AD FALCON API Manual

Elements

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Contents

1 Elements

The `% Elements` section defines element connectivity. Each element references node IDs and a material name (the material identifier used in `% Materials`).

For general rules about comments, numeric formats, and list/range syntax, see Input File Structure.

1.1 Section header

FALCON treats section names as case-insensitive and whitespace-insensitive, so these headers are equivalent:

```
% Elements
%Elements
% elements
%   ELEMENTS
% Element_S
% Element-s
```

1.2 Syntax

```
% Elements
<ElementID> <ElementType> <NodeID1> <NodeID2> ... <NodeIDN> <MaterialName>
<ElementID> <ElementType> <NodeID1> <NodeID2> ... <NodeIDN> <MaterialName>
...
%%%
```

1.3 Element line rules

- **ElementID**: integer identifier (recommended unique).
- **ElementType**: case-sensitive token that must match one of the supported types listed below.
- **NodeIDs**: exactly `N` node IDs (the count depends on `ElementType`).
- **MaterialName**: the last token on the line; must match a material defined in `% Materials`.

1.3.1 Multiple element definitions

- Define multiple elements by repeating the element line format; each non-empty line inside `% Elements` defines one element.
- Use a unique `ElementID` per line to avoid ambiguity.

1.4 Node ordering and orientation (read first)

FALCON uses the node order exactly as you provide it to build the element mapping. If the ordering is wrong, the element can become geometrically inverted and the solver may stop with a **negative Jacobian** error.

1.4.1 2D elements (plane strain / axisymmetric)

For 2D elements, list the **corner nodes counterclockwise (CCW)** around the element boundary.

For higher-order elements with mid-side nodes, the mid-side nodes must be inserted **between the two corner nodes that define that edge**, while still traversing the boundary CCW.

For axisymmetric analyses, apply the same 2D ordering rules in the (r,z) plane (treat `r` as `x` and `z` as `y`).

- **Triangle N3** (`N3...`): `Node1 Node2 Node3` are the three corners in CCW order around the boundary (each node is adjacent to the next).
- **Triangle N6** (`N6...`): `corner–mid(corner–corner)–corner–mid–corner–mid`, specifically:
  - `Node1` = corner 1
  - `Node2` = mid-side on edge (Node1–Node3)
  - `Node3` = corner 2
  - `Node4` = mid-side on edge (Node3–Node5)
  - `Node5` = corner 3
  - `Node6` = mid-side on edge (Node5–Node1)
  - Corner nodes are `Node1`, `Node3`, `Node5` and must be CCW.
- **Quadrilateral N4** (`N4...`): `Node1 Node2 Node3 Node4` are the four corners in CCW order around the boundary (each node is adjacent to the next).
- **Quadrilateral N8** (`N8...`): `corner–mid–corner–mid–corner–mid–corner–mid`, specifically:
  - `Node1` = corner 1
  - `Node2` = mid-side on edge (Node1–Node3)
  - `Node3` = corner 2
  - `Node4` = mid-side on edge (Node3–Node5)
  - `Node5` = corner 3
  - `Node6` = mid-side on edge (Node5–Node7)
  - `Node7` = corner 4
  - `Node8` = mid-side on edge (Node7–Node1)
  - Corner nodes are `Node1`, `Node3`, `Node5`, `Node7` and must be CCW.

If you see a negative Jacobian for a 2D element, the first fix is usually to **reverse the corner-node order** (swap any two corner nodes, and keep the mid-side nodes on their corresponding edges).

1.4.2 3D tetrahedra (T10 / N10)

For 3D tetrahedra, the first four nodes are the corner vertices and must form a **right-handed (positive-volume) orientation**. A convenient check is that the signed volume is positive:

$$V = \frac{1}{6}(\mathbf{x}_2 - \mathbf{x}_1) \cdot \big((\mathbf{x}_3 - \mathbf{x}_1) \times (\mathbf{x}_4 - \mathbf{x}_1)\big) > 0$$

For 10-node tetrahedra, after the four corners, the six mid-edge nodes must be listed on these edges (in this order):

- `Node5` = edge (Node1–Node2)
- `Node6` = edge (Node2–Node3)
- `Node7` = edge (Node3–Node1)
- `Node8` = edge (Node1–Node4)
- `Node9` = edge (Node2–Node4)
- `Node10` = edge (Node3–Node4)

1.4.3 Principal nodes (pressure DOFs)

In coupled / fully coupled analyses, pore-pressure DOFs exist only on **principal (corner) nodes**:

- `N6` / `N8`: only corner nodes are principal (`Node1,Node3,Node5` and `Node1,Node3,Node5,Node7`).
- `T10` / `N10`: only the first 4 corner nodes are principal.

This does not change the element-orientation rules: 2D corner nodes must be **counter-clockwise (CCW)**, and 3D tetrahedra must be **right-handed (positive volume)**.

1.5 Supported element types

FALCON validates `ElementType` strictly against a fixed set of supported tokens. The supported types are:

1.5.1 2D triangles

ElementType	Nodes	Notes
`N3P1`, `N3P3`, `N3P7`	3	Uncoupled only.
`N3P1!`, `N3P3!`, `N3P7!`	3	Starts inactive.
`N6P3`, `N6P6`, `N6P7`	6	Uncoupled.
`N6P3!`, `N6P6!`, `N6P7!`	6	Starts inactive.

ElementType	Nodes	Notes
N6P3C, N6P6C, N6P7C	6	Coupled (saturated).
N6P3C!, N6P6C!, N6P7C!	6	Coupled + starts inactive.
N6P3F, N6P6F, N6P7F	6	Fully coupled (unsaturated).
N6P3F!, N6P6F!, N6P7F!	6	Fully coupled + starts inactive.

1.5.2 2D quadrilaterals

ElementType	Nodes	Notes
N4P1, N4P1!	4	Uncoupled; ! = starts inactive.
N4P1C, N4P1C!	4	Coupled (saturated).
N4P1F, N4P1F!	4	Fully coupled (unsaturated).
N4P4, N4P4!	4	Uncoupled; ! = starts inactive.
N4P9, N4P9!	4	Uncoupled; ! = starts inactive.
N4P9C!	4	Coupled + starts inactive.
N4P9F!	4	Fully coupled + starts inactive.
N8P4	8	Uncoupled.
N8P4C, N8P4C!	8	Coupled (saturated).
N8P4F, N8P4F!	8	Fully coupled (unsaturated).
N8P8, N8P8!	8	Uncoupled; ! = starts inactive.
N8P8C, N8P8C!	8	Coupled (saturated).
N8P8F, N8P8F!	8	Fully coupled (unsaturated).
N8P9, N8P9!	8	Uncoupled; ! = starts inactive.
N8P9C, N8P9C!	8	Coupled (saturated).
N8P9F, N8P9F!	8	Fully coupled (unsaturated).

1.5.3 3D tetrahedra

ElementType	Nodes	Notes
T10P4, T10P4!	10	Uncoupled; ! = starts inactive.
T10P4C, T10P4C!	10	Coupled (saturated).
T10P4F, T10P4F!	10	Fully coupled (unsaturated).
N10P10, N10P10!	10	Alias for T10P4 (same variants).
N10P10C, N10P10C!	10	Coupled alias.

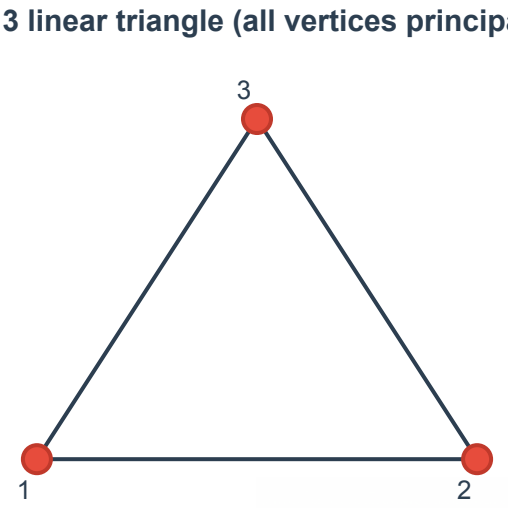

Figure 1: N3 triangle

ElementType	Nodes	Notes
`N10P10F`, `N10P10F!`	10	Fully coupled alias.
`N10P4`, `N10P4!`	10	Also supported.
`N10P4C`, `N10P4C!`	10	Coupled.
`N10P4F`, `N10P4F!`	10	Fully coupled.

1.5.4 Infinite elements (brief)

Do **not** define infinite elements directly in `% Elements`. Infinite elements are generated by the dedicated `% Infinite Elements` section; see Infinite Elements.

1.6 Element schematics

1.7 Examples

1.7.1 Uncoupled (plane strain / axisymmetric)

```
% Elements
1 N4P4   1 2 3 4    Clay
2 N3P3   2 5 3      Clay
%%%
```

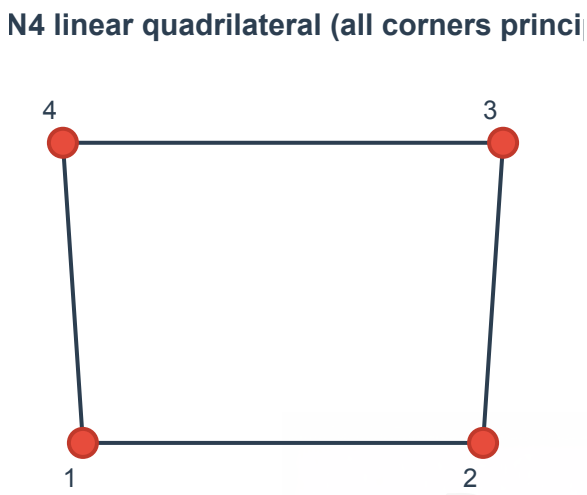

Figure 2: N4 quadrilateral

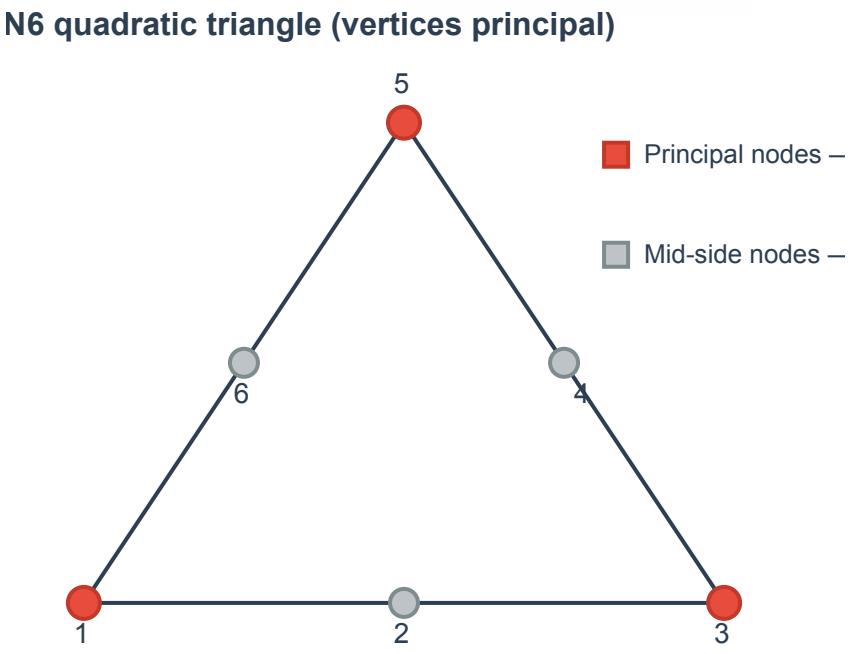

Figure 3: N6 triangle

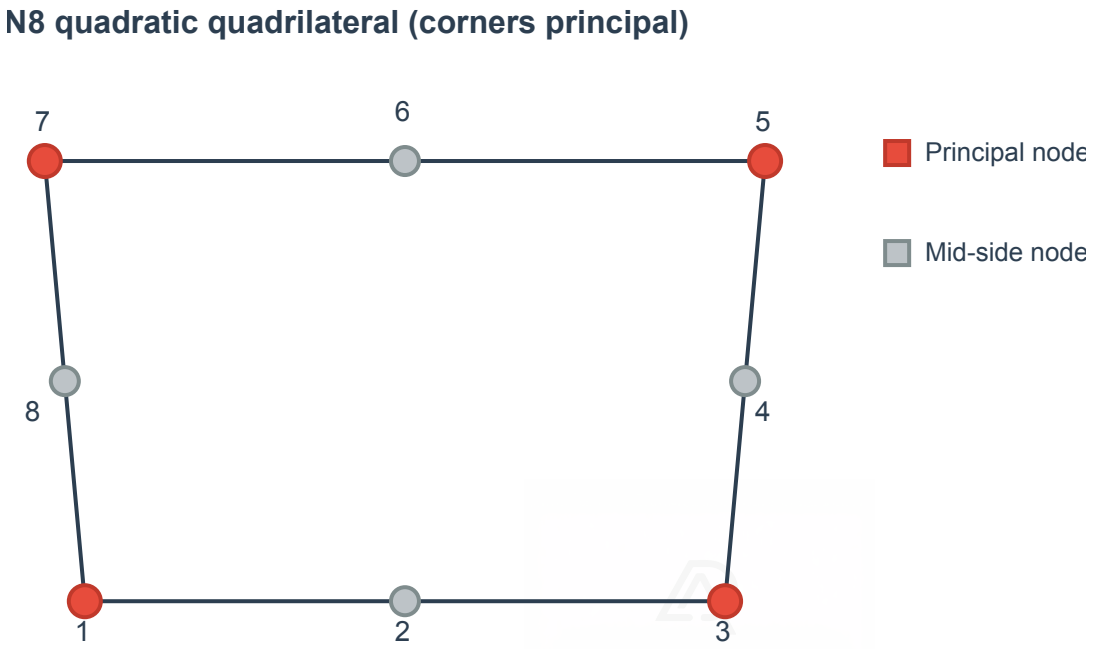

Figure 4: N8 quadrilateral

1.7.2 Coupled (note the C suffix)

```
% Elements
1 N4P1C  1 2 3 4   Clay
2 N6P6C  1 5 2 6 3 7   Clay
%%%
```

1.7.3 Fully coupled and initially inactive (note F!)

```
% Elements
1 N8P8F!  1 5 2 6 3 7 4 8   Clay
%%%
```

1.8 Troubleshooting

- **Wrong element type**: if the type is not recognized, use one of the supported types above.
- **Wrong node count**: the number of node IDs must match the element type (e.g., 6 node IDs for `N6...`).
- **Missing node/material**: ensure all referenced node IDs exist in `% Nodes` and material IDs

exist in `% Materials`.