



RN-7473

**B. E. IV (Sem. VII) (Mech.) Examination**  
**May / June - 2010**  
**Mechanical Design Analysis**  
*(Elective - I)*

Time : 3 Hours]

[Total Marks : 100

**Instructions :**

(1)

नीचे दृश्यावले निशानीवाणी विगतो उत्तरवडी पर अवश्य लपवी.  
Fillup strictly the details of signs on your answer book.

Name of the Examination :  
**B. E. 4 (Sem. 7) (Mech.)**

Name of the Subject :  
**Mechanical Design Analysis (Elective - 1)**

Subject Code No. : **7 4 7 3** Section No. (1, 2,.....): **1&2**

Seat No. :

Student's Signature

- (2) Attempt **all** questions.
- (3) Figures to the **right** indicate **full** marks.
- (4) Assume **suitable data** if **necessary**.
- (5) Use of **calculator** is permissible.

**SECTION - I**

- 1 (a) Answer the following : (any **five**) **10**
- (1) Define body force and surface force.
  - (2) Explain in brief plain strain condition.
  - (3) What is state of pure shear ?
  - (4) Write down equilibrium equations for plane stress state. (Assume XY plane)
  - (5) Explain in brief maximum shear stress theory.
  - (6) What is  $\pi$  plane ?
  - (7) Write down strain displacement relationship in cartesian co-ordinates.

- (b) Derive Saint-Venant's equations of compatibility for a solid body. **10**

**OR**

- (b) The displacement field in micro units for a body is given by **10**

$$u = (x^2 + y)i + (3 + z)j + (x^2 + 2y)k.$$

Determine the principal strains at (3,1,-2) and the direction of the minimum principal strain.

**2** Attempt the following :

- (a) The following state of strain exists at a point p **3**

$$[E_{ij}] = \begin{bmatrix} 0.02 & -0.04 & 0 \\ -0.04 & 0.06 & -0.02 \\ 0 & -0.02 & 0 \end{bmatrix}$$

in the direction PQ having direction cosines  $n_x = 0.6$ ,  
 $n_y = 0$  and  $n_z = 0.8$ .

Determine  $E_{PQ}$ .

- (b) With respect to the frame of reference OXYZ, the following state of stress exists. Determine principal stresses and their associated directions. **10**  
Also, check on the invariances of  $I_1, I_2, I_3$

$$[\tau_{ij}] = \begin{bmatrix} 1 & 2 & 1 \\ 2 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix}.$$

**3** Answer the following :

- (i) If the body forces are zero, prove that **9**  
 $\nabla^2(\sigma_x + \sigma_y) = 0$  is the governing equation for both the plane stress and plain strain problem.

**OR**

- (i) Prove that  $\phi = \frac{p \cdot r \cdot \theta}{\mu} \sin\theta$  is Airy's stress function **9**

where  $p$  is the load per unit length. Hence find

$\sigma_r$ ,  $\sigma_\theta$  and  $\tau_{r\theta}$ .

- (ii) Derive the governing equation of Torsion in terms of warping function. **8**

**OR**

- (ii) Derive the general expression for the deflection of a cantilever beam with the point load at the free end. **8**

### SECTION - II

- 4 (a) Attempt following questions : **10**

(1) Draw So'derberg and Goodman diagram.

(2) What is thermal stress ?

(3) What is stress relaxation ?

(4) Draw three element rectangular rosette.

(5) What are the assumptions made in calculation of bending stress ?

- (b) Derive the following equation for cylindrical bending of rectangular plate in one direction as, **10**

$$D \frac{d^2 y}{dx^2} = -M = \frac{D}{r}.$$

- 5 (a) Derive equation of stress for circular plate with clamped edges subjected to bending **9**

$$\left(\sigma_r\right)_{\max} = \frac{3qa^2}{4h^2}.$$

**OR**

- (a) Derive the following equation for a circular hollowing rotating disc of radius  $r_i$  and  $r_0$  **9**

$$(\sigma_r)_{\max} = \frac{3+\mu}{8} \rho w^2 (r_0^2 - r_i^2)$$

$$(\sigma_\theta)_{\max} = \frac{3+\mu}{4} \rho w^2 \left[ r_0^2 + \frac{(1-\mu)}{(3+\mu)} r_i^2 \right]$$

- (b) Explain the design for finite life subjected to completely reversed stresses problem. **6**

- 6** (a) Write a short note on strain gauge. **7**

- (b) Four element rectangular rosette applied on **8**

Al-specimen gives strain readings as  $\epsilon_A = 300 \times 10^{-6}$ ,

$\epsilon_B = 200 \times 10^{-6}$ ,  $\epsilon_C = 600 \times 10^{-6}$ ,  $\epsilon_D = 700 \times 10^{-6}$ .

Determine principal stresses and their directions.

Assume  $E = 0.675 \times 10^6 \text{ kg/cm}^2$  and  $\mu = 0.33$  for aluminium.

**OR**

- (b) Do the thermal analysis of thin circular solid disc. **8**