**Purpose:**
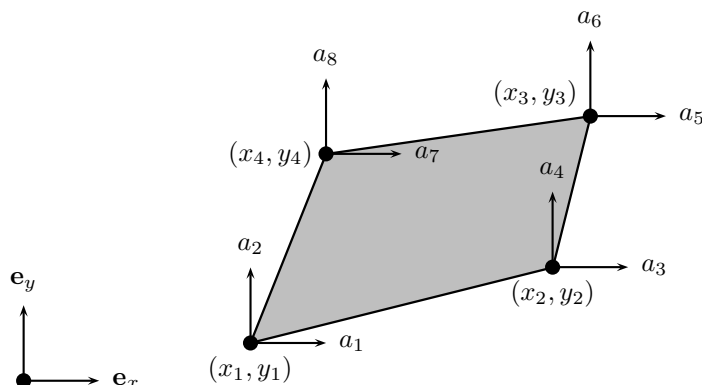
Compute the element stiffness matrix for a 4 noded large deformation element in plane strain.



**Syntax:**

Ke=plan4gie(ec,t,D,ed,es)

**Description:**

plan4gie provides the element stiffness matrix Ke for a 4 node large deformation element in plane strain. The element use 4 gauss integration points gp $= 1, 2, 3, 4$ to evaluate the integrals. The element nodal coordinates $x_1, y_1, x_2$ etc. in the undeformed configuration are supplied to the function by ec

$$
\text{ec} = \begin{bmatrix} x_1 & x_2 & x_3 & x_4 \\ y_1 & y_2 & y_3 & y_4 \end{bmatrix}
$$

The element thickness $t$ is supplied by t, ed contain the current element displacement vector obtained by the function extract and es the second Piola-Kirchhoff stress tensor.

$$
\text{ed} = \mathbf{a}^{eT} = \begin{bmatrix} a_1 \ a_2 \ \dots \ a_8 \end{bmatrix} \qquad \text{es\{gp\}} = \mathbf{S} = \begin{bmatrix} S_{11} \\ S_{22} \\ S_{12} \end{bmatrix}
$$

where es is defined as a cell structure. The material properties are supplied by the constitutive matrix $\mathbf{D}$ (also stored as a cell structure) of type $(3 \times 3)$ given as

$$
\text{D\{gp\}} = \mathbf{D} = \begin{bmatrix} D_{11} & D_{12} & D_{13} \\ D_{21} & D_{22} & D_{23} \\ D_{31} & D_{32} & D_{33} \end{bmatrix}
$$

**Purpose:**

Compute strains and deformation gradient in a 4 node large deformation element.
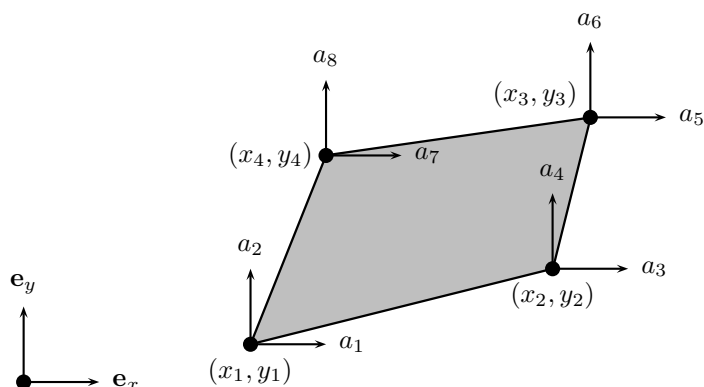


**Syntax:**

[ee,eff]=plan4gis(ec,ed)

**Description:**

plan4gis computes the Green-Lagrange strains and the deformation gradient in the 4 gauss integration points $\mathsf{gp} = 1, 2, 3, 4$

$$\mathsf{ee\{gp\}} = \mathbf{E} = \begin{bmatrix} E_{xx} \\ E_{yy} \\ 2E_{xy} \end{bmatrix} \qquad \mathsf{eff\{gp\}} = \mathbf{F} = \begin{bmatrix} \dfrac{\partial x}{\partial x^\circ} \\ \dfrac{\partial x}{\partial y^\circ} \\ \dfrac{\partial y}{\partial x^\circ} \\ \dfrac{\partial y}{\partial y^\circ} \end{bmatrix}$$

where both ee and ef are defined as a cell structure. The input variables ec and ed are defined in plan4gie.

**Purpose:**

Compute internal element force vector in a 4 node large deformation element in plane strain.
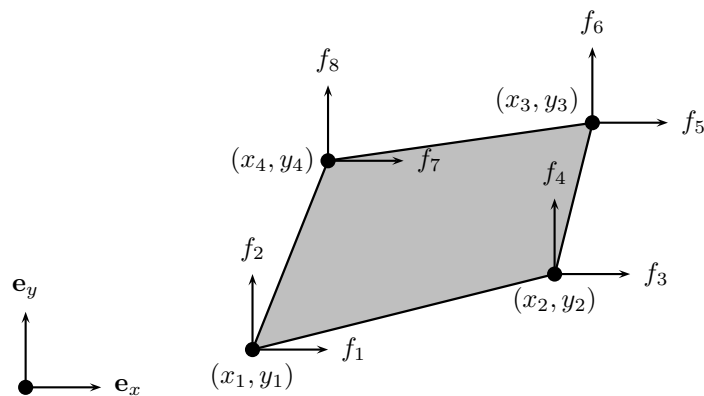


**Syntax:**

ef=plan4gif(ec,t,ed,es)

**Description:**

plan4gif computes the internal element forces vector

$$\mathsf{ef} = \mathbf{F}_{\text{int}}^{T} = \begin{bmatrix} f_1 & f_2 & \cdots & f_6 \end{bmatrix}$$

The input variables ec, t, es and ed are defined in plan4gie. To form the global internal force vector use can be made of insert.