Mechanics of Materials

Ferdinand P.Beer, E.Russel Johnston, Jr., John T.Dewolf

Other Reference:
J.Wat Oler "Lectures notes on Mechanics od Materials"
Ibrahim A.Assakkaf "Lectures notes on Mechanics od Materials"

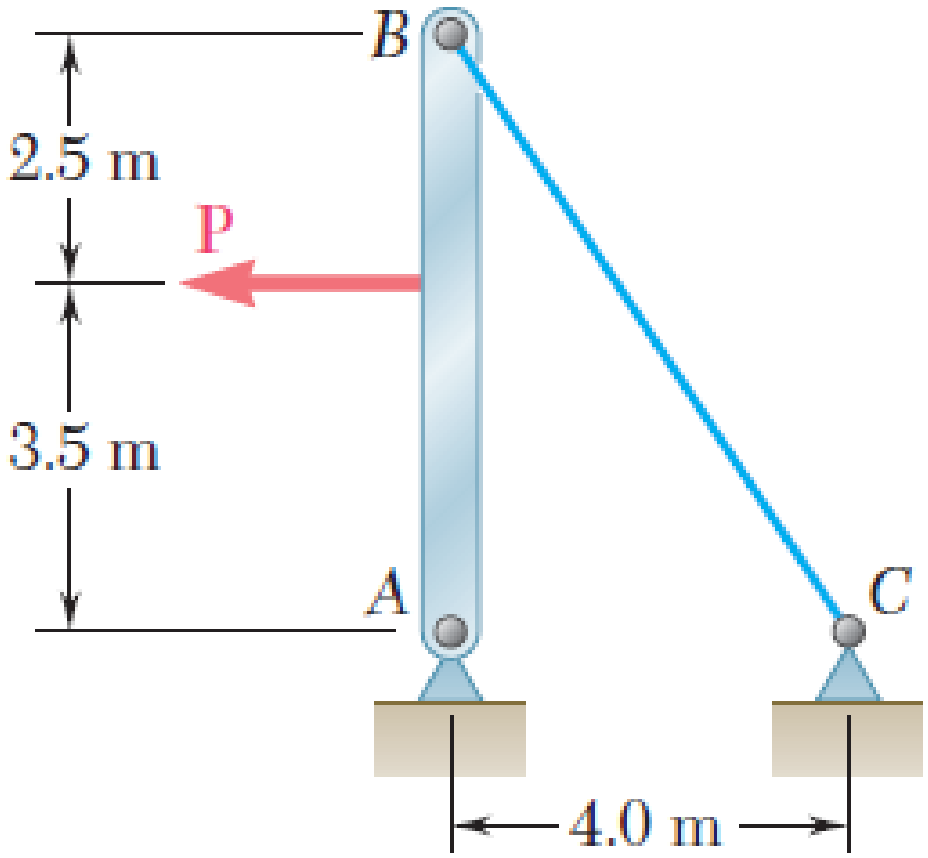
Homework-02

By: Kaveh Karami
Associate Prof. of Structural Engineering
https://prof.uok.ac.ir/Ka.Karami

Homework-02

❑ Problem 01

The 4-mm-diameter cable BC is made of a steel with E =200 GPa. Knowing that the maximum stress in the cable must not exceed 190 MPa and that the elongation of the cable must not exceed 6 mm, find the maximum load P that can be applied as shown.



Key Answer: 1.988 kN.

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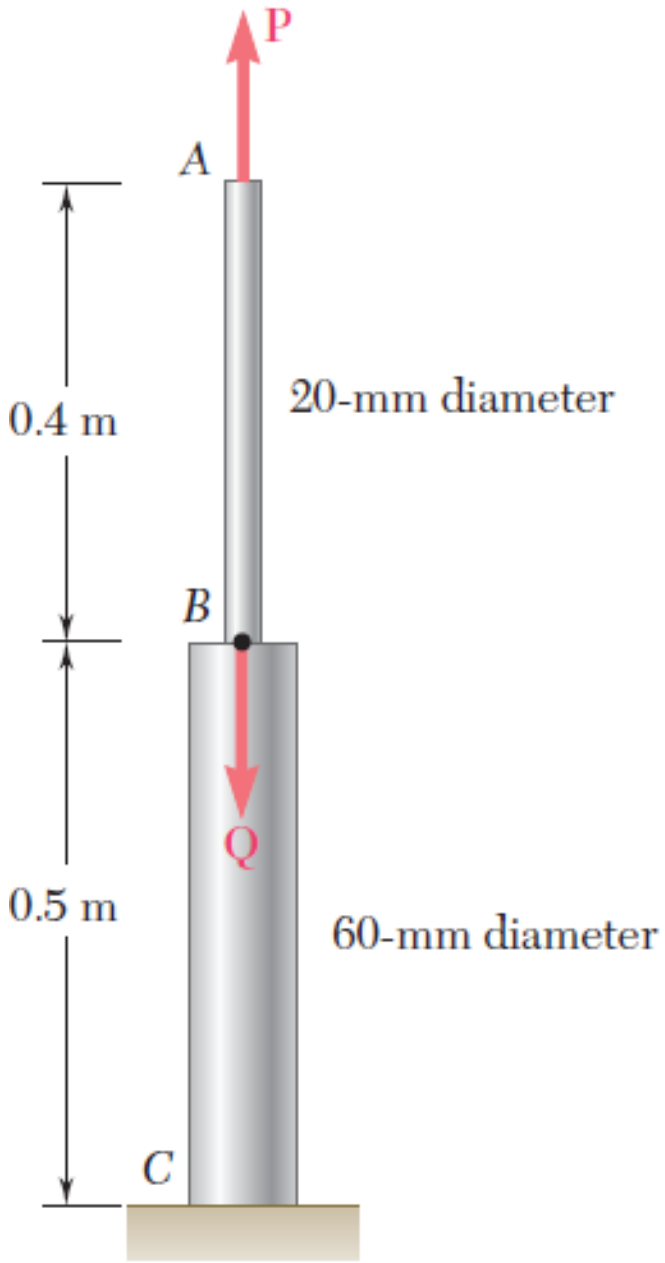
❑ Problem 02

Both portions of the rod ABC are made of an aluminum for which E =70 GPa. Knowing that the magnitude of P is 4 kN, determine (a) the value of Q so that the deflection at A is zero, (b) the corresponding deflection of B.



Key Answer: (a) 32.8 kN. (b) 0.0728 mm↓

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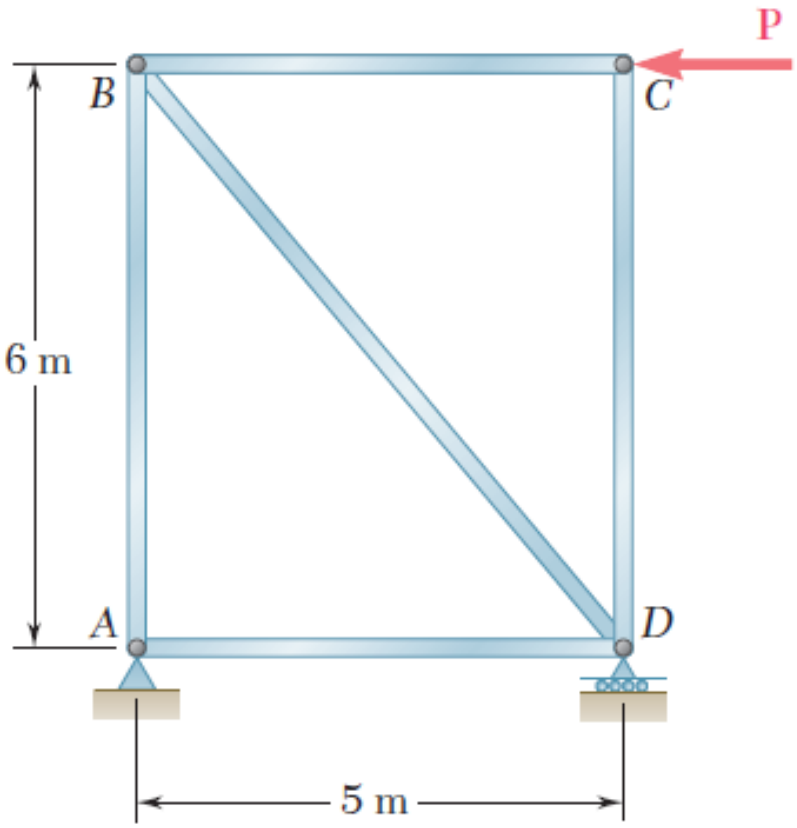
❑ Problem 03

The steel frame (E =200 GPa) shown has a diagonal brace BD with an area of 1920 mm^2 . Determine the largest allowable load P if the change in length of member BD is not to exceed 1.6 mm.



Key Answer: 50.4 kN.

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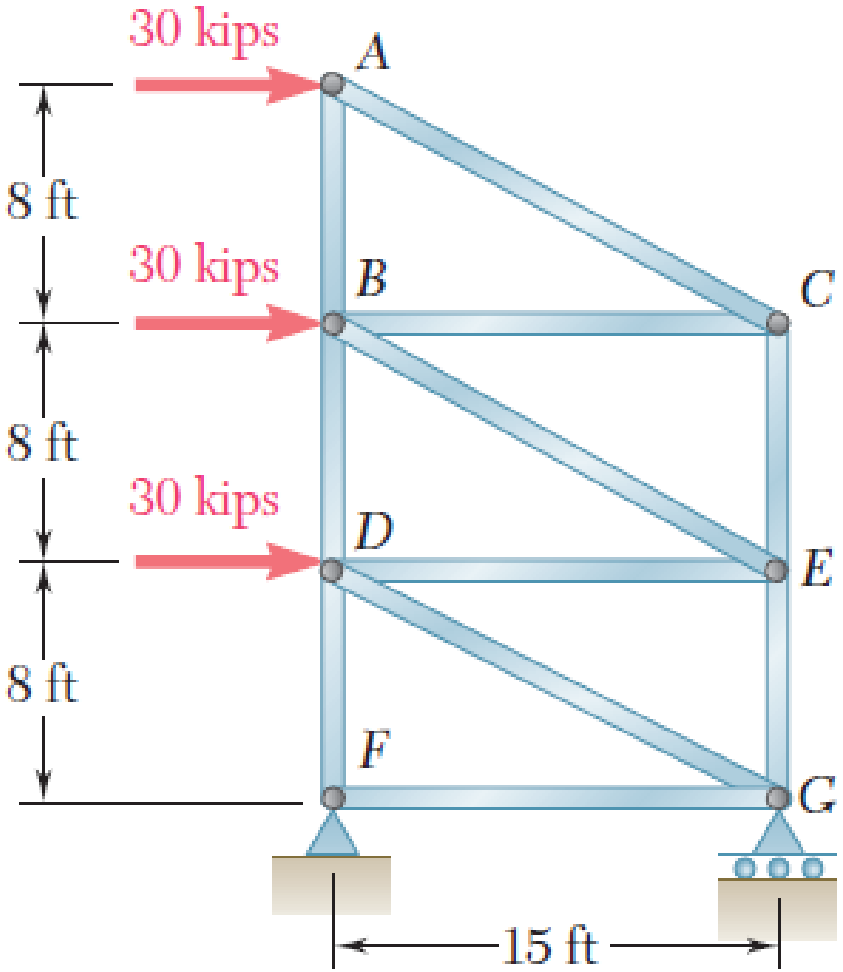
❑ Problem 04

For the steel truss (E = 29×10^6 psi) and loading shown, determine the deformations of members BD and DE, knowing that their cross-sectional areas are 2 in^2 and 3 in^2, respectively.



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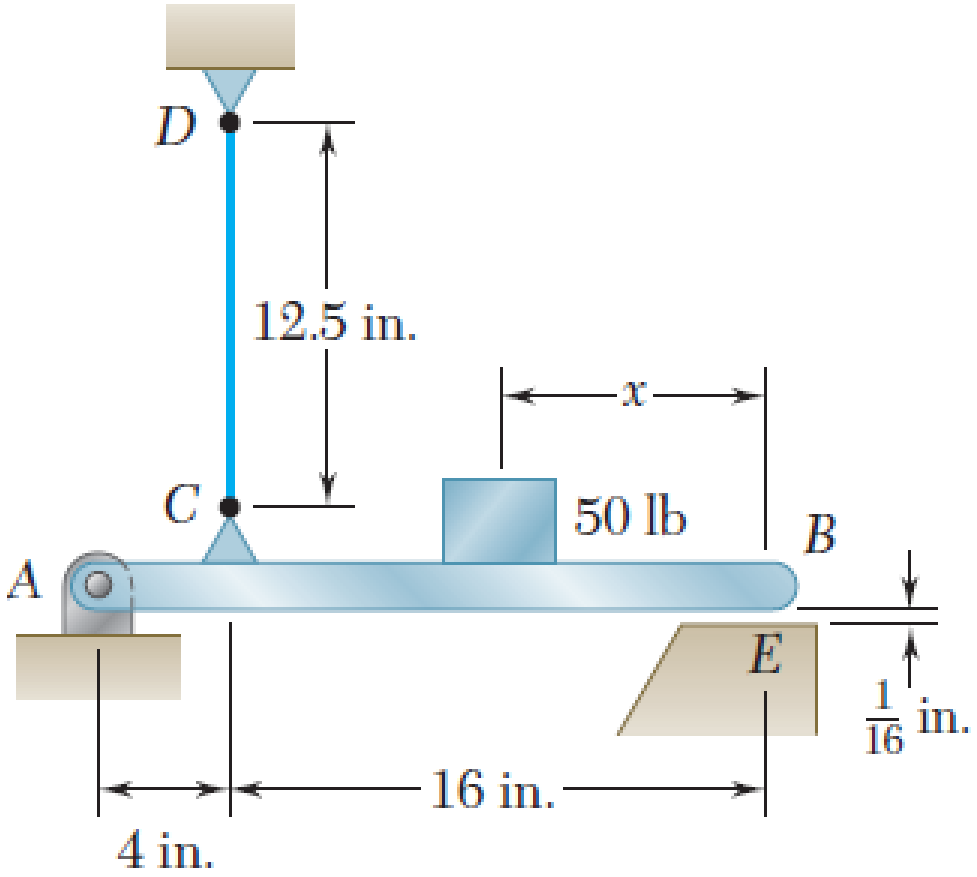
❑ Problem 05

The length of the $\frac{3}{32}$ in.-diameter steel wire CD has been adjusted so that with no load applied, a gap of $\frac{1}{16}$ in. exists between the end B of the rigid beam ACB and a contact point E. Knowing that E = 29×10^{6} psi, determine where a 50-lb block should be placed on the beam in order to cause contact between B and E.



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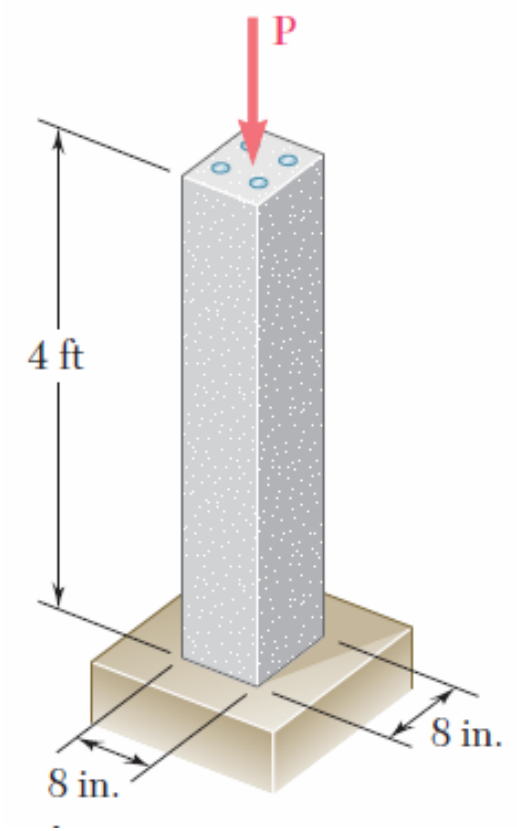
❑ Problem 06

A 4-ft concrete post is reinforced with four steel bars, each with a $\frac{3}{4}$ in. diameter. Knowing that $E_s = 29\times10^6$ psi and $E_c = 3.6\times10^6$ psi, determine the normal stresses in the steel and in the concrete when a 150-kip axial centric force P is applied to the post.



Key Answer: (steel) 215.80 ksi; (concrete) 21.962 ksi.

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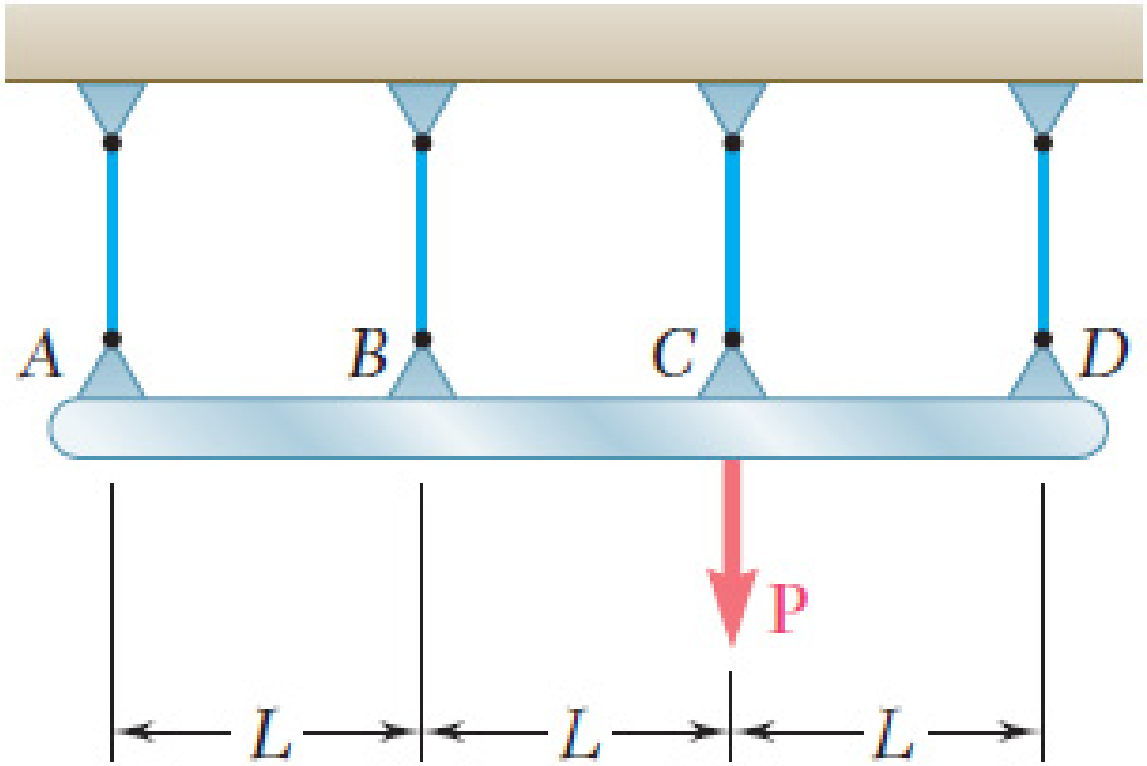
❑ Problem 07

The rigid bar ABCD is suspended from four identical wires. Determine the tension in each wire caused by the load P shown.



Key Answer: $T_A = P/10\,;\, T_B = P/5\,;\, T_C = 3P/10\,;\, T_D = 2P/5$

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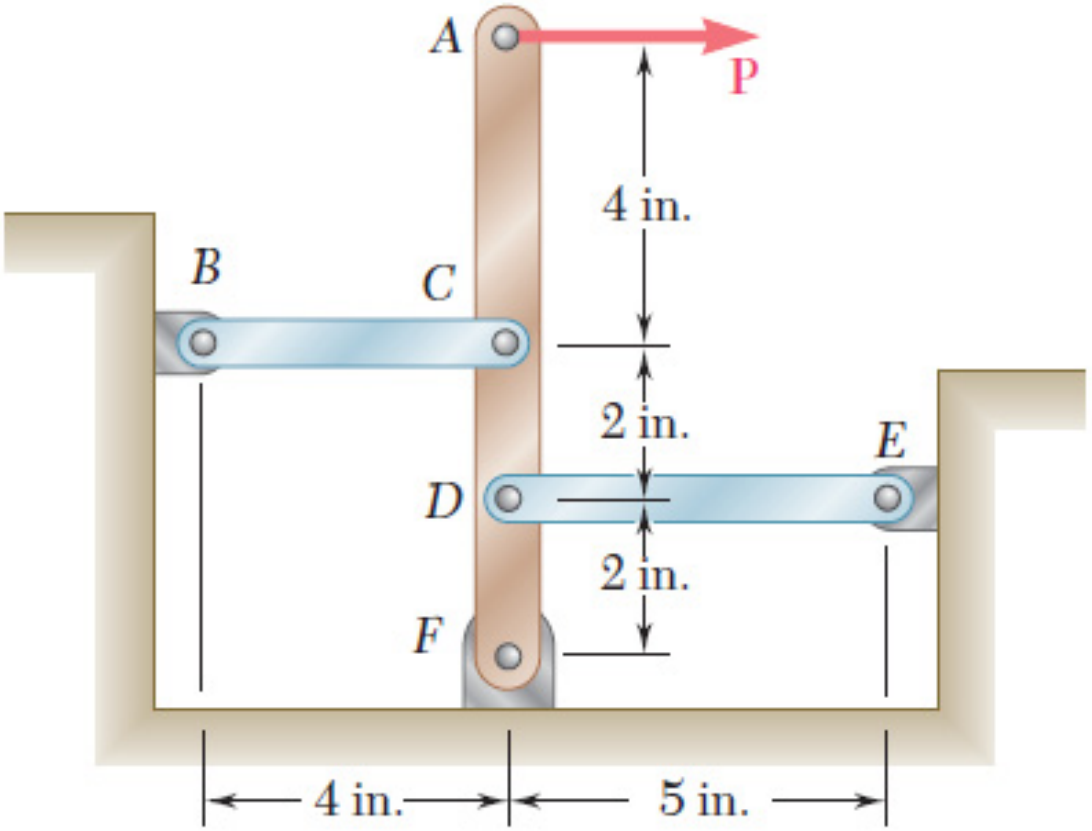
❑ Problem 08

Links BC and DE are both made of steel ($E = 29\times10^6$ psi) and are $\frac{1}{2}$ in. wide and $\frac{1}{4}$ in. thick. Determine (a) the force in each link when a 600-lb force P is applied to the rigid member AF shown, (b) the corresponding deflection of point A.



Key Answer:(a) (BC) 1000 lb; (DE) -400 lb.

(b) 2.21×10^{-3} *in.* $\rightarrow$

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❑ Problem 09

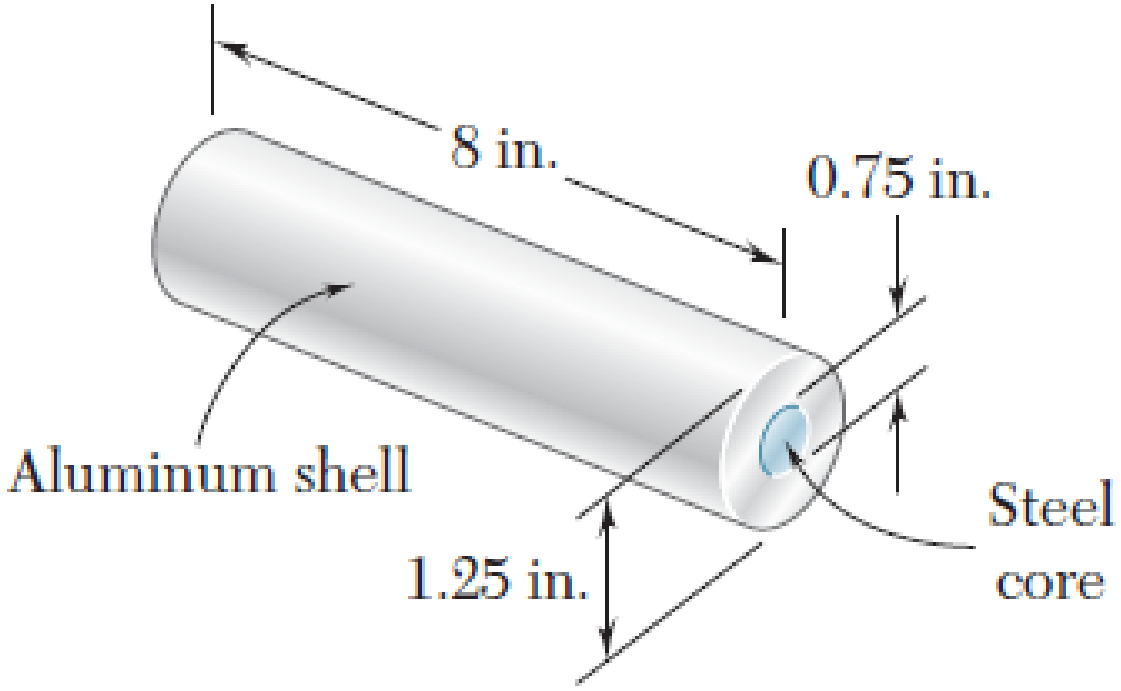
The assembly shown consists of an aluminum shell fully bonded to a steel core and is unstressed. Determine (a) the largest allowable change in temperature if the stress in the aluminum shell is not to exceed 6 ksi, (b) the corresponding change in length of the assembly.

$$E_s = 29\times10^6 \ psi$$

$$a_s = 6.5\times10^{-6} \ \frac{1}{F^o}$$

$$E_a = 10.6\times10^6 \ psi$$

$$a_a = 12.9\times10^{-6} \ \frac{1}{F^o}$$



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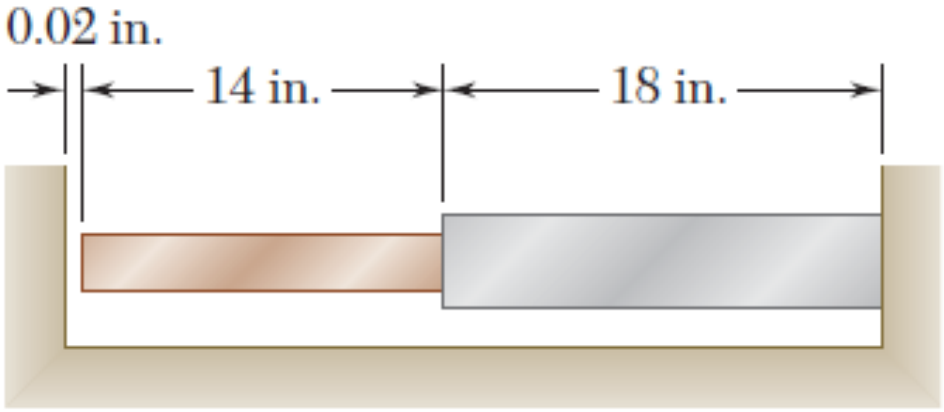
❑ Problem 10

Knowing that a 0.02-in. gap exists when the temperature is $75\,F^o$, determine (a) the temperature at which the normal stress in the aluminum bar will be equal to -11 ksi, (b) the corresponding exact length of the aluminum bar.



Bronze	Aluminum
$A = 2.4\ \text{in}^2$	$A = 2.8\ \text{in}^2$
$E = 15 \times 10^6\ \text{psi}$	$E = 10.6 \times 10^6\ \text{psi}$
$\alpha = 12 \times 10^{-6}/°\text{F}$	$\alpha = 12.9 \times 10^{-6}/°\text{F}$

Key Answer:(a) $201.6\,C^o$. (b) 18.0107 in.

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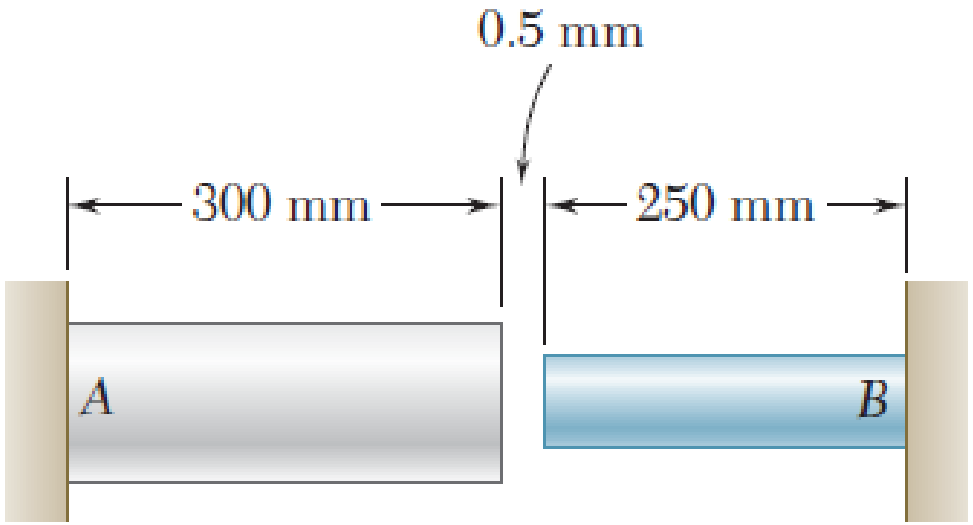
❑ Problem 11

At room temperature ($20\,C^o$) a 0.5-mm gap exists between the ends of the rods shown. At a later time when the temperature has reached $140\,C^o$, determine (a) the normal stress in the aluminum rod, (b) the change in length of the aluminum rod.



Aluminum	Stainless steel
$A = 2000\ \text{mm}^2$	$A = 800\ \text{mm}^2$
$E = 75\ \text{GPa}$	$E = 190\ \text{GPa}$
$\alpha = 23 \times 16^{-6}/°\text{C}$	$\alpha = 17.3 \times 10^{-6}/°\text{C}$

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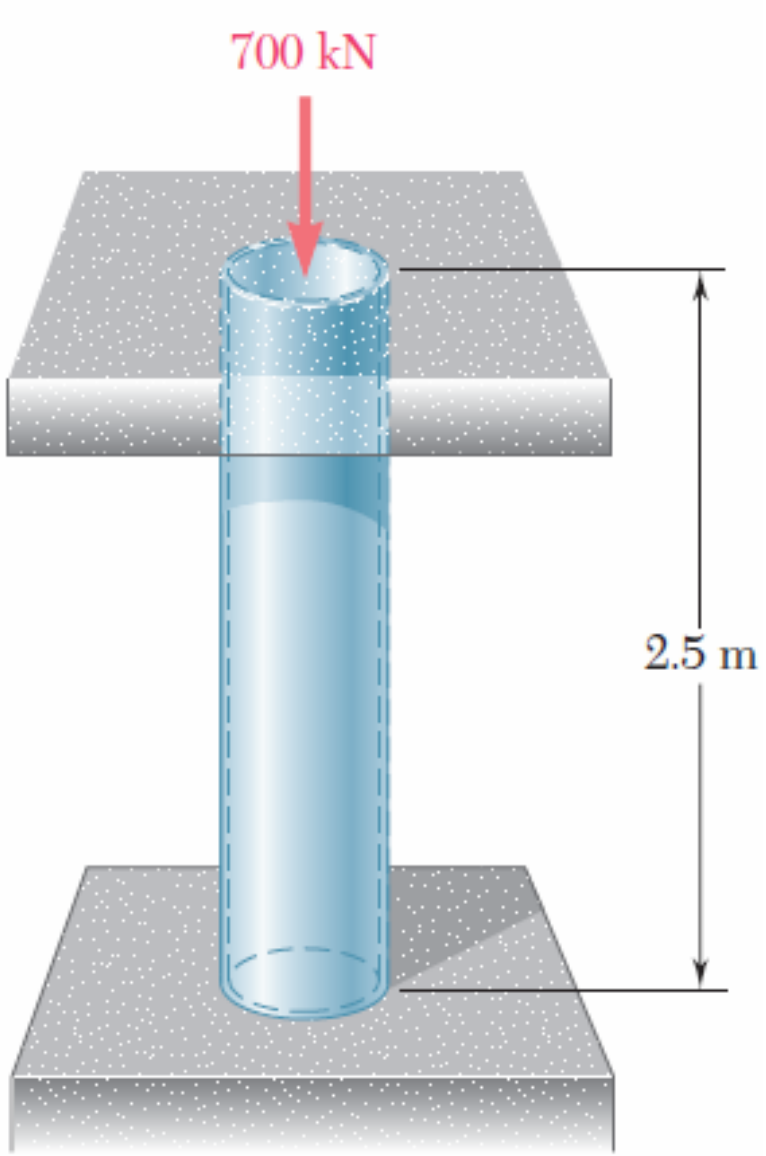
❑ Problem 12

A 2.5-m length of a steel pipe of 300-mm outer diameter and 15-mm wall thickness is used as a column to carry a 700-kN centric axial load. Knowing that E =200 GPa and $\upsilon = 0.30$, determine (a) the change in length of the pipe, (b) the change in its outer diameter, (c) the change in its wall thickness.



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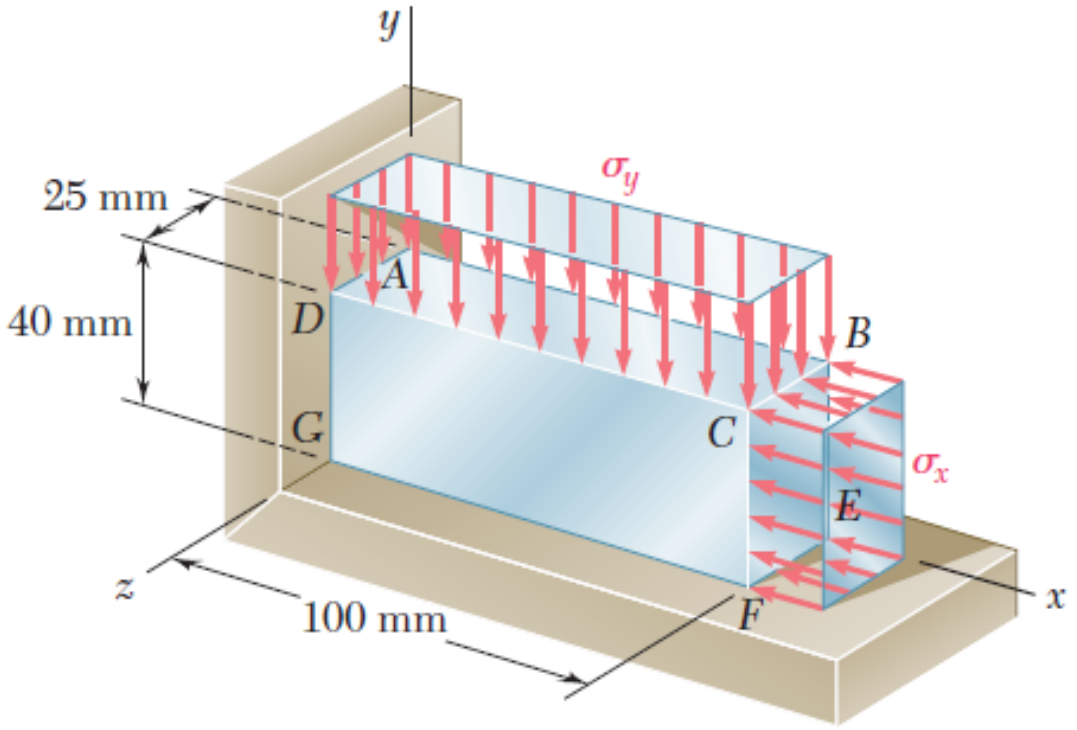
❑ Problem 13

The block shown is made of a magnesium alloy for which E =45 GPa and $\upsilon = 0.35$. Knowing that σ_x =-180 MPa, determine (a) the magnitude of σ_y for which the change in the height of the block will be zero, (b) the corresponding change in the area of the face ABCD, (c) the corresponding change in the volume of the block.



Key Answer: $(a) -63.0 < Mpa.$ $(b) -13.5\ mm^2$ $(c) -540\ mm^3$

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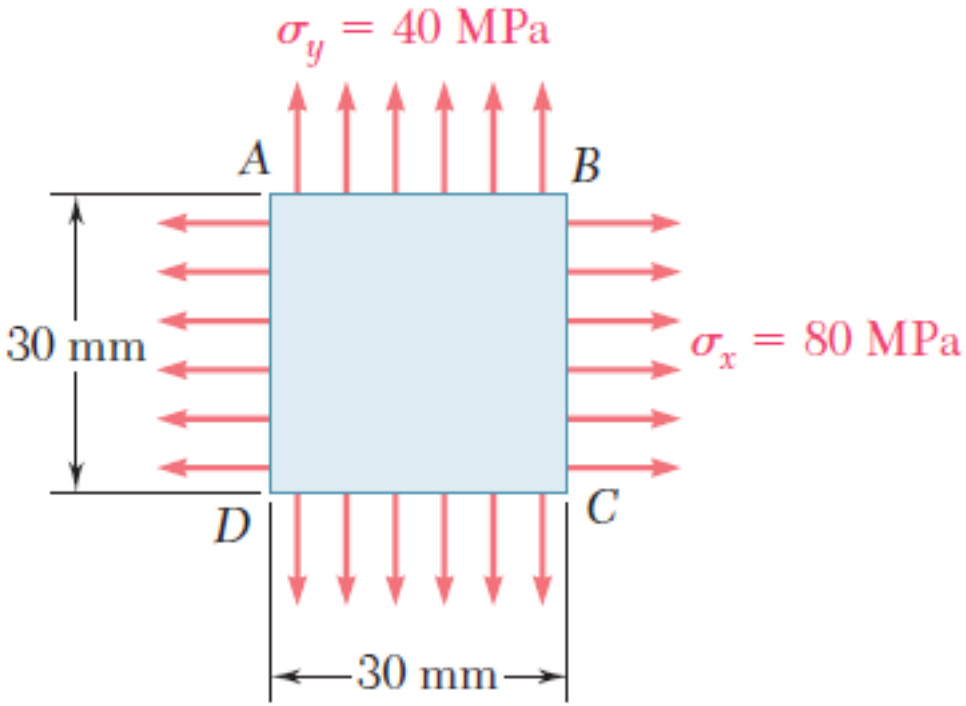
❑ Problem 14

A 30-mm square was scribed on the side of a large steel pressure vessel. After pressurization the biaxial stress condition at the square is as shown. For E =200 GPa and $\upsilon = 0.30$, determine the change in length of (a) side AB, (b) side BC, (c) diagonal AC.



Key Answer: $(a)\,10.20\mu m.$ $(b)\,2.40\mu m.$ $(c)\,8.910\mu m.$

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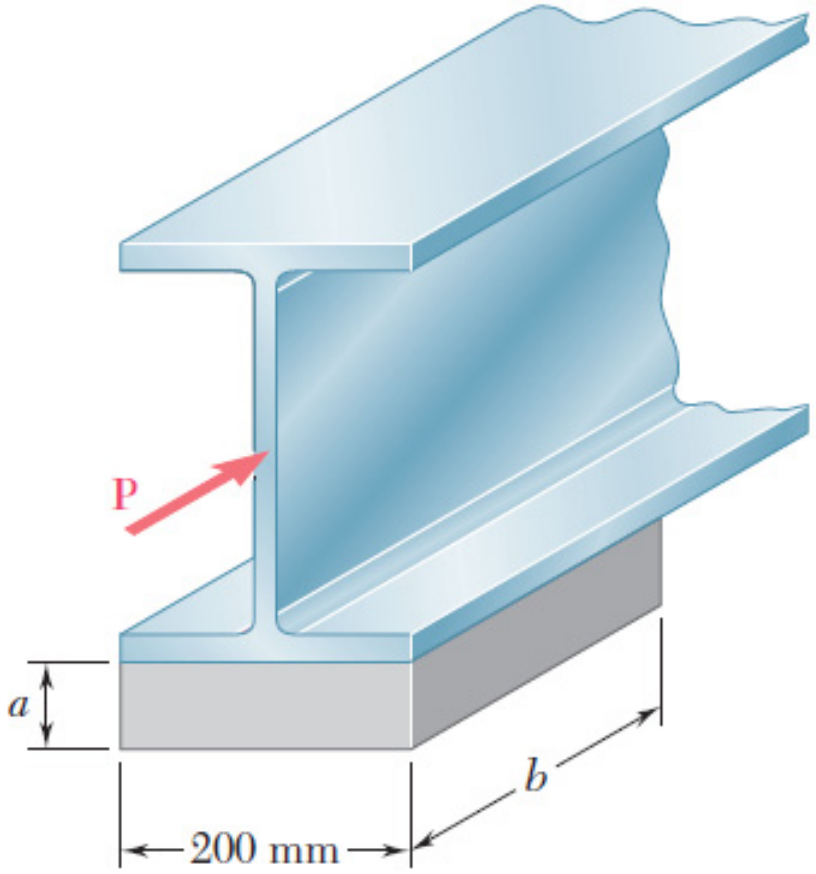
❑ Problem 15

An elastomeric bearing (G =0.9 MPa) is used to support a bridge girder as shown to provide flexibility during earthquakes. The beam must not displace more than 10 mm when a 22-kN lateral load is applied as shown. Knowing that the maximum allowable shearing stress is 420 kPa, determine (a) the smallest allowable dimension b, (b) the smallest required thickness a.



Key Answer: (a) 262 mm. (b) 21.4 mm.

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❑ Problem 16

Knowing that P =10 kips, determine the maximum stress when (a) r =0.50 in., (b) r =0.625 in.