

**Department of Mechanical & Aerospace Engineering
Carleton University**

**MAAE2202 Mechanics of Solids I
Mid-Term Assignment**

March 2012

Read the following instructions carefully:

1. Answer all of the questions in the space provided and staple the answer sheets together with this cover page for submission.
2. Your submission of the answers for marking is ***optional***. However, marks obtained in this assignment will be added to your ***passed*** Final Examination marks as a ***bonus***. The maximum total bonus marks from this assignment is **15**.
3. All questions carry equal marks.
4. You are strongly encouraged to complete this assignment by yourself. If it helps to promote learning from one another, you may work as a group of no more than 3 students. All students in the group must be identified (see Item 7 below) and each must still submit individual answer sheets, albeit with the same answers. All students in a group will receive the same marks.
5. Students are reminded of the academic integrity standards as stated in the University Calendar. Those found in violation of these standards will be penalised accordingly.
6. The deadline for the assignment is: ***Friday, 2nd March 2012 at 2:30 p.m.*** It is to be submitted into the drop-box located near the general office of the Department of Mechanical & Aerospace Engineering (between rooms ME3165 and ME3144).
7. Please mark an "X" in one of the boxes below, and write your name and student number in the appropriate column. Please initial beside your name.

Individual

Group

Name

Student #

Name

Student #

_____ 1. _____

2. _____

3. _____

Submitted by:

Question 1 (5 marks):

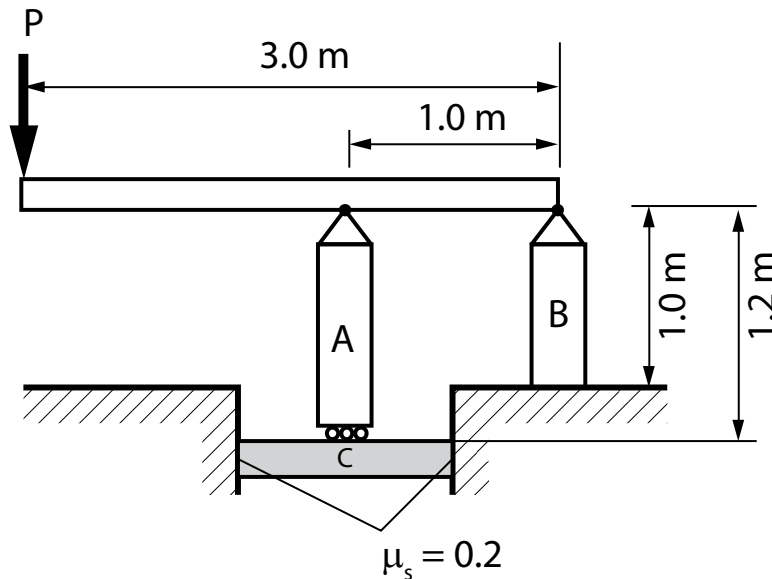
Part A:

An axial member of length 601.0 mm is initially unstressed. It is desired to cool the member to shrink it and place it between two rigid supports spaced 600.0 mm apart (shrink fitting). Properties for the axial member: $A = 1000 \text{ mm}^2$, $E = 70 \text{ GPa}$, and $\alpha = 23 \times 10^{-6} \text{ 1/K}$. Determine:

- The minimum temperature change in the axial member needed to install it between the rigid supports.
- The resultant residual force in the axial member once the installed member returns to room temperature.

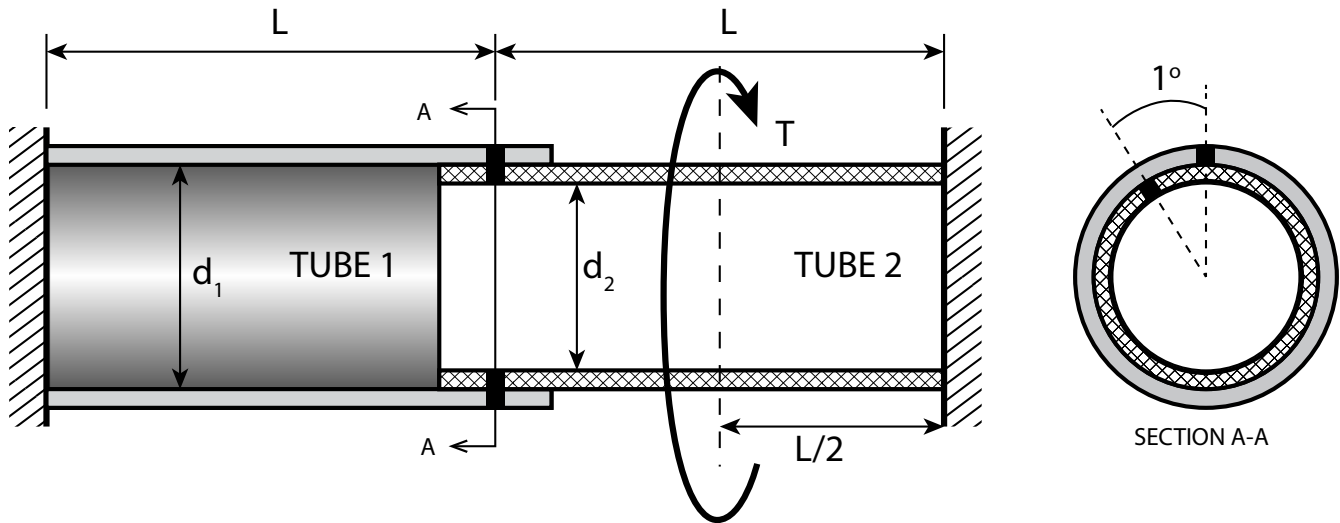
Part B:

Later on, it is desired to remove the shrink fit member from Part A from the rigid supports. It is determined that cooling the member to remove it is not feasible; thus it needs to be removed by mechanical force. The simple lever arrangement illustrated below is proposed. Column A exerts a force in the centre of the shrink fit member (member C). Determine the necessary force P required to remove the shrink fit member if the coefficient of static friction between it and the rigid support walls is $\mu_s = 0.2$.



Question 2 (6 marks):

A hollow circular tube 1 (inner diameter d_1 , wall thickness t) fits over the end of circular tube 2 (d_2 , t), as shown in the figure below. The far ends of both tubes are fixed. Initially, the centerline of a hole through Tube 2 makes an angle of 1° with the centerline of a hole through Tube 1.



Givens: $G_1 = 80\text{GPa}$, $G_2 = 30\text{GPa}$, $L = 1.5\text{m}$, $t = 5\text{mm}$, $d_1 = 100\text{mm}$, $d_2 = 90\text{mm}$

- Determine what torque T needs to be applied to Tube 2 at $L/2$ in order to align the holes in the tubes.
- Once the pin holes are aligned, a pin is inserted and the torque T is removed. Determine the reactive torques at the support end of each tube (make sure to show a FBD).

Hint: for thin walled tubes, you can use the approximation $J \cong \frac{\pi t d^3}{4}$

Question 3 (4 marks):

A bar AB of length L is held between two rigid supports and heated nonuniformly in such a manner that the temperature increase ΔT at distance x from end A is given by the expression: $\Delta T = (\Delta T_B x^3)/L^3$. Derive a formula for the stress in the bar due to the temperature change, assuming a modulus of elasticity, E , and coefficient of thermal expansion, α .

