5E3175

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B.Tech. (Sem.V) (Main/Back) Exam Dec. 2012
Mechanical Engineering
5ME1 Advanced Mechanics of Solids

[Time : 3 Hours] [Total Marks : 80]
[Min. Passing Marks : 24]

Instructions to Candidates :
Attempt any five questions, selecting one question from each unit. All questions carry equal marks. Schematic diagrams must be shown wherever necessary. Any data you feel missing suitably be assumed and stated clearly. Units of quantities used/calculated must be stated clearly.

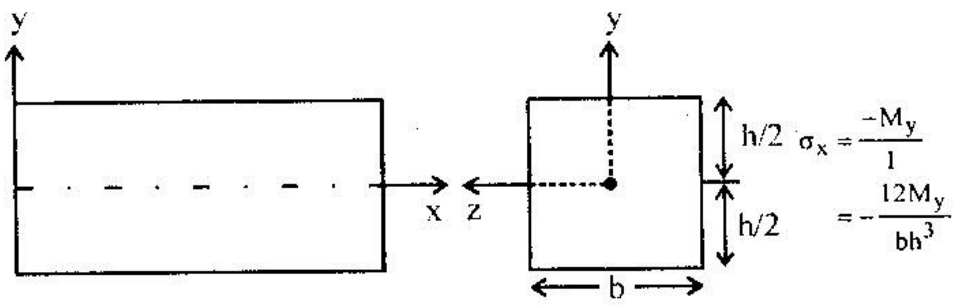
Unit - I

1. (a) Define state of stress at a point. **(3)**
   (b) Derive expression for stress component on an arbitrary plane in terms of rectangular stress components. **(5)**
   (c) The state of stress at a point is characterized by the matrix shown. Determine T_{22} such that there is at least one plane passing through the point in such a way that the resultant stress on that plane is zero. Determine the direction cosines of the normal to that plane. **(4+4)**

$$[T_{ij}] = \begin{bmatrix} 0 & 2 & 1 \\ 2 & T_{22} & 2 \\ 1 & 2 & 0 \end{bmatrix}$$

OR

1. (a) Explain the terms (i) pure shear stress (ii) stress invariants and its property. **(2+3)**
   (b) Explain Mohr's circle diagram for 3 dimensional state of stress indicating Mohr's stress plane π. **(3)**
   (c) Consider the rectangular beam shown below. According to the elementary theory of bending the "fibre stress" in the elastic range due to bending is given by



where M is bending moment which is a function of x. Assume that $\sigma_z = \tau_{zx} = \tau_{zy} = 0$ and also that $\tau_{xy} = 0$ at the end bottom and further that $\sigma_z = 0$ at the bottom. Using differential equations of equilibrium, determine τ_{xy} and σ_y. **(4+4)**

Unit - II

2. The rectangular components of a small strain at a point is given by the following matrix. Determine the principal strains and the direction of the maximum unit strain (i.e. ε_{max}) **(16)**

$$[\varepsilon_{ij}] = p\begin{bmatrix} 1 & 0 & 0 \\ 0 & 0 & -4 \\ 0 & -4 & 3 \end{bmatrix}, \text{ where } p = 10^{-4}$$

OR

2. (a) If the displacement field is given by
   $U_x = Kxy,\ U_y = Kxy,\ U_z = 2K(x+y)z$
   where K is a constant small enough to ensure applicability of the small deformation theory.

(i) Write down the strain matrix.

(ii) What is the strain in direction $n_x = n_y = n_z = \frac{1}{\sqrt{3}}$ **(5+3)**

(b) The displacement field for a body is given by

$$u = K(x^2 + y)i + K(y + z)j + K(x^2 + 2z^2)K$$

where $K = 10^{-3}$. At a point P(2, 2, 3), consider two line segments PQ and PR having the following direction cosines before deformation.

$$PQ: n_{x_1} = n_{y_1} = n_{z_1} = \frac{1}{\sqrt{3}}$$

$$PR: n_{x_2} = n_{y_2} = \frac{1}{\sqrt{2}}, n_{z_2} = 0$$

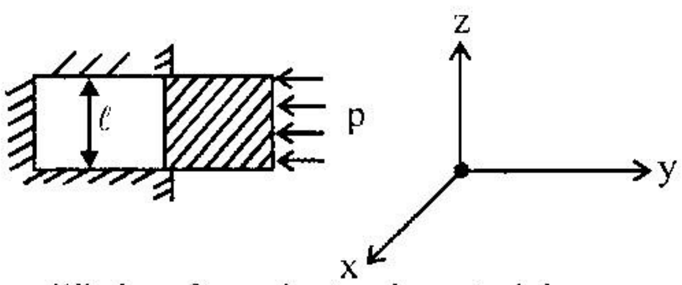
Determine the angle between the two segments before and after deformation. **(2+6)**

Unit - III

3. **(a)** A rubber cube is inserted in a cavity of same form and size in a steel block and from right hand open side it is pressed by a steel block with a pressure of p pascals as shown in figure. Taking axes as shown in its figure and considering steel is be absolutely hard and no friction exists between steel and rubber find.

(i) The pressure of rubber against the box walls and

(ii) The extreme shear stresses in rubber. **(4+4)**



(b) Derive displacement equations of equilibrium for an isotropic material. **(8)**

OR

3. **(a)** Define isotropic, anisotropic and orthotropic materials giving two examples of each type. **(8)**

(b) For the given strain matrix at a point, determine the stress matrix. Take $E = 207 \times 10^6$ kPa and $G = 80 \times 10^6$ kPa for the steel material **(8)**

$$[\epsilon_{ij}] = \begin{bmatrix} 0.001 & 0 & -0.002 \\ 0 & -0.003 & 0.0004 \\ -0.002 & 0.0004 & 0 \end{bmatrix}$$

Unit - IV

4. **(a)** Derive Winkler - Bach formula to find bending stresses in initially curved beams. **(8)**

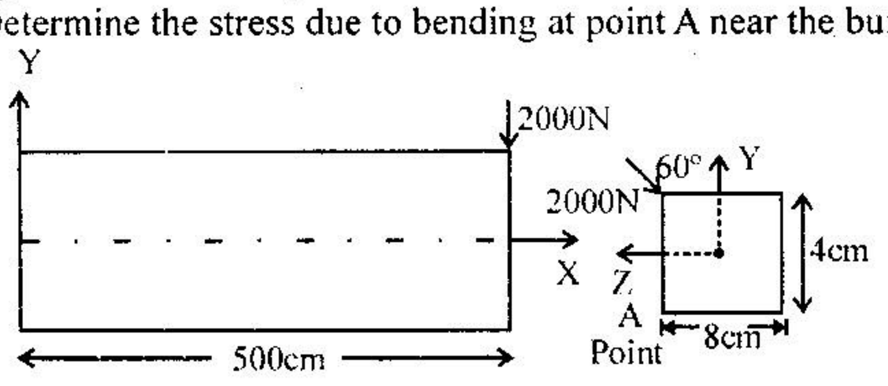
(b) A curved bar of square section 3 cm sides, mean radius of curvature 4.5 cm is initially unstressed. If a bending moment of 300 N-cm is applied to bar to straighten it, find the stresses at inner and outer faces. **(6+2)**

OR

4. **(a)** Define shear centre. Explain difference between symmetrical and unsymmetrical bending. **(2+3)**

(b) Indicate the flow of distribution of shear stress due to transverse shear and shear centre location for a thin walled inverted T section. **(3)**

(c) A cantilever beam of rectangular section is subjected to a load of 2000 N which is inclined at an angle of 60° to the vertical as shown in figure below. Determine the stress due to bending at point A near the built in end? **(8)**



Unit - V

5. (a) What is a composite tube? How is it formed? What advantage does it offer? **(1+1+2)**

(b) Draw the stress profile for σ_r and σ_θ for the thick cylinder subjected to

(i) Internal pressure alone,

(ii) External pressure alone. **(2+2)**

(c) Derive expressions for radial and circumferential stresses induced in a rotating disc of uniform thickness. Also find value of σ_r and σ_θ induced in a solid disc of uniform thickness. **(6+2)**

OR

5. (a) A flat steel disk of 150 cm diameter with a 30 cm diameter hole is shrink around a solid steel shaft. The shrink - fit allowance is 1 part in 1000 (i.e. an allowance of 0.0150 cm in radius). $E = 2.18 \times 10^6$ kg f/cm^2. Assume that equations as for solid disk are applicable to rotating solid shaft also.

Take v = 0.3 for steel, and p = 8.1 gm/cm^3

(i) What are stresses due shrink - fit?

(ii) At what rpm will the shrink fit loosen up as a result of rotation? **(4+6)**

(b) A thick - walled steel cylinder with radii a = 5 cm and b = 10cm is subjected to an internal pressure P. The yield stress in tension for the material is 350 mpa. Using a FOS of 1.5, determine the maximum working pressure P according to

(i) Maximum Normal stress theory

(ii) Maximum Shear stress theory **(3+3)**

(Take allowable shear stress as 0.5 times allowable tensile stress in the material).