Faculty of Engineering	**Philadelphia University** **Mechanics of materials (620213)**	Mechanical Eng. Dep.

Second Exam — **allowed time 50 minutes**

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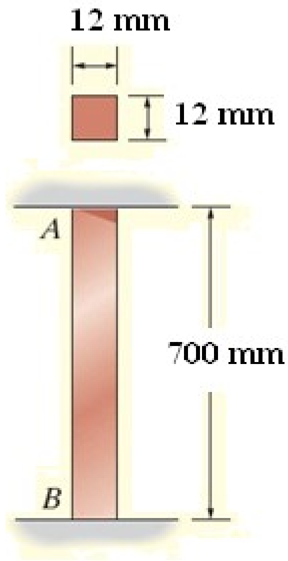
Student Name: **Student ID number:**

Problem #1: a steel bar (E = 200GPa and $\alpha = 12x10^{-6}$) as shown in the figure is constrained to just fit between two fixed supports when T_1 = 20 C^o. if the temperature is raised to T_2 = 80C^o, determine the average thermal stress developed in the bar **(6marks)**



Solution:

Apply static equilibrium to the F.B.D

$F_A = F_B = F$ ---- (1)

Due to the thermal expansion the member will extend deflection :

$$\delta_T = \alpha . \Delta T . L$$

From compatibility:

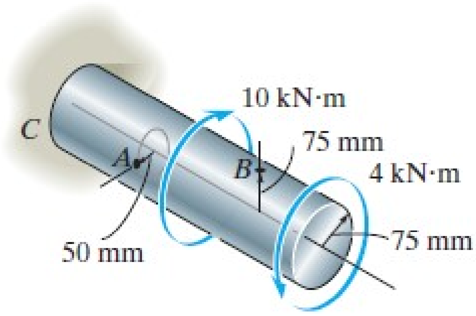
$$\delta_{A/B} = 0 = \delta_T - \delta_F$$

$$0 = \alpha \Delta T L - \frac{FL}{EA} \Rightarrow F = \alpha \Delta T E A = 12x10^{-6}(80-20)(12x10^{-3})^2(200x10^9) = 20.736kN$$

The stress developed due to the thermal expansion

$$\sigma = \frac{F}{A} = \frac{20.736x10^3}{(12x10^{-3})^2} = 144MPa$$

Problem #2: The solid shaft is fixed to the support at C and subjected to the torsional loadings shown. Determine the shear stress at points A and B **(7 marks)**



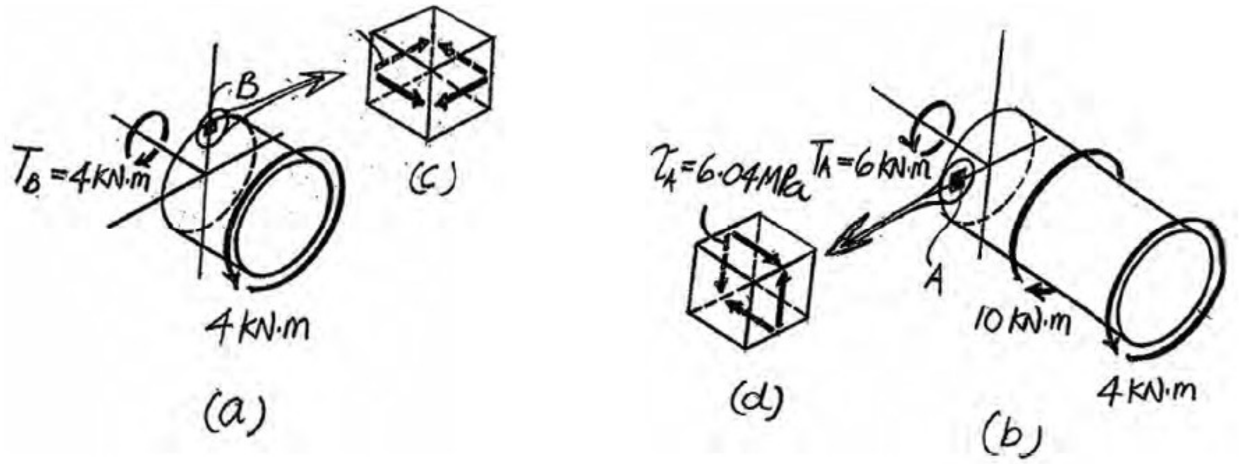
The internal torques developed at Cross-sections pass through shown in Fig. *a* and *b*, respectively.

The polar moment of inertia of the shaft is $J = \frac{\pi}{2}(0.075^4) = 4$ point B, $\rho_B = C = 0.075$ Thus,

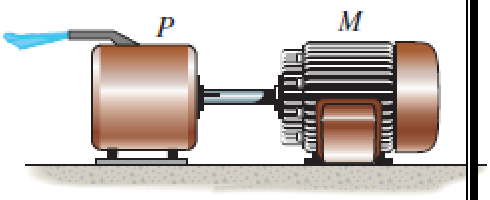
$$\tau_B = \frac{T_B c}{J} = \frac{4(10^3)(0.075)}{49.70(10^{-6})} = 6.036(10^6)\text{ Pa} = 6.04\text{ MP}$$

From point A, $\rho_A = 0.05$ m.

$$\tau_A = \frac{T_A \rho_A}{J} = \frac{6(10^3)(0.05)}{49.70\,(10^{-6})} = 6.036(10^6)\text{ Pa} = 6.04\text{ MP}$$



Problem #3: *The A-36 tubular steel shaft is 2 m long and has an outer diameter of 60 mm. It is required to transmit 60 kW of power from the motor M to the pump P. Determine the smallest angular velocity the shaft can have if the allowable shear stress is* τ_{allow}= *80 Mpa.* **(7 marks)**



The polar moment of inertia of the shaft is $J = \frac{\pi}{2}(0.03^4) = 0.405(10^{-6})\pi\ \text{m}^4$. Thus,

$$\tau_{\text{allow}} = \frac{Tc}{J}; \qquad 80(10^6) = \frac{T(0.03)}{0.405(10^{-6})\pi}$$

$$T = 3392.92\ \text{N}\cdot\text{m}$$

$$P = T\omega; \qquad 60(10^3) = 3392.92\ \omega$$

$$\omega = 17.68\ \text{rad/s} = 17.7\ \text{rad/s}$$ **Ans.**