(-10000).(250)}{(613592.3152)(75000)} = -54.32 * 10^{-6}\ rad$$

$$\phi_{E/D} = \frac{T_{DE} \cdot L_{DE}}{J\,G} = \frac{(-90000).(100)}{(613592.3152)(75000)} = -195.57 * 10^{-6}\ rad$$

$$\tau_{max} = \frac{T_{max} \cdot c}{J} = \frac{(90000.)(25)}{(613592.3152)} = 3.667\ MPa$$