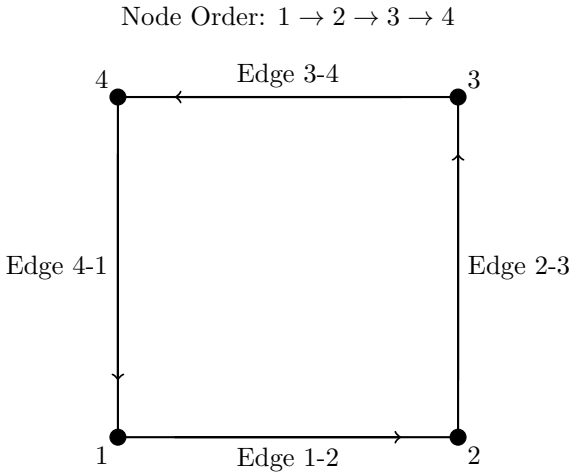
Consistent Node Ordering for FEM Elements

Four-Node Isoparametric Quadrilateral Element

In a four-node isoparametric quadrilateral element, nodes should be oriented in a consistent order, typically counterclockwise starting from the bottom-left corner. The node numbering is as follows:



Jacobian Determinant for Orientation Check

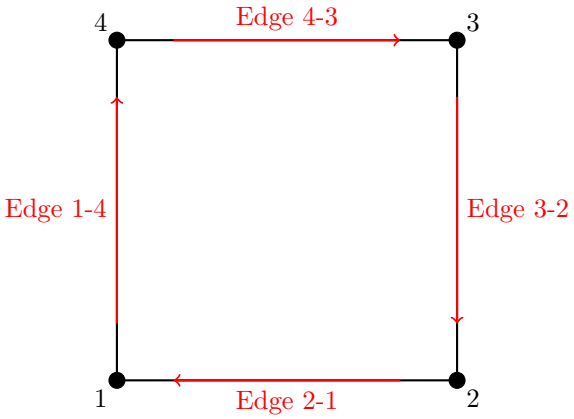
The Jacobian determinant $\det(J)$ is used to verify the orientation of elements. For a correctly oriented element (counterclockwise), $\det(J) > 0$. For a flipped element (clockwise), $\det(J) < 0$.

To check the orientation:

$$\det(J) = \frac{\partial x}{\partial \xi}\frac{\partial y}{\partial \eta} - \frac{\partial x}{\partial \eta}\frac{\partial y}{\partial \xi}$$

Example of Incorrect Orientation (Flipped Element)

If nodes are ordered clockwise (e.g., $1 \to 4 \to 3 \to 2$), the element is flipped:



Correct this orientation by reordering nodes to follow a counter-clockwise sequence.