

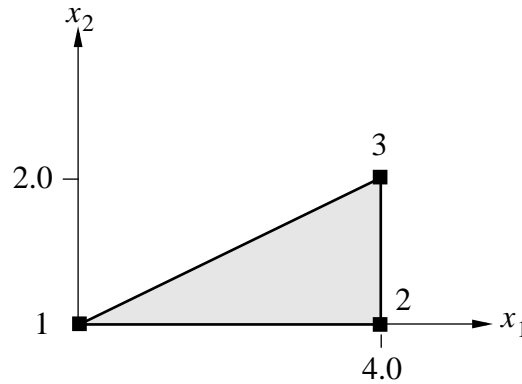
**CE 222— FINITE ELEMENT METHODS**

**PROBLEM SET #4**

**Problem 1**

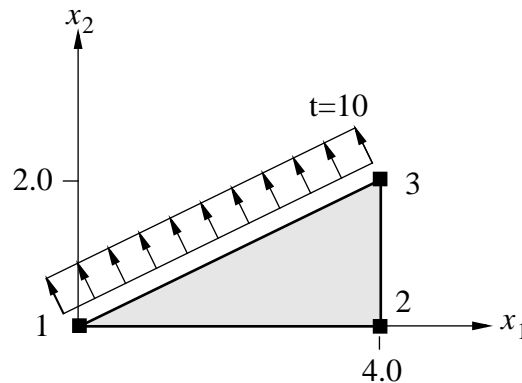
This problem pertains to the single CST element shown below. The element is in plane strain and the material has  $E=10,000$  and  $\nu=0.25$ .

- a) Determine the strains and stresses in the element due to the following nodal displacements: nodes 1 and 2 have zero displacement; node 3 has a displacement of 1.0 in the  $x_2$  direction and zero in the  $x_1$  direction.
- b) With the stresses from part (a) determine the corresponding equivalent nodal forces.
- c) Determine the  $2 \times 2$  submatrix of the element stiffness matrix for the two DOF at node 3. What is the relationship between the answers for part (b) and part (c)?



**Problem 2**

For the element in Problem 1, determine the element load vector for the traction boundary condition shown below.



**Problem 3**

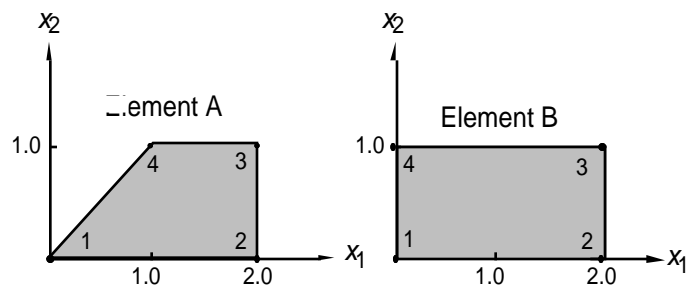
- a) For the element in Problem 1, compute the equivalent nodal forces for a uniform initial strain of 1.0 (normal components only). Are the nodal forces for the element in equilibrium with each other?
- b) Show in general that the element load vector for an initial strain contains nodal forces that are in equilibrium with each other.

#### Problem 4

Two four node elements are shown below with specific nodal coordinates. Assuming the following form of the displacements over an element:

$$u_1(x_1, x_2) = a + bx_1 + cx_2 + dx_1x_2$$

$$u_2(x_1, x_2) = e + fx_1 + gx_2 + hx_1x_2$$



Use the direct procedure to obtain the shape function for node 3 for each element (A and B). Plot the shape function for Node 3 over the element. Plot the shape function along the edges of the element. Does the shape function for Node 3 provide a compatible trial function for a Rayleigh–Ritz procedure? Explain.