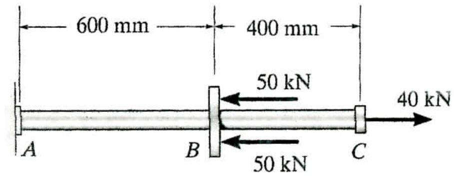
NAME:________________________________ SID #____________________

Question 1:

The 20-mm diameter steel rod (E = 200-GPa) is subjected to the axial forces shown. Determine:

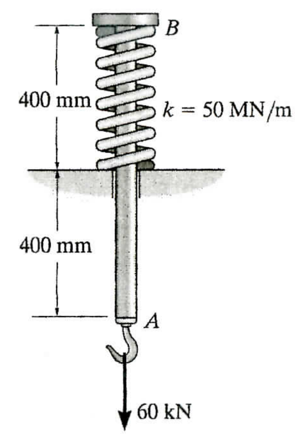
a-The displacement of end C.

b-The displacement of point B.



Question 2:

The 20-mm diameter steel rod (E = 200-GPa) is attached to a spring with stiffness k = 50 MN/m.as shown. Find displacement of end A due to 60-kN load.

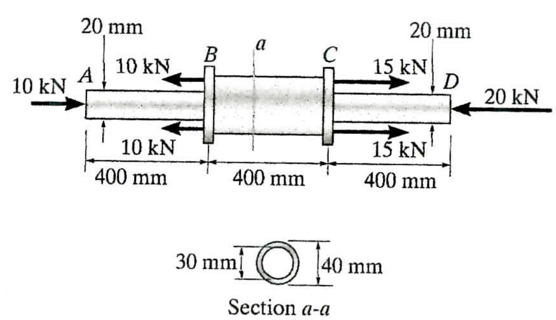


Question 3:

Segment AB and CD of the assembly are solid circular rod with 20-mm diameter, and segment BC is tube with cross section shown. Assembly is made of 6061-T6 aluminum E= 68.9-GPa. After axial loads are applied determine:

a-The displacement of end D with respect to A.

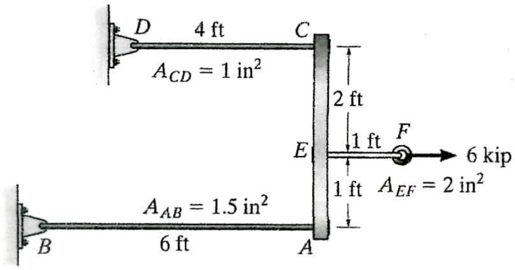
b-The displacement of point C with respect to A.



NAME:_____________________________ SID #___________________

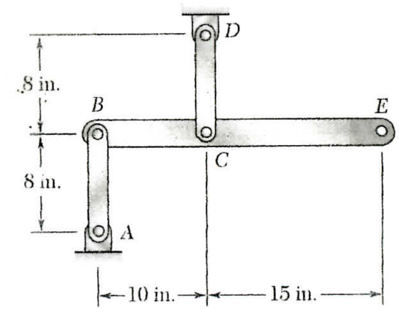
Question 4:

The assembly consists of three titanium Ti-6A1-4v (E = 17,400-ksi) rods and a rigid bar AC. If a force of 6-kips applied to the ring F, determine the displacement of point F.



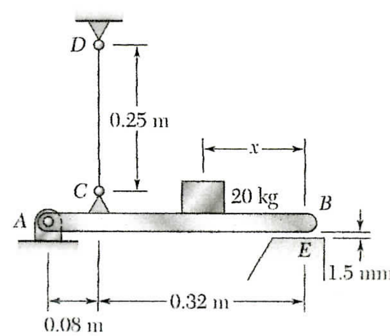
Question 5:

In the assembly shown links AB and CD are made of steel (E = 29,000-ksi) and have a uniform rectangular cross section of 2 ¼ by1-in. If a vertical downward load of 10-kips is applied at E, determine the vertical movement of point E.



Question 6:

The length of the 2-mm diameter steel wire CD (E = 200-GPa) has been adjusted so that with no load applied a gap of 1.5-mm exists between the end B of the rigid bar ACB and a contact point E. Determine where a 20-kg block should be placed in order to cause contact between B and E.



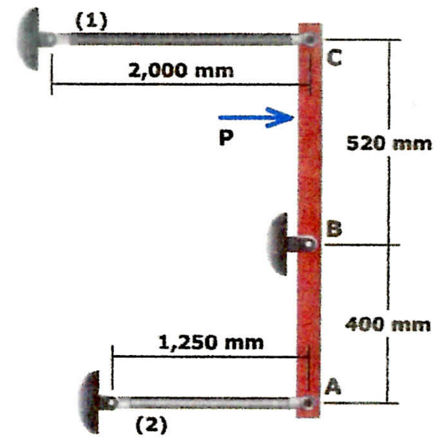
Sample Quizzes

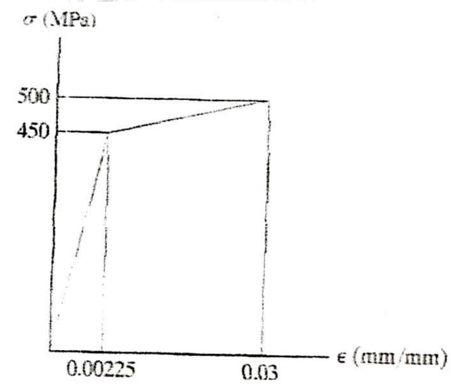
ME 218 SEC 01 **Quiz # 2** **Page 2-2**
Date: 1-22-'15

NAME:________________________________ **SID #**________________________

Question 1: (20 Points)
The rigid bar ABC is pinned at B and connected to two steel bars at A and C.
Bar (1) has cross sectional area of A= 300-mm^2 and bar (2) has A = 200-mm^2. After load P is applied the normal strain in bar (1) is measured to be $\varepsilon = +910 \times 10^{-6}$ mm/mm.
Nothing that bar (1) is in Tension and bar (2) is in Compression, determine:
a- The normal stress and the normal force in bar(1).
b- The normal strain, normal stress and the normal force in bar(2).
c-Use diagram shown to find permanent deformation in bar (2) if stress reaches to 475-MPa.

$$\sigma = \frac{P}{A_0} \qquad \epsilon = \frac{\delta}{L_0} \qquad \sigma = E\epsilon$$

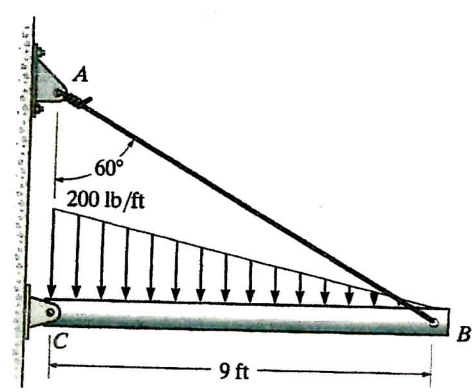


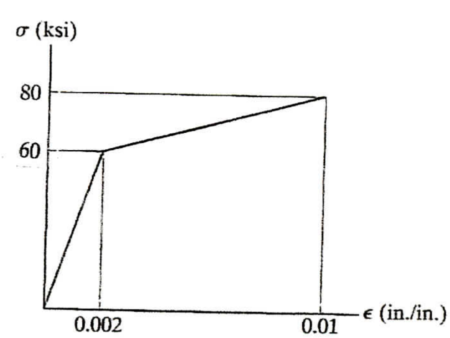


ME 218 SEC 03 **Quiz #3** **Page 1**
Date: 10-17-'13

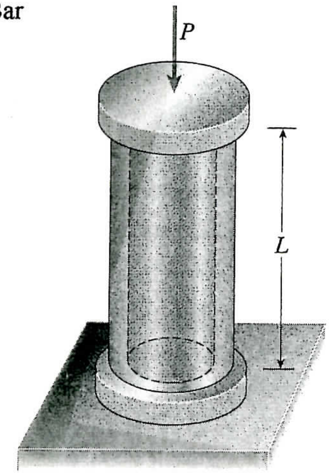
NAME:________________________________ **SID #**________________________

Question 1 : (20 Points)
The rigid bar CB is supported by a pin at C and a steel wire AB with diameter of 0.16-in and the stress-strain diagram shown. Determine:
a- The normal stress and strain in the wire.
b- The total change in the length and diameter of the wire given $\upsilon = 0.33$.
c- Is there a permanent deformation in the wire if load is removed? Explain.
d- What would be the permanent stretch in the wire if stress reaches to 70-ksi?

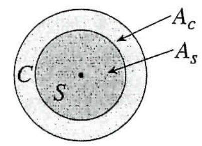




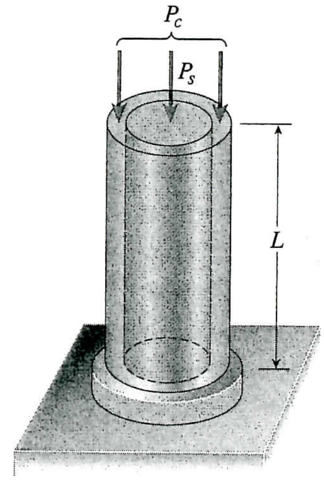
Question 1: Composite Bar



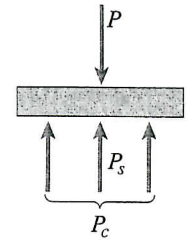
(a)



(b)

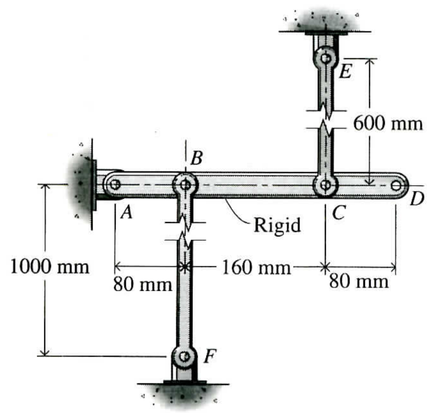


(c)



(d)

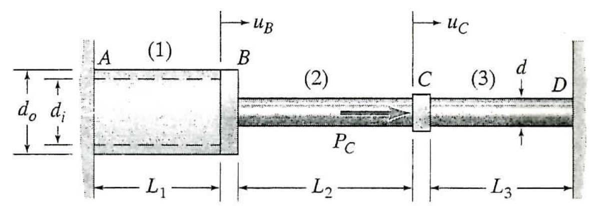
Question 2: Indeterminate Structure



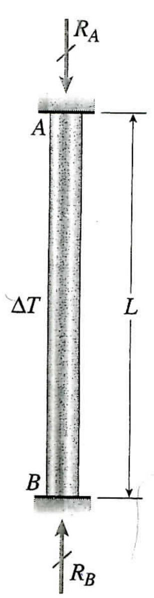
$d_o = 2$ in., $d_i = 1.5$ in., $d = 0.75$ in.

$L_1 = L_2 = 30$ in., $L_3 = 50$ in.

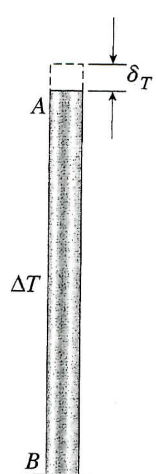
$P_C = 12$ kips, $E_1 = 30 \times 10^3$ ksi, $E_2 = E_3 = 10 \times 10^3$ ksi



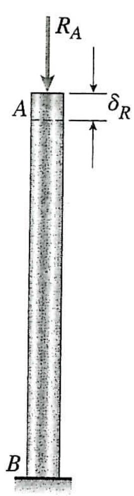
Question 3: Bar with uniform temperature increase ΔT



(a)

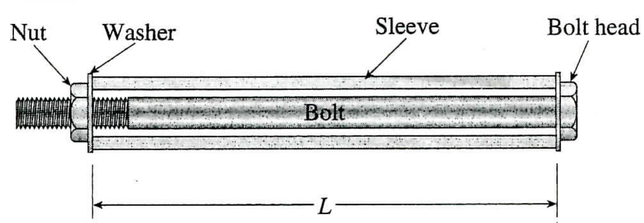


(b)

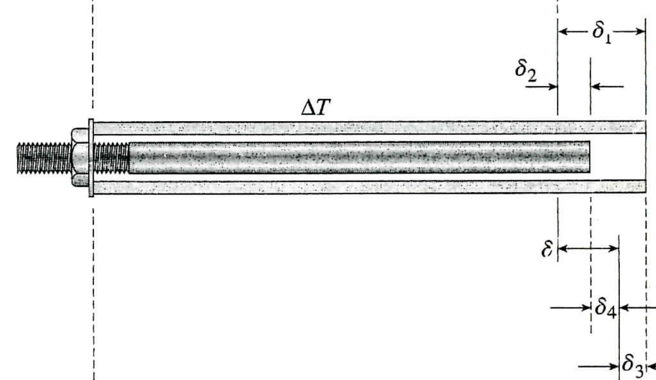


(c)

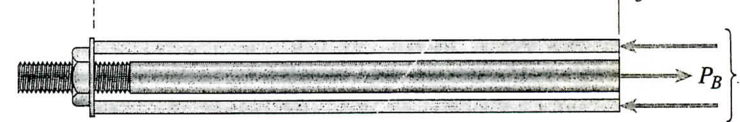
Question 4: Sleeve and bolt with uniform temperature increase ΔT



(a)



(b)



(c)

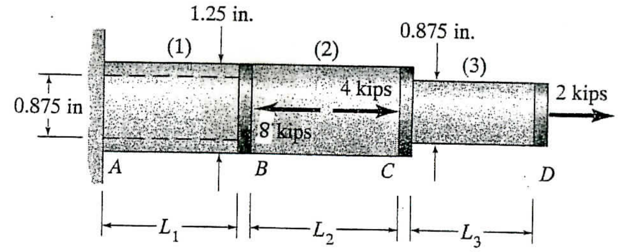
Date: 10-14-10

Question 1: (20 Points)

The three-segment axially loaded bar consists of a tube section AB with outer diameter of 1.25-in and inner diameter of 0.875-in, a solid section BC with diameter of 1.25-in, and a solid section CD with 0.875-in diameter. If bar is made of steel with $E = 29\times 10^6$-psi and the segments have the length of $L_1 = L_2 = L_3 = 10$-in. Determine:

a-The stress σ in segments AB, BC and CD.

b-The total displacement δ of the bar.

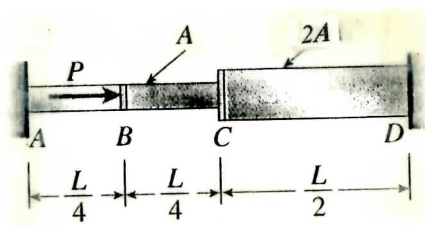


Question 2: (20 Points)

The axially loaded bar ABCD is held between two ***rigid supports A and D***. Segment ABC is made of Aluminum with $E_{Al} = 14.5\times10^6$ psi and cross-sectional area of $A = 1.5\text{-in}^2$. Segment CD is made of steel with $E_{St} = 29\times10^6$ psi and cross-sectional area of $2A = 3\text{-in}^2$. For $L = 48$-in and $P = 36$ kips, use method of your choice to find :

a- The normal stresses in each segment of the bar.

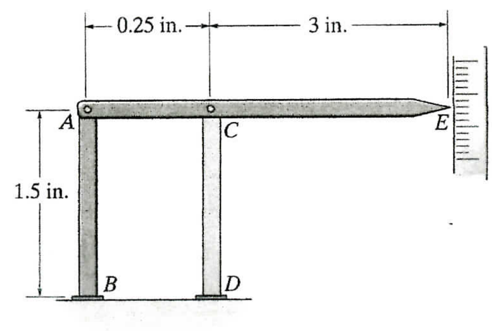
b- The displacement of point C.



NAME:________________ SID #________________

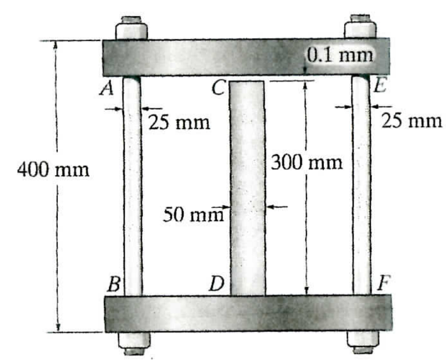
Question 1:
The device is used to measure a change in temperature. Bar AB is made of A-36 steel, and Bar CD is made of 2014-T6 aluminum alloy. When the temperature is 75° F pointer ACE is in horizontal position. Determine the vertical displacement of the pointer at E when the temperature rises to 150° F.

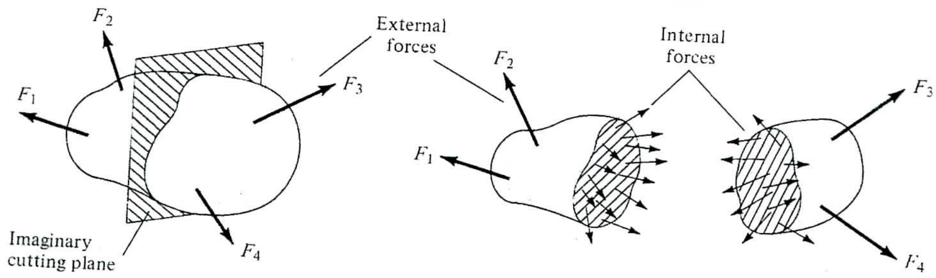
Answer:
$\delta_E = 0.00995$ in



Question 2:
The assembly shown consists of two A992 steel bolts AB and EF and an 6061-T6 aluminum rod CD. When the temperature is at 30° C, the gap between the rod and rigid member AE is 0.1-mm. Determine the normal stress developed in the bolts and the rod if the temperature rises to130° C. Assume BF is also rigid.

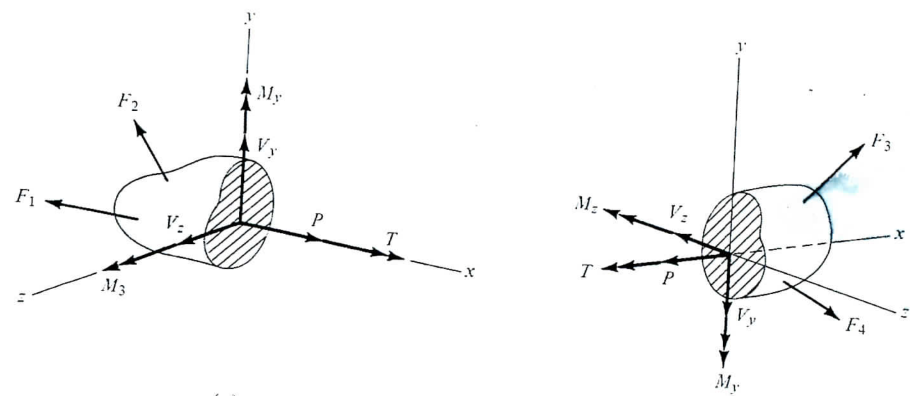
Answers:
$\sigma_{Bolt} = 33.8$ MPa (T)
$\sigma_{Rod} = 16.9$ MPa (C)





(a) (b)

Internal forces exposed by an imaginary cutting plane.



(a) (b)

Figure 2-2 Internal actions on either side of an imaginary cutting plane.

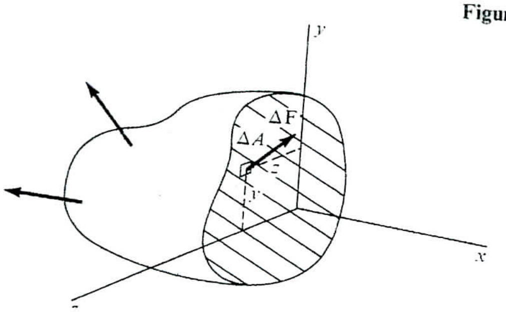


Figure 2-5 Force $\Delta \mathbf{F}$ acting on area ΔA of a cut section.

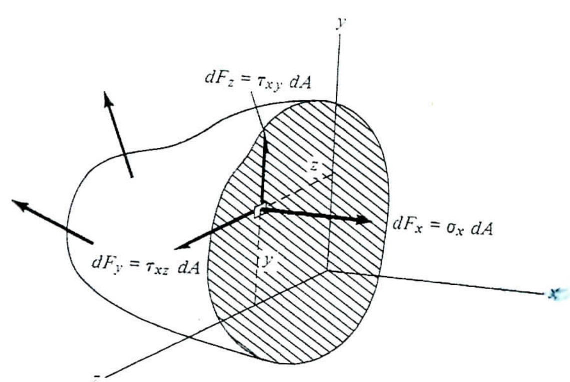


Figure 2-7 Forces on a typical infinitesimal area dA in terms of stress components.

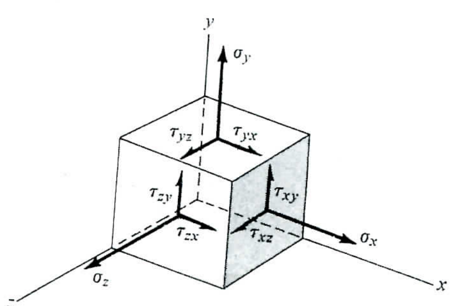


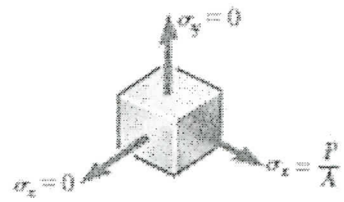
Figure 2-9 Stress components on an infinitesimal cubical element at a point.

Lateral Strain

- Earlier in the chapter we learn that, when a homogeneous slender bar is axially loaded, the resulting stress and strain satisfy Hooke's Law, as long as the proportional limit is not exceeded. Assuming that the load P is directed along the x axis, we have $\sigma_x = \frac{P}{A}$, where A is the cross-sectional area of the bar, and, from Hooke's law

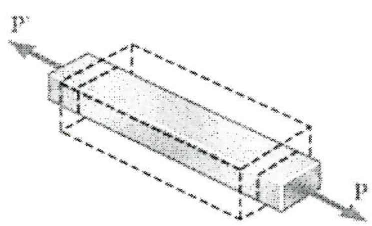
$$\mathrm{E} = \frac{\sigma_x}{\epsilon} \text{ or } \epsilon = \frac{\sigma_x}{\mathrm{E}}$$

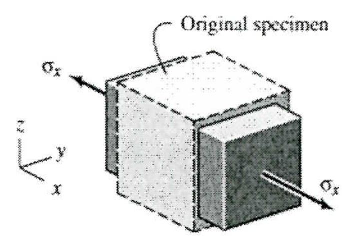
Where E is the modulus of elasticity of the material. We also note that the normal stresses on faces respectively perpendicular to the y and z-axes are zero: $\boldsymbol{\sigma_y = \sigma_x = 0}$



It would be tempting to conclude that the corresponding strains ϵ_y **and** ϵ_z **are also zero**. This however is not the case. In all engineering materials, the elongation produced by an axial tensile force **P** in the direction of the force is accompanied by a contraction in any transverse direction.

- ✓ In this section and the following sections, all materials considered will be assumed to be both homogeneous and isotropic; their mechanical properties will be assumed independent of both position and direction. (Isotropic: Identical in all directions; invariant with respect to direction.)





- ✓ For the loading shown we must have $\epsilon_y = \epsilon_z$, this common value of strain is known as lateral strain.

- An important constant for a given material is its Poisson's Ratio, named after the French Mathematician Simeon Denis Poisson (1781-1840) and denoted by the Greek Letter $\nu(nu)$.

$$\nu = -\frac{\epsilon_y}{\epsilon_x} = -\frac{\epsilon_z}{\epsilon_x}$$

$$\nu = -\frac{\textbf{\textit{lateral strain}}}{\textbf{\textit{axial strain}}}$$

Where; **lateral strain** $=\epsilon_y, \epsilon_z$ and **axial strain** $= \epsilon_x$

- ✓ Note the use of a minus sign in the above equation to obtain a positive value for ν, the axial and lateral strains having opposite signs for all engineering materials.

- For ϵ_y and ϵ_z we write the following relations, which fully describe the condition of strain under an axial load applied in a direction parallel to the x axis:

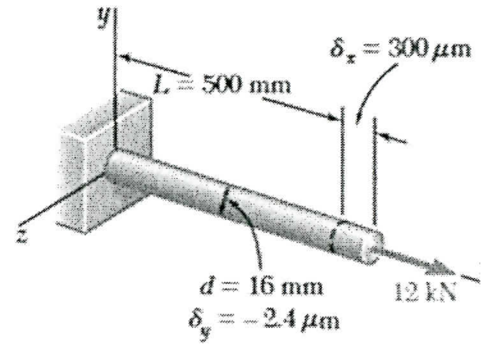
$$\epsilon_x = \frac{\sigma_x}{\mathrm{E}}, \ \epsilon_y = \epsilon_z = -\frac{\nu\sigma_x}{\mathrm{E}}$$

- Relation between Shear Modulus of Elasticity (G), Modulus of elasticity (E) and Poisson's Ratio (ν)

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

Example #1

A 500-mm-long, 16-mm-diameter rod made of a homogenous, isotropic material is observed to increase in length by 300 μm, and to decrease in diameter by 2.4 μm when subjected to an axial 12-kN load. Determine the modulus of elasticity and Poisson's ratio of the material.



The cross-sectional area of the rod is

$$A = \pi r^2 = \pi(8 \times 10^{-3}\,\text{m})^2 = 201 \times 10^{-6}\,\text{m}^2$$

Choosing the x axis along the axis of the rod (Fig. 2.37), we write

$$\sigma_x = \frac{P}{A} = \frac{12 \times 10^3\,\text{N}}{201 \times 10^{-6}\,\text{m}^2} = 59.7\,\text{MPa}$$

$$\epsilon_x = \frac{\delta_x}{L} = \frac{300\,\mu\text{m}}{500\,\text{mm}} = 600 \times 10^{-6}$$

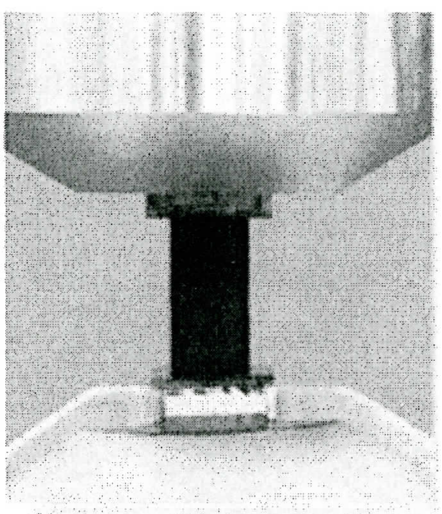
$$\epsilon_y = \frac{\delta_y}{d} = \frac{-2.4\,\mu\text{m}}{16\,\text{mm}} = -150 \times 10^{-6}$$

From Hooke's law, $\sigma_x = E\epsilon_x$, we obtain

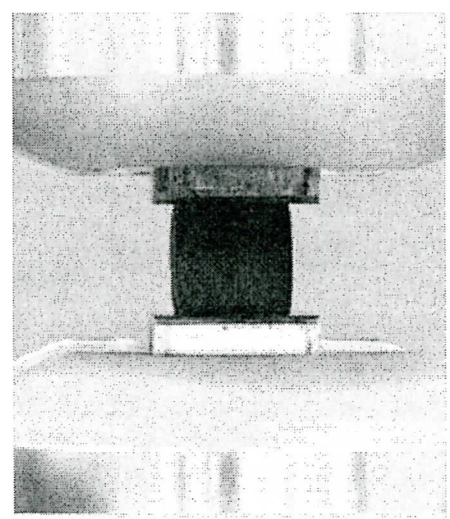
$$E = \frac{\sigma_x}{\epsilon_x} = \frac{59.7\,\text{MPa}}{600 \times 10^{-6}} = 99.5\,\text{GPa}$$

and, from Eq. (2.26),

$$\nu = -\frac{\epsilon_y}{\epsilon_x} = -\frac{-150 \times 10^{-6}}{600 \times 10^{-6}} = 0.25$$



When the rubber block is compressed $(-\epsilon_y)$ its sides will expand $(+\epsilon_x)$

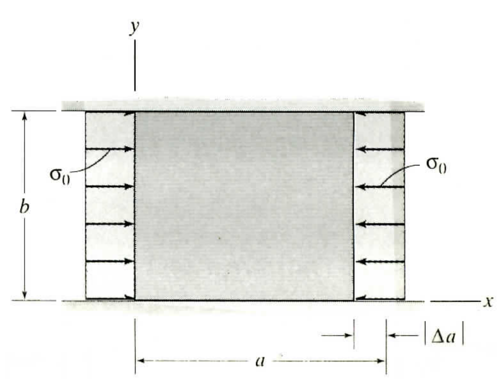


NAME:_______________________________ SID #_____________________

Question 1: (20 Points)
In a standard tensile test a 20-mm diameter rod made of an experimental plastic is subjected to a tensile force of P = 6-kN. Knowing that an elongation of 1.4-mm and a decrease in diameter of 0.085-mm are observed in a 150-mm gage length, determine the modulus of elasticity E, the modulus of rigidity G and the Poisson's ratio υ in this material.

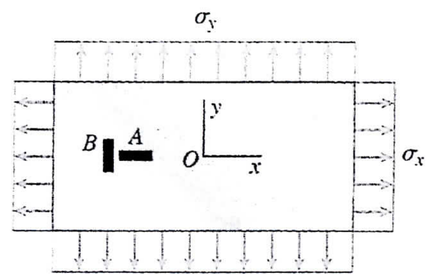
Question 2: (20 Points)
A solid cast-iron cylinder is subjected to an axial compressive load of P = 90-kips. For E = 15,000-ksi, L = 30", d = 3" and $\upsilon = 0.3$, determine:
a- The changes in the length L, the diameter d and the volume V.
b- If cylinder is constrained all around its length on outside surface so that it can not expand in the x and z directions, find the change in the length of the cylinder.

Question 3: (20 Points)
A thin rectangular elastic plate of 2-in thickness is compressed between two rigid smooth surfaces (top & bottom) and by an applied stress of $\sigma_x = \sigma_o = -10$-ksi. For a = 10-in , b = 8-in , E = 10,000-ksi and $\upsilon = 0.3$:
a-Determine σ_y the restraining stress induced to the plate by rigid surfaces.
b-Find Δa and Δt he changes in the length and the thickness of the plate.



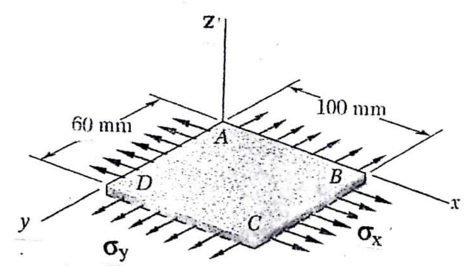
NAME:________________________________ SID #____________________

Question 4: (20 Points)
A rectangular 20-in by 12-in plate with thickness t = 0.25-in when loaded, shows an elongation of 0.02-in in the x direction and a shortening of – 0.0084-in in the y direction. For $E = 30\times10^{6}$-psi and $\nu = 0.3$, determine:
a- the reading of strain gages A and B in the x and y directions.
b- the stresses σ_x and σ_y.
c- the change in the thickness and volume of the plate.



NAME:________________________________ SID #____________________

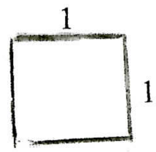
Question 5: (20 Points)
When a 100-mm by 60-mm copper plate with thickness of t = 20-mm is loaded **bi-axially**, the strains in x and y directions are measured as: $\varepsilon_x = 700\times10^{-6}$ mm/mm and $\varepsilon_y = -817\times10^{-6}$ mm/mm. For E = 120-GPa and $\nu = 0.3$, determine:
a-The normal stresses σ_x and σ_y and the axial loads P_x and P_y.
b-The change in the length, width and thickness of the plate.
c-If the plate was restrained from movement in the z-direction, what would be the reading of ε_x under the same loading ?



Note:
Deformations δ are generally very small and when added to the original lengths it does not change the significance digits. Therefore the following procedures must be used to calculate the changes in the areas and the volumes.

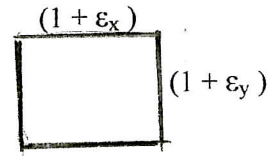
Unit Area:

Before Deformation



Area = 1 x 1

After Deformation



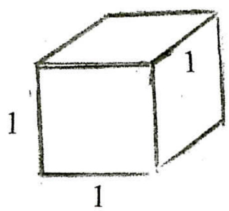
Area = $(1 + \varepsilon_x)(1 + \varepsilon_y) = 1 + \varepsilon_x + \varepsilon_y + \varepsilon_x \varepsilon_y$

Change in Unit Area = $(1 + \varepsilon_x + \varepsilon_y) - (1 \times 1) = \varepsilon_x + \varepsilon_y$

Change in Area A = $\Delta A = A(\varepsilon_x + \varepsilon_y)$

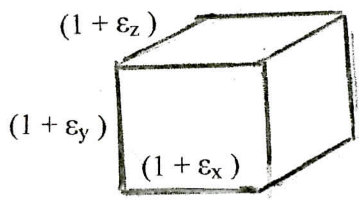
Unit Volume:

Before Deformation



Volume = 1 x 1 x 1

After Deformation



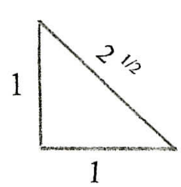
Volume = $(1 + \varepsilon_x)(1 + \varepsilon_y)(1 + \varepsilon_z)$
$= 1 + \varepsilon_x + \varepsilon_y + \varepsilon_z + 0 + 0 + \ldots$

Change in Unit Volume = e = $(1 + \varepsilon_x + \varepsilon_y + \varepsilon_z) - (1 \times 1 \times 1) = \varepsilon_x + \varepsilon_y + \varepsilon_z$

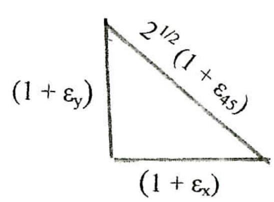
Change in Volume V = $\Delta V = V(\varepsilon_x + \varepsilon_y + \varepsilon_z)$

Strain Along 45° Line:

Before Deformation



After Deformation



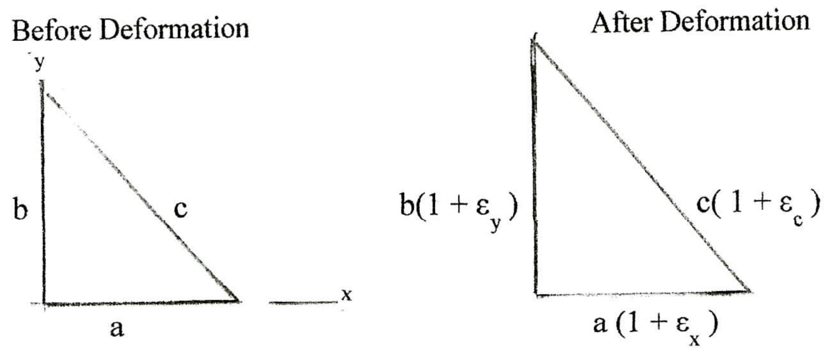
Using $c^2 = a^2 + b^2$: $2 \times (1 + \varepsilon_{45})^2 = (1 + \varepsilon_x)^2 + (1 + \varepsilon_y)^2$

Or: $2 \times (1 + \varepsilon_{45}^2 + 2\varepsilon_{45}) = (1 + \varepsilon_x^2 + 2\varepsilon_x) + (1 + \varepsilon_y^2 + 2\varepsilon_y)$

Letting $\varepsilon_{45}^2 = \varepsilon_x^2 = \varepsilon_y^2 = 0$ we find: $4\varepsilon_{45} = 2\varepsilon_x + 2\varepsilon_y$

Or: **Strain Along 45° Line: $\varepsilon_{45} = ½(\varepsilon_x + \varepsilon_y)$**

Deformation along an oblique line:



$$c^2 = a^2 + b^2$$

$$c^2(1+\varepsilon_c)^2 = a^2(1+\varepsilon_x)^2 + b^2(1+\varepsilon_y)^2$$

or $$c^2(1+\varepsilon_c^2+2\varepsilon_c) = a^2(1+\varepsilon_x^2+2\varepsilon_x) + b^2(1+\varepsilon_y^2+2\varepsilon_y)$$

Letting $\varepsilon_c^2 = \varepsilon_x^2 = \varepsilon_y^2 = 0$ and $c^2 = a^2 + b^2$ we find:

$$\varepsilon_c c^2 = \varepsilon_x a^2 + \varepsilon_y b^2$$

or Strain along the oblique line C : $$\boldsymbol{\varepsilon_c = (a^2/c^2)\,\varepsilon_x + (b^2/c^2)\,\varepsilon_y}$$

Since deformations are: $\delta_a = \varepsilon_x a$, $\delta_b = \varepsilon_b b$ and $\delta_c = \varepsilon_c c$ we can write the above equation as:

$$\varepsilon_c c = \varepsilon_x a\,(a/c) + \varepsilon_b b\,(b/c)$$

or Deformation along the oblique line C: $$\boldsymbol{\delta_c = \delta_a\,(a/c) + \delta_b\,(b/c)}$$

Appendix B Typical Properties of Selected Materials Used in Engineering[1,5]

(U.S. Customary Units)

Material	Specific Weight, lb/in³	Ultimate Strength			Yield Strength[3]		Modulus of Elasticity, 10^6 psi	Modulus of Rigidity, 10^6 psi	Coefficient of Thermal Expansion, 10^{-6}/°F	Ductility, Percent Elongation in 2 in.
		Tension, ksi	Compres-sion,[2] ksi	Shear, ksi	Tension, ksi	Shear, ksi				
Steel										
Structural (ASTM-A36)	0.284	58			36	21	29	11.2	6.5	21
High-strength-low-alloy										
ASTM-A709 Grade 50	0.284	65			50		29	11.2	6.5	21
ASTM-A913 Grade 65	0.284	80			65		29	11.2	6.5	17
ASTM-A992 Grade 50	0.284	65			50		29	11.2	6.5	21
Quenched & tempered										
ASTM-A709 Grade 100	0.284	110			100		29	11.2	6.5	18
Stainless, AISI 302										
Cold-rolled	0.286	125			75		28	10.8	9.6	12
Annealed	0.286	95			38	22	28	10.8	9.6	50
Reinforcing Steel										
Medium strength	0.283	70			40		29	11	6.5	
High strength	0.283	90			60		29	11	6.5	
Cast Iron										
Gray Cast Iron										
4.5% C, ASTM A-48	0.260	25	95	35			10	4.1	6.7	0.5
Malleable Cast Iron										
2% C, 1% Si, ASTM A-47	0.264	50	90	48	33		24	9.3	6.7	10
Aluminum										
Alloy 1100-H14 (99% Al)	0.098	16		10	14	8	10.1	3.7	13.1	9
Alloy 2014-T6	0.101	66		40	58	33	10.9	3.9	12.8	13
Alloy 2024-T4	0.101	68		41	47		10.6		12.9	19
Alloy 5456-H116	0.095	46		27	33	19	10.4		13.3	16
Alloy 6061-T6	0.098	38		24	35	20	10.1	3.7	13.1	17
Alloy 7075-T6	0.101	83		48	73		10.4	4	13.1	11
Copper										
Oxygen-free copper (99.9% Cu)										
Annealed	0.322	32		22	10		17	6.4	9.4	45
Hard-drawn	0.322	57		29	53		17	6.4	9.4	4
Yellow Brass (65% Cu, 35% Zn)										
Cold-rolled	0.306	74		43	60	36	15	5.6	11.6	8
Annealed	0.306	46		32	15	9	15	5.6	11.6	65
Red Brass (85% Cu, 15% Zn)										
Cold-rolled	0.316	85		46	63		17	6.4	10.4	3
Annealed	0.316	39		31	10		17	6.4	10.4	48
Tin bronze (88 Cu, 8Sn, 4Zn)	0.318	45			21		14		10	30
Manganese bronze (63 Cu, 25 Zn, 6 Al, 3 Mn, 3 Fe)	0.302	95			48		15		12	20
Aluminum bronze (81 Cu, 4 Ni, 4 Fe, 11 Al)	0.301	90	130		40		16	6.1	9	6

(Table continued on page A14)

Appendix B Typical Properties of Selected Materials Used in Engineering[1,5]

(SI Units)

Material	Density kg/m³	Ultimate Strength: Tension, MPa	Ultimate Strength: Compression,[2] MPa	Ultimate Strength: Shear, MPa	Yield Strength[3]: Tension, MPa	Yield Strength[3]: Shear, MPa	Modulus of Elasticity, GPa	Modulus of Rigidity, GPa	Coefficient of Thermal Expansion, 10^{-6}/°C	Ductility, Percent Elongation in 50 mm
Steel										
Structural (ASTM-A36)	7860	400			250	145	200	77.2	11.7	21
High-strength-low-alloy										
ASTM-A709 Grade 345	7860	450			345		200	77.2	11.7	21
ASTM-A913 Grade 450	7860	550			450		200	77.2	11.7	17
ASTM-A992 Grade 345	7860	450			345		200	77.2	11.7	21
Quenched & tempered										
ASTM-A709 Grade 690	7860	760			690		200	77.2	11.7	18
Stainless, AISI 302										
Cold-rolled	7920	860			520		190	75	17.3	12
Annealed	7920	655			260	150	190	75	17.3	50
Reinforcing Steel										
Medium strength	7860	480			275		200	77	11.7	
High strength	7860	620			415		200	77	11.7	
Cast Iron										
Gray Cast Iron										
4.5% C, ASTM A-48	7200	170	655	240			69	28	12.1	0.5
Malleable Cast Iron										
2% C, 1% Si, ASTM A-47	7300	345	620	330	230		165	65	12.1	10
Aluminum										
Alloy 1100-H14 (99% Al)	2710	110		70	95	55	70	26	23.6	9
Alloy 2014-T6	2800	455		275	400	230	75	27	23.0	13
Alloy-2024-T4	2800	470		280	325		73		23.2	19
Alloy-5456-H116	2630	315		185	230	130	72		23.9	16
Alloy 6061-T6	2710	260		165	240	140	70	26	23.6	17
Alloy 7075-T6	2800	570		330	500		72	28	23.6	11
Copper										
Oxygen-free copper (99.9% Cu)										
Annealed	8910	220		150	70		120	44	16.9	45
Hard-drawn	8910	390		200	265		120	44	16.9	4
Yellow-Brass (65% Cu, 35% Zn)										
Cold-rolled	8470	510		300	410	250	105	39	20.9	8
Annealed	8470	320		220	100	60	105	39	20.9	65
Red Brass (85% Cu, 15% Zn)										
Cold-rolled	8740	585		320	435		120	44	18.7	3
Annealed	8740	270		210	70		120	44	18.7	48
Tin bronze (88 Cu, 8Sn, 4Zn)	8800	310			145		95		18.0	30
Manganese bronze (63 Cu, 25 Zn, 6 Al, 3 Mn, 3 Fe)	8360	655			330		105		21.6	20
Aluminum bronze (81 Cu, 4 Ni, 4 Fe, 11 Al)	8330	620	900		275		110	42	16.2	6

(Table continued on page A15