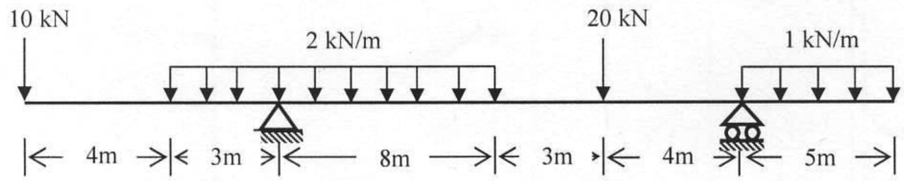
University of Asia Pacific
Department of Civil Engineering
Final Examination Spring 2012 (Set A)
Program: B. Sc. Engineering (Civil)

Course Title: Mechanics of Solids I — Course No: CE 211

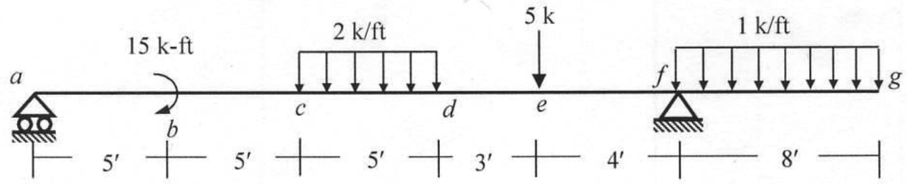
Time: 3 hours — Full marks: 100 (= 10 × 10)

Answer any **10** of the following **14** questions.

1. Draw the axial force, shear force and bending moment diagrams for the beam shown below.

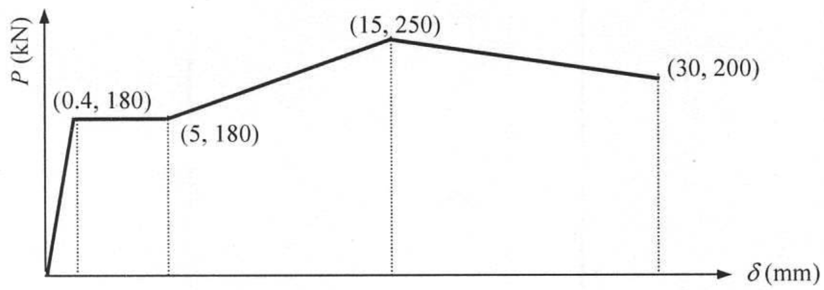


2. For the beam *abcdefg* loaded as shown in the figure below
   (i) Derive the equations for shear force and bending moment using Singularity Functions.
   (ii) Calculate shear force at the left of point *e* and bending moment at the right of point *b*.

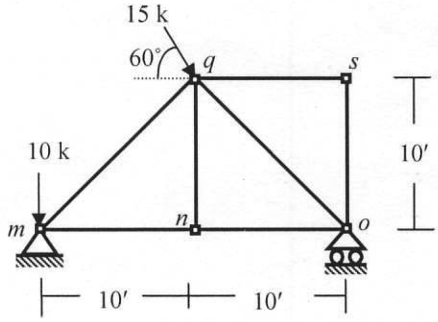


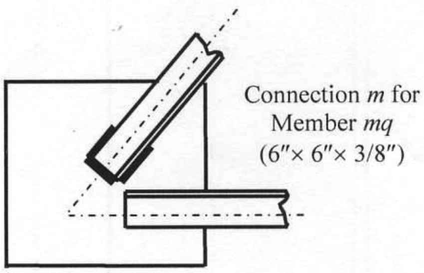
3. Briefly discuss the following terms
   (i) Modulus of Elasticity
   (ii) Modulus of Resilience
   (iii) Yield Strength
   (iv) Ultimate Strength
   (v) Modulus of Toughness.

4. Figure below shows the axial force (P) vs. elongation (δ) diagram of a 180 mm long mild steel specimen of 25 mm diameter. Calculate its
   (i) Young's modulus,
   (ii) Apparent breaking strength,
   (iii) Energy needed to break the specimen,
   (iv) Modulus of Resilience.

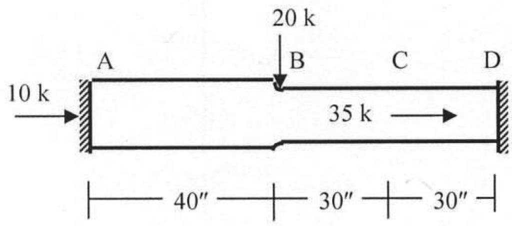


5. For the truss shown below, calculate the lengths of 3/8-inch weld required on three sides to connect the member *mq* to a gusset plate as shown [Given: Allowable shear stress = 16 ksi].



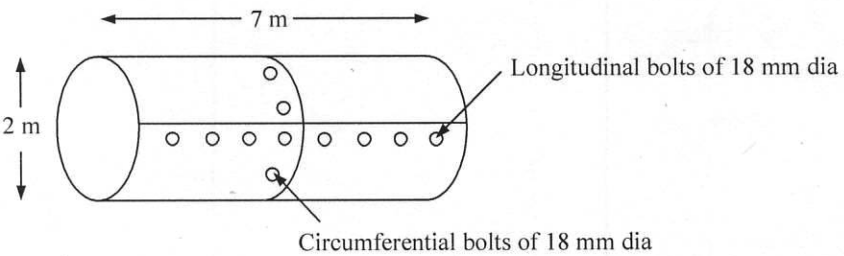


6. Draw the axial force diagram of the statically indeterminate axially loaded bar shown below [Given: E = 3000 ksi, Members AB and BCD are (8″ × 3″/8) and (6″ × 3″/8) sections respectively].

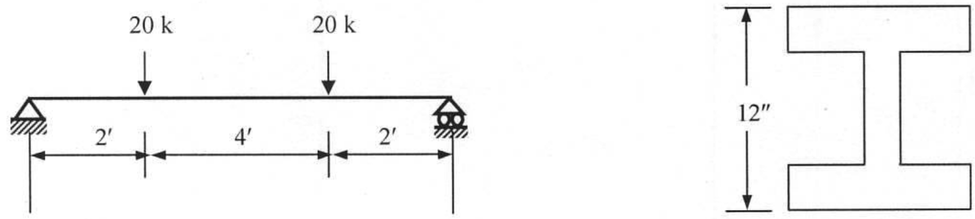


7. For a gas cylinder of 2 m diameter and 5 mm wall thickness, calculate the
   (i) maximum internal pressure that the cylinder can be subjected to
   (ii) corresponding tangential and longitudinal stresses and strains in the wall of the cylinder
   (iii) required spacing of 18 mm diameter bolts (both longitudinal and circumferential) to resist the wall stresses

   [Given: Allowable tensile stress in the wall = 90 MPa, Allowable shear stress in bolts = 80 MPa, Modulus of elasticity = 20 GPa, Poisson's ratio = 0.25].



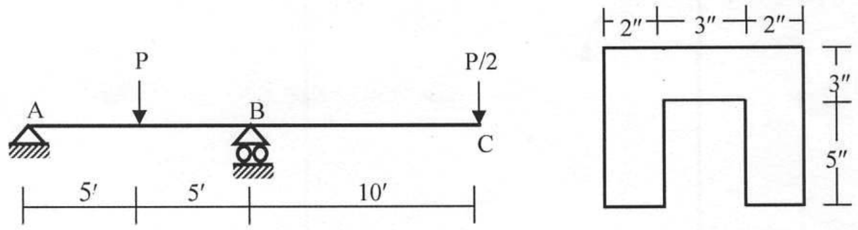
8. The simply supported beam shown below carries symmetrical loads of 20 k each. If the allowable stress in either tension or compression is 20 ksi, calculate the required moment of inertia for the 12″ deep symmetrical cross-section.



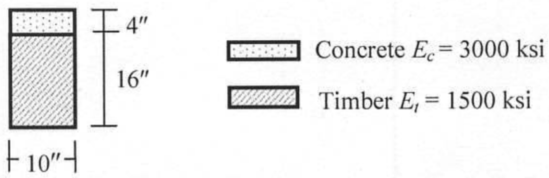
9. For the beam ABC shown below, the allowable tensile and compressive bending stresses in the cross-section are 9 ksi and 5 ksi respectively.

   (i) Calculate the maximum allowable value of the load P.

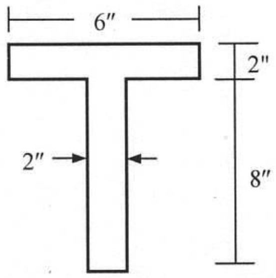
   (ii) Draw the bending stress diagram over cross-section B for the value of P calculated in (i).



10. For the beam shown in Question No. 9, draw the flexural stress and strain diagrams over the composite cross-section at B when P = 50 k.



11. Draw the shear stress diagram over the cross-section shown below and locate the position and value of the minimum and maximum stresses, if the applied shear force V= 60 k.

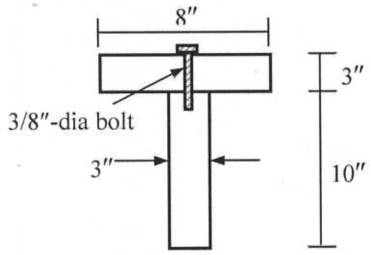


12. For the beam shown in Question No. 9, the allowable flexural shear stress is 55 psi.

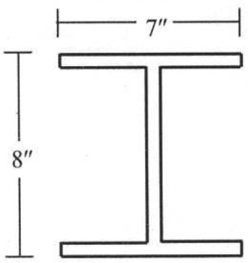
   (i) Calculate the maximum allowable value of the load P.

   (ii) Draw the shear stress diagram over cross-section C for the value of P calculated in (i).

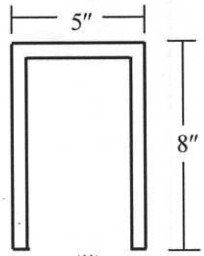
13. Calculate the spacing of 3/8″ bolts to resist the maximum shear force in the beam shown in Question No. 9 with P = 10 k and cross-section shown below [Given: Allowable shear stress = 12 ksi].



14. Locate shear center of the cross-sections shown below and comment on the results.



(i)



(ii)

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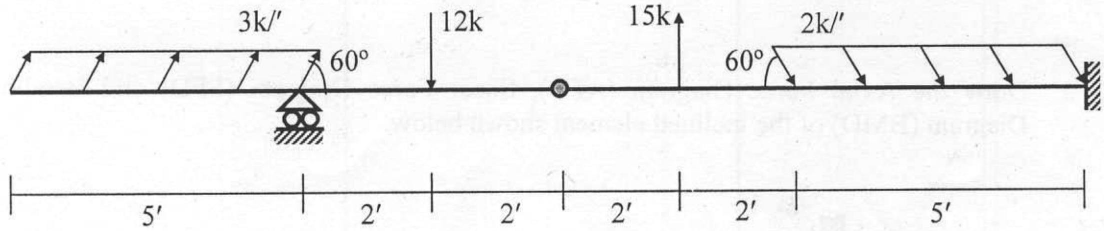
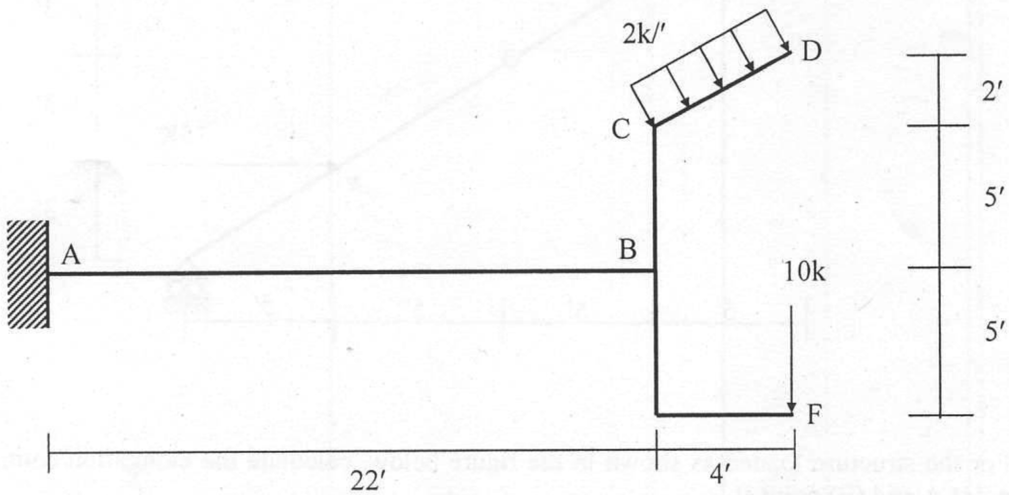
[Answer **any 10 (ten)** of the following 14 questions]

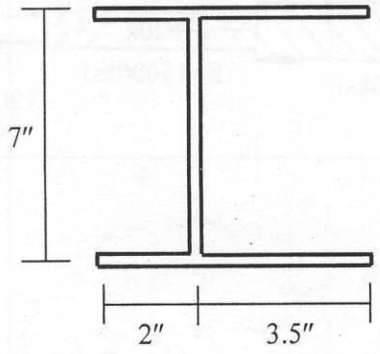
1. Draw the Axial Force Diagram (AFD), Shear Force Diagram (SFD) and Bending Moment Diagram (BMD) of the beam shown below.



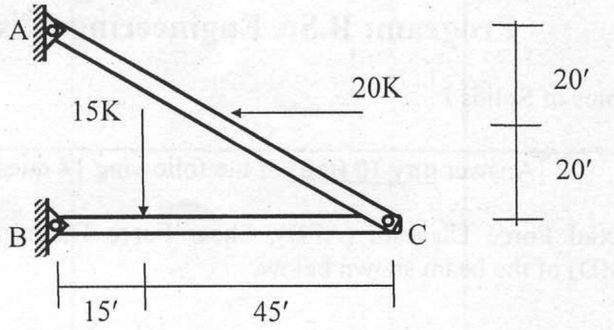
2. Draw the Axial Force Diagram (AFD), Shear Force Diagram (SFD) and Bending Moment Diagram (BMD) of beam AB shown below.



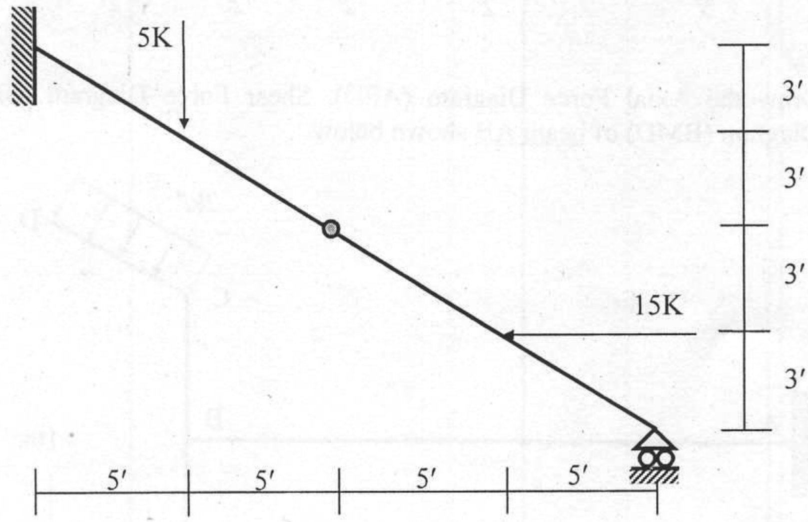
3. Determine the location of shear center of the cross-section shown below. Thickness is 0.1″ throughout.



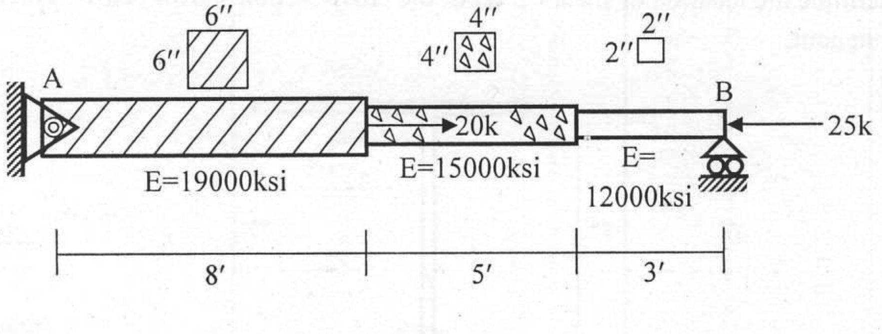
4. Draw the Axial Force Diagram (AFD), Shear Force Diagram (SFD) and Bending Moment Diagram (BMD) of beam BC shown below.



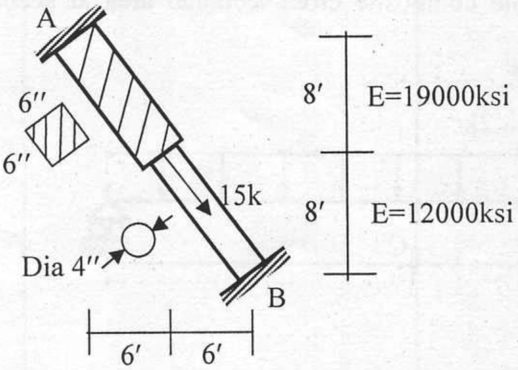
5. Draw the Axial Force Diagram (AFD), Shear Force Diagram (SFD) and Bending Moment Diagram (BMD) of the inclined element shown below.



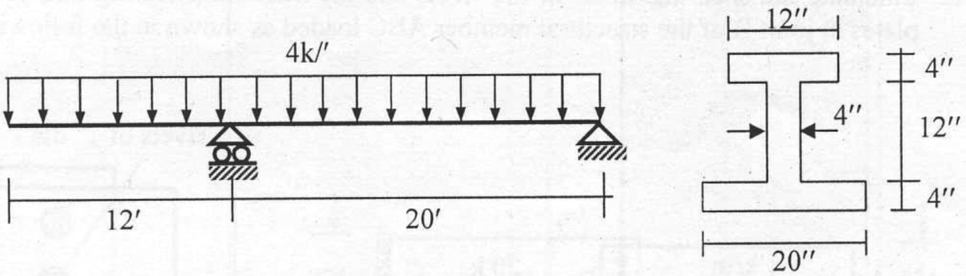
6. For the structure loaded as shown in the figure below, calculate the elongation/contraction of (i) point A and (ii) point B.



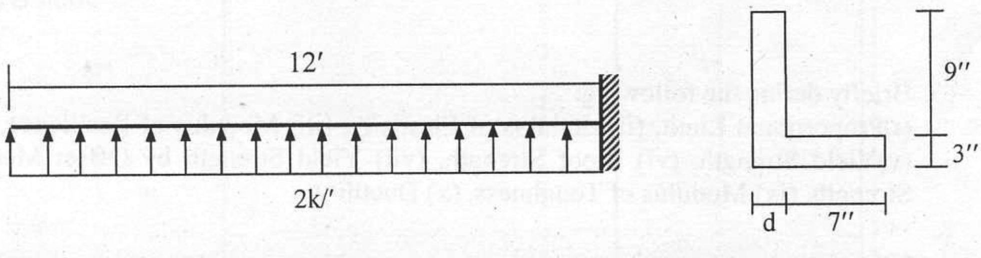
7. Draw the Axial Force Diagram (AFD) of the beam AB shown below.



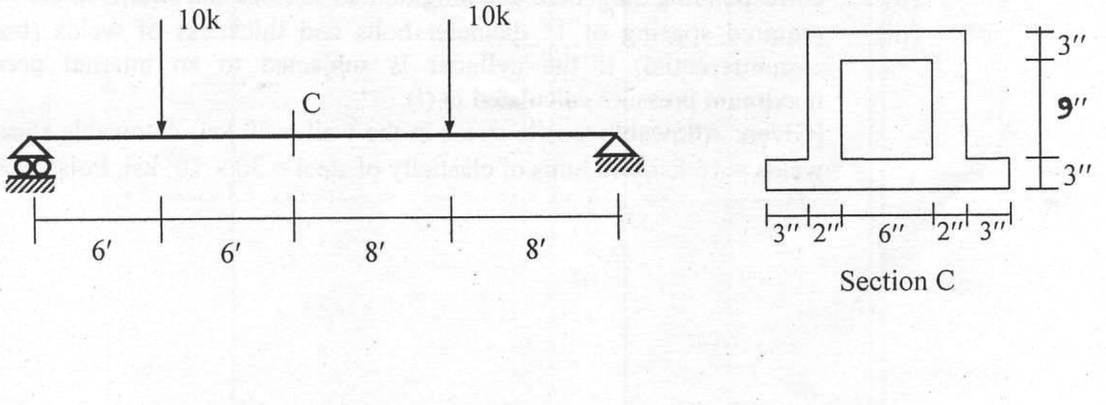
8. For the beam loaded as shown in the figure below, calculate the maximum tensile and compressive stress for bending moment only.



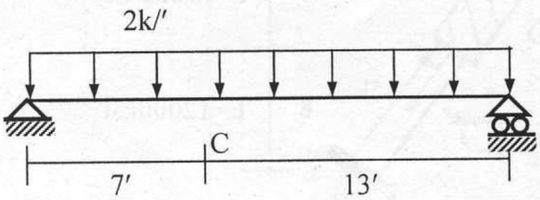
9. For the beam loaded as shown in the figure shown below, calculate the minimum value of the dimension "d" if the maximum allowable tensile and compressive stress for flexure (i.e. bending moment) of the material of the beam is 1000 psi and 8000 psi respectively.

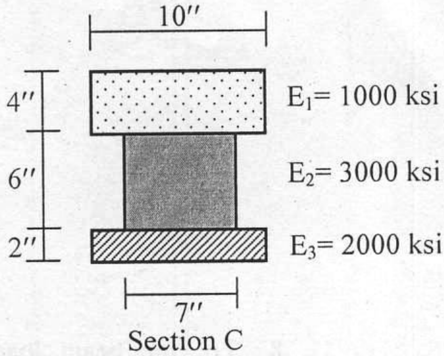


10. For the beam loaded as shown in the figure below, calculate the minimum and maximum value of shear stress across the cross section "c" of the beam, which is 12 feet from the left support.



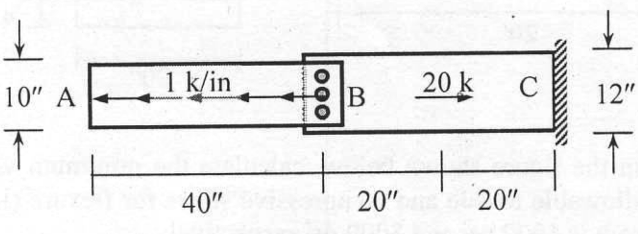
11. For the simply supported beam loaded as shown below, draw the flexural stress and strain diagrams over the composite cross-sectional area at section C which is 7 feet from the left support.



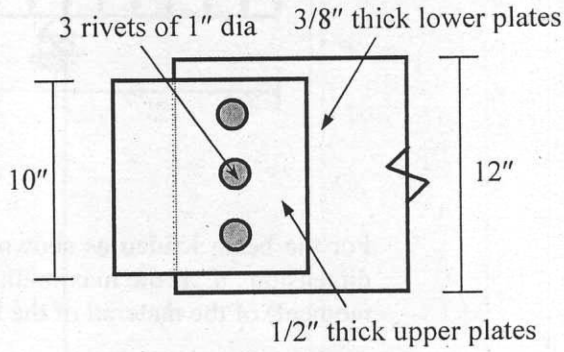


Section C

12. Calculate the shearing stress in the rivets and the maximum tearing and bearing stresses in the plates at joint B of the structural member ABC loaded as shown in the following figure.



Member ABC



Joint B (Lap Joint)

13. Briefly define the following:
(i)Proportional Limit, (ii)Modulus of Elasticity, (iii) Modulus of Resilience, (iv)Poisson's Ratio, (v)Yield Strength, (vi) Proof Strength, (vii) Yield Strength by Offset Method, (viii) Ultimate Strength, (ix) Modulus of Toughness, (x) Ductility.

14. For a gas cylinder of 6′ diameter and 0.25″ wall thickness, calculate the
(i) maximum internal pressure that the cylinder can be subjected to,
(ii) corresponding tangential and longitudinal stresses and strains in the wall of the cylinder,
(iii) required spacing of 1″ diameter bolts and thickness of welds (both longitudinal and circumferential) if the cylinder is subjected to an internal pressure one-third the maximum pressure calculated in (i).
[Given: Allowable tensile stress in the wall = 20 ksi, Allowable shear stress in bolts and welds = 16 ksi, Modulus of elasticity of steel = 30×10^3 ksi, Poisson's ratio = 0.25].

List of Useful Formulae for CE 211

- Axial stress, $\sigma = P/A$
- Shear stress, $\tau = V/A$

- For weld design, shear stress, $\tau = V/(0.707\ Lt) \Rightarrow L = V/(0.707t\ \tau)$

- Strain, $\varepsilon = \Delta/L$
- Modulus of Elasticity, $E = \sigma_p/\varepsilon_p$
- Poisson's ratio, $\nu = -\varepsilon_{lat}/\varepsilon_{lomg}$
- Modulus of Resilience = $\sigma_p\ \varepsilon_p/2 = \sigma_p^2/2E$
- Shear stress, $\tau = G\ \gamma$ where G = Shear Modulus of Elasticity
- $G = E/(2\ (1 + \nu))$

❖ **Three normal and shear strains**

- $\varepsilon_{xx} = \sigma_{xx}/E - \nu\sigma_{yy}/E - \nu\sigma_{zz}/E$
- $\varepsilon_{yy} = -\ \nu\sigma_{xx}/E + \sigma_{yy}/E - \nu\sigma_{zz}/E$
- $\varepsilon_{zz} = -\ \nu\sigma_{xx}/E - \nu\sigma_{yy}/E + \sigma_{zz}/E$
- $\gamma_{xy} = \tau_{xy}/G$
- $\gamma_{yz} = \tau_{yz}/G$
- $\gamma_{zx} = \tau_{zx}/G$

❖ **Axial deformation,** $u_B - u_A = P_{xx}L/AE$

❖ **Thin-Walled Pressure Vessels**

- Transverse stress, $\sigma_t = pD/2t$
- Longitudinal stress, $\sigma_l \cong pD/4t$
- Transverse strain, $\varepsilon_t = \sigma_t/E - \nu\sigma_l/E = (pD/2Et)\ (1-\nu/2)$
- Longitudinal strain, $\varepsilon_l = \sigma_l/E - \nu\sigma_t/E = (pD/2Et)\ (0.5-\nu)$

❖ **Bolt Connections**

- $(pD/2)\ S_l = \tau_{all}\ (\pi d^2/4) \Rightarrow S_l = (\tau_{all}/p)\ (\pi d^2/2D)$
- $p\ (\pi D^2/4) = [\pi(D + t)/S_h]\ [\tau_{all}\ (\pi d^2/4)] \Rightarrow S_h \cong (\tau_{all}/p)\ (\pi d^2/D)$

❖ **Weld Connections**

- $pDL/2 = \tau_{all}\ (0.707t_l\ L) \Rightarrow t_l = (p/\tau_{all})\ (0.707D)$
- $p\ (\pi D^2/4) = \tau_{all}\ [0.707\ t_h\pi(D + t)] \Rightarrow t_h \cong (p/\tau_{all})\ (0.353D)$

❖ **Bending stress,** $\sigma_x = -\ M_z\ y/I_z$

- Plastic moment, $M_p = \sigma_{yp}\ Z$
- Aspect ratio, $\alpha = Z/S$
  where Z is called the plastic Section Modulus and S is called the elastic section modulus
- Shear stress, $\tau = VQ/\ \bar{I}\ b$
- Shear flow, $q = VQ/\ \bar{I}$