Exam.Code:1014
Sub. Code: 35206

2124
M.E. (Mechanical Engineering)
First Semester
MME-103: Advanced Mechanics of Materials

Time allowed: 3 Hours **Max. Marks: 50**

NOTE: Attempt five questions in all, selecting atleast two questions from each part. Assume suitably the missing data, if any. Use usual notations and symbols for derivations. All questions carry equal marks.

x-x-x

Part-A

Q.1 **(a)** What is a stress-strain diagram?
(b) What is the difference between elastic limit and proportional limit.
(c) What is offset strain?
(d) How are the concepts of yield stress and yield point different?
(e) For the alloy steel whose stress-strain diagram is shown in Figure 1 and Figure 2 (zoomed), determine the following properties as appropriate: modulus of elasticity, yield strength, modulus of resilience, ultimate tensile strength, strain at fracture, and the percent elongation.

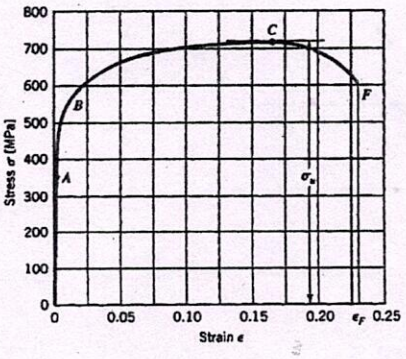

Figure 1

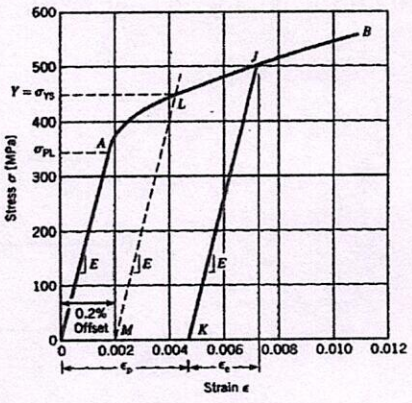

Figure 2

Q.2 A steel shaft of circular section is subjected to a torque T. The controlling factor in the design of the shaft is the angle of twist per unit length ϕ/L. The maximum allowable twist is 0.005 rad/m, and the maximum shear stress is $\tau_{max} = 30$ MPa. Determine the diameter at which the maximum allowable twist, and not the maximum shear stress, is the controlling factor. For steel use $G = 77$ GPa.

Q.3 The state of stress at a point in a machine part is given by $\sigma_{xx} = -10$, $\sigma_{yy} = 30$, $\sigma_{xy} = 15$, and $\sigma_{zz} = \sigma_{xz} = \sigma_{yz} = 0$. Determine the principal stresses and orientation of the principal axes at the point.

Q.4 Consider any point in a stressed member for which values of σ_1, σ_2, and σ_3 are known. For any plane through the point, let the N axis be normal to the plane and the S axis coincide with the shear component of the stress for the plane. Three Mohr's circles of stress can be constructed by choosing σ_{NN} and σ_{NS} as coordinate axes. Show that the coordinates (σ_{NN}, σ_{NS}) locate a point that is either on the circles or in the shaded area between the biggest outer circle and the two smaller inner circles, see figure Figure 3.

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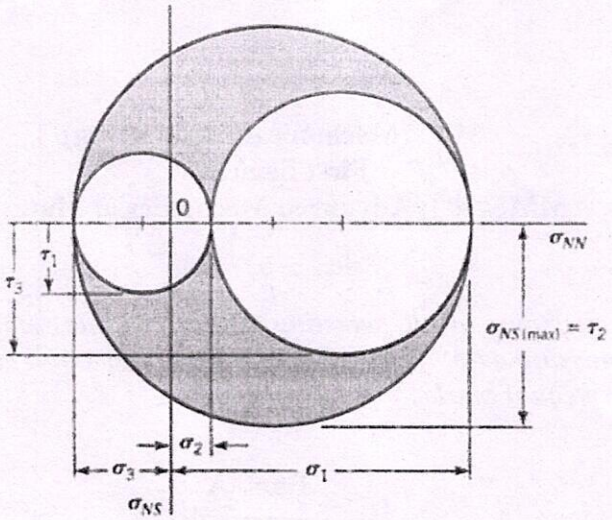

Figure 3

Part-B

Q.5 For small-displacement plane strain, the strain components in the plate ABCD, see Figure 4, in terms of the coordinate system (x,y), are $\epsilon_{xx} = Cy(L-x)$, $\epsilon_{yy} = Dy(L-x)$, $\gamma_{xy} = -(C+D)(A^2 - y^2)$ where A, C, and D are known constants. The displacement components (u,v) are $u(0,0) = 0$, $v(0,0) = 0$ and the slope $\partial u(x,y)/\partial y$ is $\partial u(0,0)/\partial y = 0$. Determine u and v as functions of (x,y).

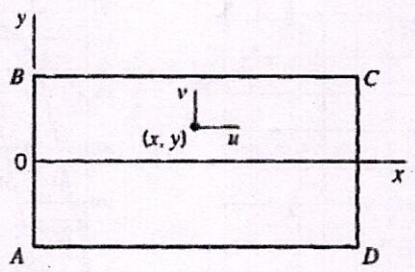

Figure 4

Q.6 A strain rosette with gages spaced at an angle θ is cemented to the free surface ($\epsilon_{zz} = \epsilon_{xz} = \epsilon_{yz} = 0$) of a member, see Figure 5. Under a deformation of the member, the extensional strains measured by gages a, b, and c are ϵ_a, ϵ_b, and ϵ_c respectively.

(a) Derive equations that determine the strain components ϵ_{xx}, ϵ_{yy}, ϵ_{xy} in terms of ϵ_a, ϵ_b, ϵ_c, and θ.

(b) Specialize the result for the delta rosette ($\theta = 60°$) and rectangular rosette ($\theta = 45°$).

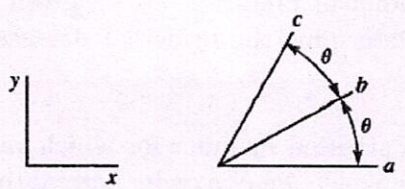

Figure 5

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Q.7 An airplane wing spar, see Figure 6, is made of an aluminum alloy ($E = 72\,\text{GPa}$ and $\nu = 0.33$), and it has a square cross-section perpendicular to the plane of the figure. Stress components σ_{xx} and σ_{yy} are uniformly distributed as shown. *Note:* Spars are long beams that provide most of the strength in an aircraft wing. They run from the wing root to the wing tip.

(a) If $\sigma_{xx} = 200\,\text{MPa}$, determine the magnitude of σ_{yy} so that the dimension $b = 20\,\text{mm}$ does not change under the load.

(b) Determine the amount by which the dimension a changes.

(c) Determine the change in the cross-sectional area of the spar.

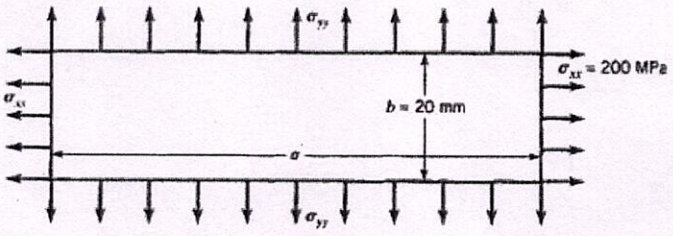

Figure 6

Q.8 The curved beam in Figure 7 has a 30 mm cross-section and radius of curvature $R = 65\,\text{mm}$. The beam is made of steel for which $E = 200\,\text{GPa}$ and $\nu = 0.29$.

(a) If $P = 6.00\,\text{kN}$, determine the deflection of the free-end of the curved beam in the direction of P.

(b) What is the error in the deflection if U_N and U_S are neglected?

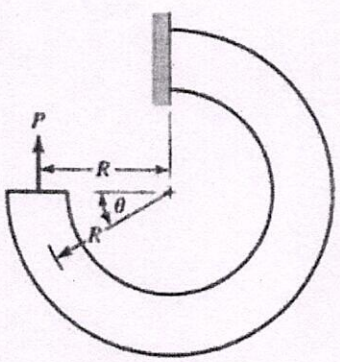

Figure 7

x - x - x