TOBB EKONOMİ VE TEKNOLOJİ ÜNİVERSİTESİ

MAK 206 Strength of Materials – 2015 Spring

QUIZ 3

6 February 2015 Ad, Soyad: **SOLUTION**

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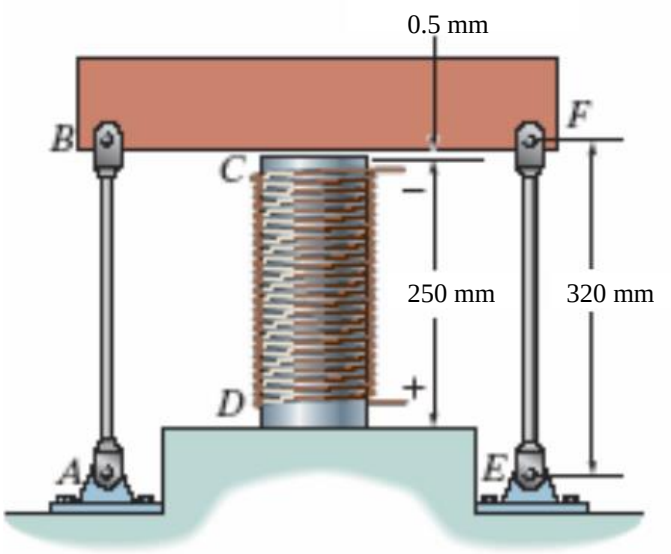
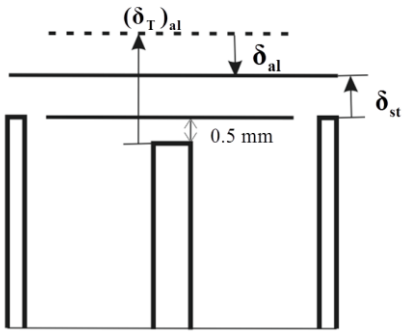
Problem: The center rod *CD* of the assembly is heated from T_1 =30°C to T_2 =180°C using electrical resistance heating. At the lower temperature T_1 the gap between *C* and the rigid bar is 0.5 mm. Determine the force in rods *AB* and *EF* caused by the increase in temperature. Rods *AB* and *EF* are made of steel, and each has a cross-sectional area of 125 mm^2. *CD* is made of aluminum and has a cross-sectional area of and 375 mm^2.

Given: E_{st}= 200 GPa, E_{al}= 70 GPa,
α_{st} = 12(10^{-6})/°C, α_{al}= 23(10^{-6})/°C



Solution: $\Delta T := T_2 - T_1$ $\Delta T = 150\,°C$



Equations of equilibrium:

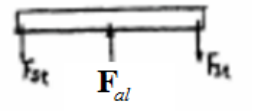
$\circlearrowleft^{+} \Sigma M_C = 0;$ $F_{AB}\cdot(b) - F_{EF}\cdot(b) = 0$

$F_{AB} = F_{EF}$

Let $F_{AB} = F_{st}$. Then, $F_{AB} = F_{EF} = F_{st}$

$+\uparrow \Sigma F_y = 0;$ $F_{AB} + F_{EF} - F_{al} = 0$

$F_{al} = 2F_{st}$ **[1]**



Compatibility:

$\delta_{st} = \delta_{al} - \Delta_{gap}$

$$\frac{F_{st}\cdot L_{st}}{E_{st}\cdot A_{st}} = \left[\alpha_{al}\cdot(\Delta T)\cdot L_{al} - \frac{F_{al}\cdot L_{al}}{E_{al}\cdot A_{al}}\right] - \Delta_{gap} \qquad \textbf{[2]}$$

Substituting **[1]** into **[2]**:

$$F_{st} := \frac{\alpha_{al}\cdot(\Delta T)\,L_{al} - \Delta_{gap}}{\frac{L_{st}}{A_{st}\cdot E_{st}} + \frac{2L_{al}}{A_{al}\cdot E_{al}}}$$

F_{st}=11.382 kN **Ans**

From **[1]**: $F_{al} := 2F_{st}$ F_{al}=22.765 kN **Ans**