

Example 1: Analysis of Three-Bar Truss

Element Stiffness Matrices: Bar 1

Bar 1 stiffness (local coordinates):
=====

Matrix: Element Stiffness (local coordinates)

row/col	1	2
1	1.00000e-01	-1.00000e-01
2	-1.00000e-01	1.00000e-01

Bar 1 stiffness (joint coordinates):
=====

Matrix: Element Stiffness (joint coordinates)

row/col	1	2	3	4
1	1.00000e-01	0.00000e+00	-1.00000e-01	-0.00000e+00
2	0.00000e+00	0.00000e+00	-0.00000e+00	-0.00000e+00
3	-1.00000e-01	0.00000e+00	1.00000e-01	0.00000e+00
4	-0.00000e+00	-0.00000e+00	0.00000e+00	0.00000e+00

Example 1: Analysis of Three-Bar Truss

Step 1: Add Elmt 1 to Global Stiffness Matrix

Matrix: Global Stiffness Matrix (incremental)

row/col	1	2	3
1	1.00000e-01	0.00000e+00	0.00000e+00
2	0.00000e+00	0.00000e+00	0.00000e+00
3	0.00000e+00	0.00000e+00	0.00000e+00

Step 2: Add Elmt 2 to Global Stiffness Matrix

Matrix: Global Stiffness Matrix (incremental)

row/col	1	2	3
1	1.00000e-01	0.00000e+00	0.00000e+00
2	0.00000e+00	0.00000e+00	0.00000e+00
3	0.00000e+00	0.00000e+00	1.00000e-01

Example 1: Analysis of Three-Bar Truss

Assembly of External Load Vector:

Matrix: Load Vector: eload01

row/col	1
1	0.00000e+00
2	1.00000e+01
3	0.00000e+00

Solution of Global Displacements:

Matrix: Displacement Vector (displ01)

row/col	1
1	1.00000e+02
2	4.82843e+02
3	1.00000e+02

Example 1: Analysis of Three-Bar Truss

Elmt 1: Member Displacements and Forces:

Matrix: Geometry transformation ([a]):

row/col	1	2	3	4
1	1.00000e+00	0.00000e+00	0.00000e+00	0.00000e+00
2	0.00000e+00	0.00000e+00	1.00000e+00	0.00000e+00

Matrix: Member displacements ([v] = [a][r]):

row/col	1
1	0.00000e+00
2	1.00000e+02

Matrix: Member forces ([S] = [k][v]):

row/col	1
1	-1.00000e+01
2	1.00000e+01

--- Axial force = 10.000000 (T) ...

Example 1: Analysis of Three-Bar Truss

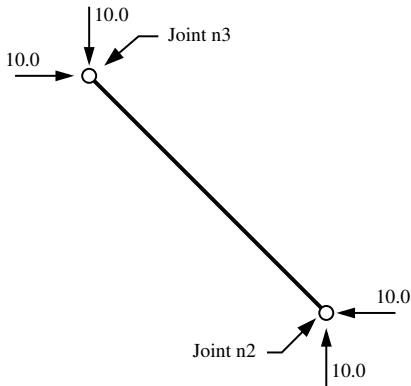
Elmt 3: Joint Displacements and Forces:

Matrix: Elmt (joint displacements [r]):

row/col	1
1	1.00000e+02
2	0.00000e+00
3	4.82843e+02
4	1.00000e+02

Matrix: Elmt (joint forces):

row/col	1
1	-1.00000e+01
2	1.00000e+01
3	1.00000e+01
4	-1.00000e+01



Example 1: Analysis of Three-Bar Truss

Elmt 3: Member Displacements and Forces:

Matrix: Geometry transformation ($[a]$):

row/col	1	2	3	4
1	-7.07107e-01	7.07107e-01	0.00000e+00	0.00000e+00
2	0.00000e+00	0.00000e+00	-7.07107e-01	7.07107e-01

Matrix: Member displacements ($[v] = [a][r]$):

row/col	1
1	-7.07107e+01
2	-2.70711e+02

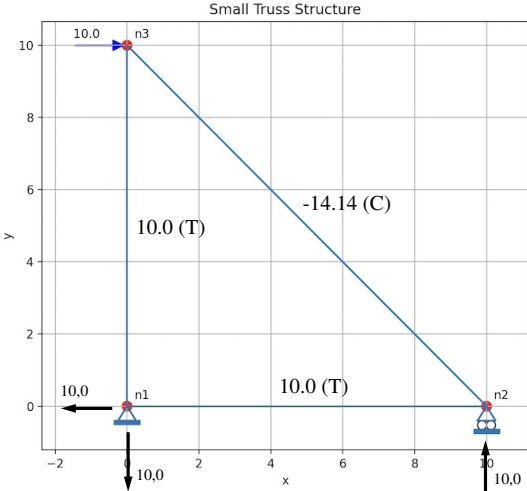
Matrix: Member forces ($[S] = [k][v]$):

row/col	1
1	1.41421e+01
2	-1.41421e+01

--- Axial force = -14.142136 (C) ...

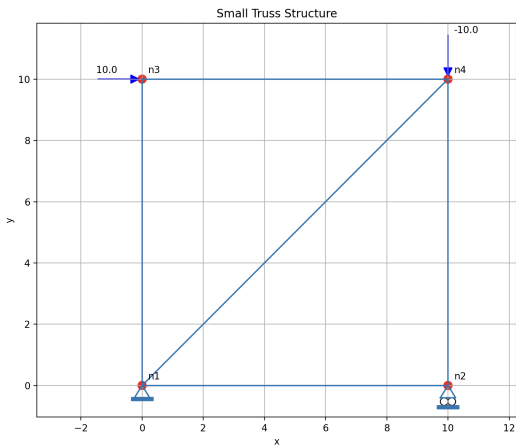
Example 1: Analysis of Three-Bar Truss

Summary of Member Forces and Reactions



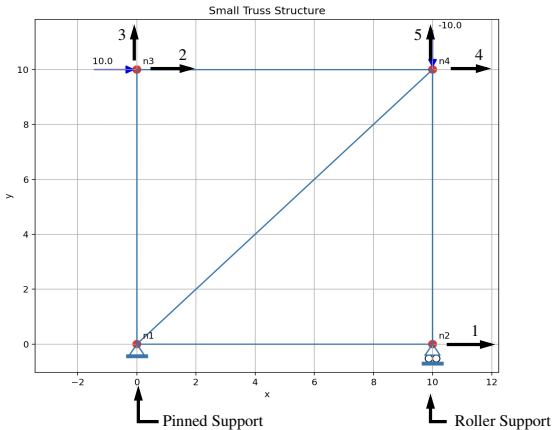
Example 2: Analysis of Five-Bar Truss

Geometry and External Loads



Example 2: Analysis of Five-Bar Truss

Boundary Conditions and Global DOF



Example 2: Analysis of Five-Bar Truss

Preliminary Observations:

- 1 Node n2 is a roller oriented horizontally – thus, we expect that the bar element connecting nodes n1 and n2 will be a zero-force member.
- 2 Taking moments about A indicates that the reaction force at B will be 20 acting upwards.
- 3 Summing forces in the vertical direction for the whole structure – the reaction force at A will be 10 acting downwards.
- 4 Support A will also have a horizontal reaction force acting right-to-left.

Example 2: Analysis of Five-Bar Truss

Specification: Nodes and Elements

Nodes

=====

Node: n1, (x,y) = (0.00, 0.00)

DOF: (x,y) = [False, False]

Map LDOF-to-GDOF: (x,y) = [0, 0]

Node: n2, (x,y) = (10.00, 0.00)

DOF: (x,y) = [True, False] kk

Map LDOF-to-GDOF: (x,y) = [1, 0]

Node: n3, (x,y) = (0.00, 10.00)

DOF: (x,y) = [True, True]

Map LDOF-to-GDOF: (x,y) = [2, 3]

Node: n4, (x,y) = (10.00, 10.00)

DOF: (x,y) = [True, True]

Map LDOF-to-GDOF: (x,y) = [4, 5]

Elements (E = A = 1.0)

=====

Bar2D: e01: Nodes (n1, n2)

Length L = 10.00000

Bar2D: e02: Nodes (n1, n3)

Length L = 10.00000

Bar2D: e03: Nodes (n2, n4)

Length L = 10.00000

Bar2D: e04: Nodes (n3, n4)

Length L = 10.00000

Bar2D: e05: Nodes (n1, n4)

Length L = 14.142136

Example 2: Analysis of Five-Bar Truss

Boundary Conditions

```
Node n1: (x,y) pin support: dof free to move --> [ False, False ]
Node n2: (x,y) roller support: dof free to move --> [ True, False ]
Node n3: (x,y) dof free to move --> [ True, True ]
Node n4: (x,y) dof free to move --> [ True, True ]
```

Nodal Loads

```
Node Load: n3
Loads: [ Fx, Fy ] = [ 10.00, 0.00 ]
Node Load: n4
Loads: [ Fx, Fy ] = [ 0.00, -10.00 ]
```

Model Compilation:

```
=====
No nodes       = 4
No elements    = 5
No node loads  = 2
```

Example 2: Analysis of Five-Bar Truss

Model Compilation: Continued ...

Node: n1

Coordinates: (x,y) = (0.00, 0.00)

DOF: (x,y) = [False, False]

Map: LDOF->GDOF: [0, 0]

Node: n2

Coordinates: (x,y) = (10.00, 0.00)

DOF: (x,y) = [True, False]

Map: LDOF->GDOF: [1, 0]

Node: n3

Coordinates: (x,y) = (0.00, 10.00)

DOF: (x,y) = [True, True]

Map: LDOF->GDOF: [2, 3]

Node: n4

Coordinates: (x,y) = (10.00, 10.00)

DOF: (x,y) = [True, True]

Map: LDOF->GDOF: [4, 5]

Element: e01, Element: e02, Element: e03, Element: e04, Element: e05

Example 2: Analysis of Five-Bar Truss

Model Compilation: Continued ...

Node Load: n3 ...

Loads: [Fx, Fy] = [10.00, 0.00]

Node Load: n4 ...

Loads: [Fx, Fy] = [0.00, -10.00]

=====

Destination Array

Matrix: Destination Array

row/col	1	2	3	4
1	0.00000e+00	0.00000e+00	1.00000e+00	0.00000e+00
2	0.00000e+00	0.00000e+00	2.00000e+00	3.00000e+00
3	1.00000e+00	0.00000e+00	4.00000e+00	5.00000e+00
4	2.00000e+00	3.00000e+00	4.00000e+00	5.00000e+00
5	0.00000e+00	0.00000e+00	4.00000e+00	5.00000e+00

Example 2: Analysis of Five-Bar Truss

Global Stiffness Matrix

Matrix: GlobalStiffness: stiff01

row/col	1	2	3	4	5
1	1.00000e-01	0.00000e+00	0.00000e+00	0.00000e+00	0.00000e+00
2	0.00000e+00	1.00000e-01	0.00000e+00	-1.00000e-01	0.00000e+00
3	0.00000e+00	0.00000e+00	1.00000e-01	0.00000e+00	0.00000e+00
4	0.00000e+00	-1.00000e-01	0.00000e+00	1.35355e-01	3.53553e-02
5	0.00000e+00	0.00000e+00	0.00000e+00	3.53553e-02	1.35355e-01

External Load Vector

Matrix: Load Vector: eload01

row/col	1
1	0.00000e+00
2	1.00000e+01
3	0.00000e+00
4	0.00000e+00
5	-1.00000e+01

Example 2: Analysis of Five-Bar Truss

Global Displacement Vector

Matrix: Displacement Vector (displ01)

row/col	1
1	0.00000e+00
2	5.82843e+02
3	0.00000e+00
4	4.82843e+02
5	-2.00000e+02

Example 2: Analysis of Five-Bar Truss

Element-Level Displacements and Member Forces

Elmt 1: Connects nodes n1 and n2

Matrix: Member displ ([v] = [a][r]):	Matrix: Member forces ([S] = [k][v]):
row/col 1	row/col 1
1 0.00000e+00	1 0.00000e+00
2 0.00000e+00	2 0.00000e+00

---> Axial force = 0.000000 (T) ...

Elmt 2: Connects nodes n1 and n3

Matrix: Member displ ([v] = [a][r]):	Matrix: Member forces ([S] = [k][v]):
row/col 1	row/col 1
1 0.00000e+00	1 0.00000e+00
2 0.00000e+00	2 0.00000e+00

---> Axial force = 0.000000 (T) ...

Example 2: Analysis of Five-Bar Truss

Elmt 5: Connects nodes n1 and n4

Matrix: Member displ ($[v] = [a][r]$):

row/col	1
1	0.00000e+00
2	2.00000e+02

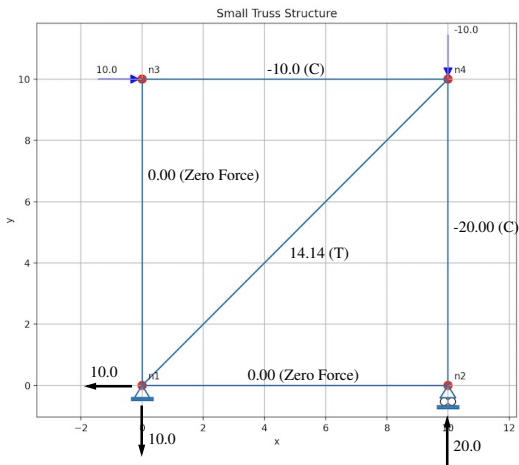
Matrix: Member forces ($[S] = [k][v]$):

row/col	1
1	-1.41421e+01
2	1.41421e+01

---> Axial force = 14.142136 (T) ...

Example 2: Analysis of Five-Bar Truss

Summary of Member Forces and Support Reactions



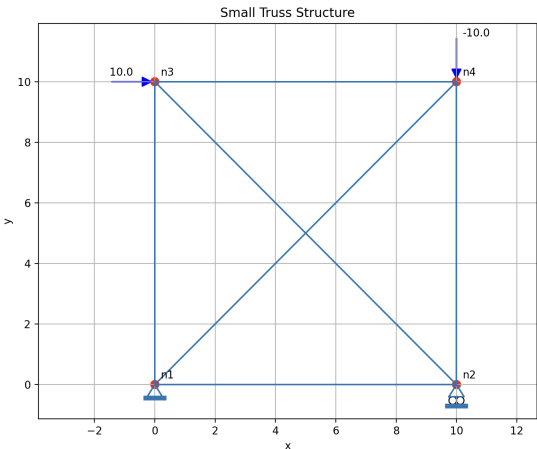
Example 3

Example 3

Analysis of Six-Bar Truss

Example 3: Analysis of Six-Bar Truss

Geometry and External Loads



Example 3: Analysis of Six-Bar Truss

Specification: Nodes and Elements

Nodes

=====

Node: n1, $(x,y) = (0.00, 0.00)$
DOF: $(x,y) = [False, False]$
Map LDOF-to-GDOF: $(x,y) = [0, 0]$

Node: n2, $(x,y) = (10.00, 0.00)$
DOF: $(x,y) = [True, False]$ kk
Map LDOF-to-GDOF: $(x,y) = [1, 0]$

Node: n3, $(x,y) = (0.00, 10.00)$
DOF: $(x,y) = [True, True]$
Map LDOF-to-GDOF: $(x,y) = [2, 3]$

Node: n4, $(x,y) = (10.00, 10.00)$
DOF: $(x,y) = [True, True]$
Map LDOF-to-GDOF: $(x,y) = [4, 5]$

Elements (E = A = 1.0)

=====

Bar2D: e01: Nodes (n1, n2)
Length L = 10.00000

Bar2D: e02: Nodes (n1, n3)
Length L = 10.00000

Bar2D: e03: Nodes (n2, n4)
Length L = 10.00000

Bar2D: e04: Nodes (n3, n4)
Length L = 10.00000

Bar2D: e05: Nodes (n1, n4)
Length L = 14.142136

Bar2D: e06: Nodes (n2, n3)
Length L = 14.142136

Example 3: Analysis of Six-Bar Truss

Boundary Conditions

```
Node n1: (x,y) pin support: dof free to move  --> [ False, False ]
Node n2: (x,y) roller support: dof free to move --> [ True, False ]
Node n3: (x,y) dof free to move              --> [ True, True ]
Node n4: (x,y) dof free to move              --> [ True, True ]
```

Nodal Loads

```
Node Load: n3
Loads: [ Fx, Fy ] = [ 10.00,  0.00 ]
Node Load: n4
Loads: [ Fx, Fy ] = [ 0.00, -10.00 ]
```

Example 3: Analysis of Six-Bar Truss

Destination Array

Matrix: Destination Array

row/col	1	2	3	4
1	0.00000e+00	0.00000e+00	1.00000e+00	0.00000e+00
2	0.00000e+00	0.00000e+00	2.00000e+00	3.00000e+00
3	1.00000e+00	0.00000e+00	4.00000e+00	5.00000e+00
4	2.00000e+00	3.00000e+00	4.00000e+00	5.00000e+00
5	0.00000e+00	0.00000e+00	4.00000e+00	5.00000e+00
6	1.00000e+00	0.00000e+00	2.00000e+00	3.00000e+00

Example 3: Analysis of Six-Bar Truss

Global Stiffness Matrix

Matrix: GlobalStiffness: stiff01

row/col	1	2	3	4	5
1	1.35355e-01	-3.53553e-02	3.53553e-02	0.00000e+00	0.00000e+00
2	-3.53553e-02	1.35355e-01	-3.53553e-02	-1.00000e-01	0.00000e+00
3	3.53553e-02	-3.53553e-02	1.35355e-01	0.00000e+00	0.00000e+00
4	0.00000e+00	-1.00000e-01	0.00000e+00	1.35355e-01	3.53553e-02
5	0.00000e+00	0.00000e+00	0.00000e+00	3.53553e-02	1.35355e-01

External Load Vector

Matrix: Load Vector: eload01

row/col	1
1	0.00000e+00
2	1.00000e+01
3	0.00000e+00
4	0.00000e+00
5	-1.00000e+01

