Date: 09/05/2018

Major Exam

CAD and Finite Element Analysis (MCL 311)

Start Time: 08:00 am

Total marks: 120

Duration: 2 Hrs.

Name:

Entry No.:

## PART-A: FE

1. Fill in the blanks (write in question paper itself) [5]

   a. Variational method (Rayleigh Ritz) makes use of the principle called_______________________ ____________________, while Galerkin method which is one of the type of ___________ ______________ method, makes use of the ____________________________ ______ to solve for a problem.

   b. In FE method, higher order shape functions ________________ the accuracy of an approximate solution, and ____________________ the required computational effort.

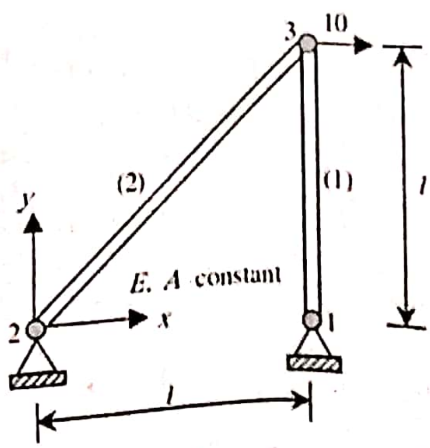
   c. If an FE element is described by cubic shape functions, then the resulting strain will be of ______ ______________ order.

   d. A Bar is a member which resist only _______________ loads, and Beam is member which resists only ________________ loads.

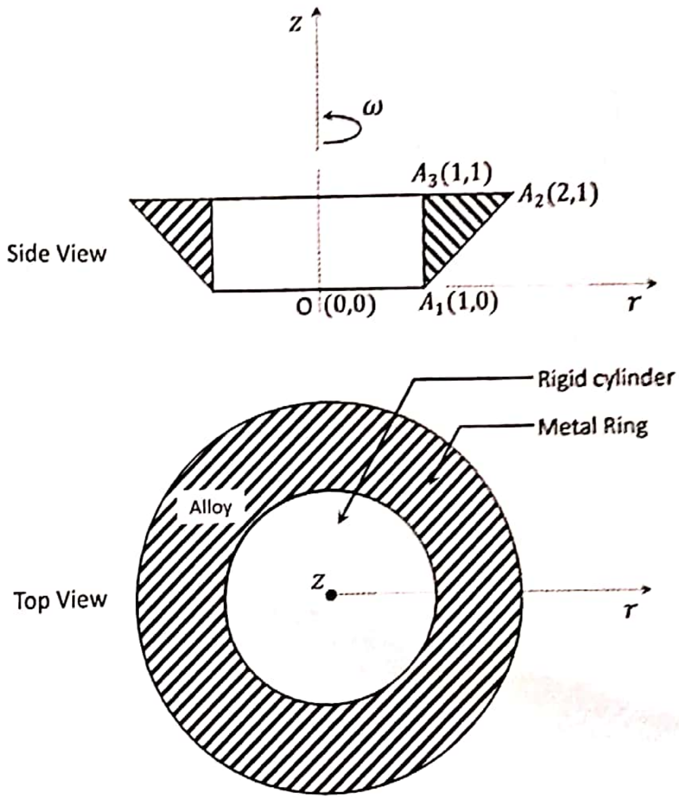
   e. Higher Skewness of an element in FEM indicates __________________ element quality.

   f. When the inertial effects due to mass of the component and externally applied load is considered, then the analysis is called ________________ analysis.

2. For the two–bar truss shown in figure below, determine the displacements of node 3 and the stresses in elements 1 and 2, using Finite Element method. Express results as function of given parameters shown in the figure. [20]



3. A metal alloy flywheel with triangular cross section is rigidly attached to a rigid solid cylinder of radius 1 m as shown in Fig. 6. The internal radius of flywheel is 1 m, external radius 2 m, and has a width ($A_1A_3$) of 1 m. The rigid cylinder is made to rotate with an angular velocity ω = 1000 rad/sec. Model the problem using Finite Element axisymmetric formulation with **only one triangular element**, and determine the extension in outer radius of the metal ring. Ignore gravitational effects. Density of metal alloy is ρ=10,000 kg/m³ and young's modulus E=200 GPa. [30]




a. Sketch the FE element, reference frame, show nodes, assumed nodal displacements
b. Develop the reduced FE formulation and determine the extension in outer radius of the ring (point $A_2$)

*[Show all the steps clearly and perform all calculations in standard SI units]*

Given, for metal alloy → $D = E \times \begin{bmatrix} 2 & 1 & 0 & 1 \\ 1 & 1 & 0 & 1 \\ 0 & 0 & 1 & 0 \\ 1 & 1 & 0 & 2 \end{bmatrix}$

For FE axisymmetric case:

$$\boldsymbol{k^e} = 2\pi\bar{r}\, A_e \overline{B^T} D \overline{B}$$ , where $\bar{r}$ is radius of the centroid

$$f^e = \frac{2\pi\bar{r}\, A_e}{3}\,[\,\bar{f_r}\,, \bar{f_z}\,, \bar{f_r}\,, \bar{f_z}\,, \bar{f_r}\,, \bar{f_z}\,]^T$$

$$\overline{B} = \begin{bmatrix} \frac{z_{23}}{\det \boldsymbol{J}} & 0 & \frac{z_{31}}{\det \boldsymbol{J}} & 0 & \frac{z_{12}}{\det \boldsymbol{J}} & 0 \\ 0 & \frac{r_{23}}{\det \boldsymbol{J}} & 0 & \frac{r_{13}}{\det \boldsymbol{J}} & 0 & \frac{r_{21}}{\det \boldsymbol{J}} \\ \frac{r_{23}}{\det \boldsymbol{J}} & \frac{z_{23}}{\det \boldsymbol{J}} & \frac{r_{13}}{\det \boldsymbol{J}} & \frac{z_{31}}{\det \boldsymbol{J}} & \frac{r_{21}}{\det \boldsymbol{J}} & \frac{z_{12}}{\det \boldsymbol{J}} \\ \frac{N_1}{\bar{r}} & 0 & \frac{N_1}{\bar{r}} & 0 & \frac{N_1}{\bar{r}} & 0 \end{bmatrix}$$

where, $z_{ij} = z_i - z_j$ , $r_{ij} = r_i - r_j$, $A_i = (r_i, z_i)$, and $J = \begin{bmatrix} r_{13} & z_{13} \\ r_{23} & z_{23} \end{bmatrix}$

also, at centroid of the triangle $N_1 = N_2 = N_3 = 1/3$