2D FRAME AND TRUSS ANALYSIS

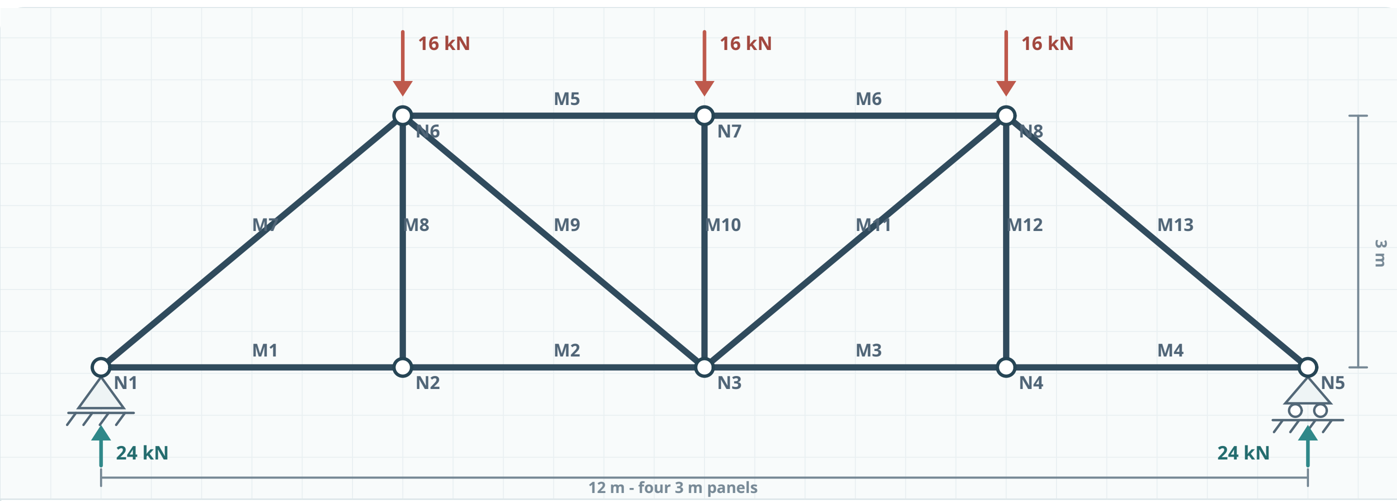
Pratt Truss Analysis: Worked Example

Four-panel Pratt truss

Hand calculation, independent checks and comparison with the Optimal Beam 2D Structural Analysis results.

Project field	Report value
Example / model	OB-EX-TRUSS-001 · Four-panel Pratt truss
Prepared and reviewed by	Tamer Hijjawi, P.Eng.
Last verified	2026-07-26

Analysis model and defined loads



Applied load — Support reaction — Pin at N1 - vertical roller at N5

LEFT VERTICAL REACTION	RIGHT VERTICAL REACTION	MAXIMUM COMPRESSION	MAXIMUM TENSION	CENTRE VERTICAL DISPLACEMENT
24.000 kN	24.000 kN	33.941 kN	24.000 kN	0.656 mm downward

Report role: This worked example documents the independent hand checks and their comparison with the analyzed model. The complete browser-generated Optimal Beam calculation package is a separate download: open the full solver package.

01 MODEL DEFINITION

Geometry, restraints, material and loading

A simply supported, four-panel Pratt truss spans 12 m and is 3 m high. Three 16 kN downward loads act at the upper panel points. All members use the same steel modulus and cross-sectional area.

Span	Height	Panels	Supports	Material	Area
12 m	3 m	4 at 3 m	Pin + roller	E = 200 GPa	5000 mm2

Node coordinates and supports

Node	X (m)	Y (m)	Support	Restrained translations
N1	0.0	0.0	Pin	UX, UY
N2	3.0	0.0	Free	-
N3	6.0	0.0	Free	-
N4	9.0	0.0	Free	-
N5	12.0	0.0	Vertical roller	UY
N6	3.0	3.0	Free	-
N7	6.0	3.0	Free	-
N8	9.0	3.0	Free	-

Support check: N1 is a pin that restrains UX and UY. N5 is a vertical roller that restrains UY only; horizontal translation at N5 remains free.

Applied nodal loads

Load	Node	FX (kN)	FY (kN)	MZ (kN m)
L1	N6	0.000	-16.000	0.000
L2	N7	0.000	-16.000	0.000
L3	N8	0.000	-16.000	0.000

02 STRUCTURAL IDEALIZATION

Member connectivity and analysis assumptions

The analytical model isolates the in-plane axial response of an ideal truss. The connectivity and assumptions below define the calculation.

Member	Connectivity	L (m)	Member	Connectivity	L (m)
M1	N1 to N2	3.000	M8	N6 to N2	3.000
M2	N2 to N3	3.000	M9	N6 to N3	4.243
M3	N3 to N4	3.000	M10	N7 to N3	3.000
M4	N4 to N5	3.000	M11	N8 to N3	4.243
M5	N6 to N7	3.000	M12	N8 to N4	3.000
M6	N7 to N8	3.000	M13	N8 to N5	4.243
M7	N1 to N6	4.243			

Included in the model

- Members are straight, prismatic and connected by ideal pins at the nodes.
- Loads are applied only at panel points, so the members carry idealized axial force.
- The material is linear elastic and all members use E = 200 GPa.
- All members use a uniform cross-sectional area of 5000 mm².
- The left support restrains global X and Y; the right support restrains global Y only.
- Member self-weight is omitted.

Outside the analysis scope

- Connection stiffness, gusset-plate behavior and joint eccentricity.
- Member buckling, yielding, fracture or code-based resistance checks.
- Geometric nonlinearity, P-Delta effects and large-displacement behavior.
- Out-of-plane response, lateral bracing and three-dimensional load paths.
- Construction tolerances, residual stress and fabrication effects.

Engineering boundary: Use the calculated forces to inform separate design checks. Verify buckling, yielding, connections, lateral bracing and code compliance for the real structure.

03 HAND CALCULATION

Global equilibrium and method of joints

Positive axial force denotes tension and negative axial force denotes compression. Global +Y is upward.

1. Determinacy

13 + 3 = 2(8) = 16

The equality is satisfied and the arranged truss is statically determinate and stable.

2. Support reactions

RAy + RBy = 48.000 kN; by symmetry RAy = RBy = 24.000 kN; RAx = 0.000 kN.

The total calculated vertical reaction equals the total applied vertical load.

3. Zero-force members

M8 = M12 = 0.000 kN

At N2 and N4, two collinear bottom-chord members meet one non-collinear vertical member with no external joint load. The non-collinear member is therefore a zero-force member.

4. Joint N1

M7 = -24 / sin(45 degrees) = -33.941 kN; M1 = +24.000 kN.

The negative end-post result is compression; the positive bottom-chord result is tension.

03 HAND CALCULATION - CONTINUED

Method of sections and unit-load displacement

5. Section through M2, M5 and M9

M2 = +24.000 kN; M9 = +11.314 kN; M5 = -32.000 kN.

Moments about N6 give M2. Vertical and horizontal equilibrium then give M9 and M5.

6. Unit-load displacement at N7

delta_N7 = sum(Ni ni Li / EA) = 0.655529 mm downward

Apply a 1 kN downward virtual load at N7. Using the real member forces Ni, virtual member forces ni, member lengths Li and EA = 1,000,000 kN gives 0.655529 mm downward.

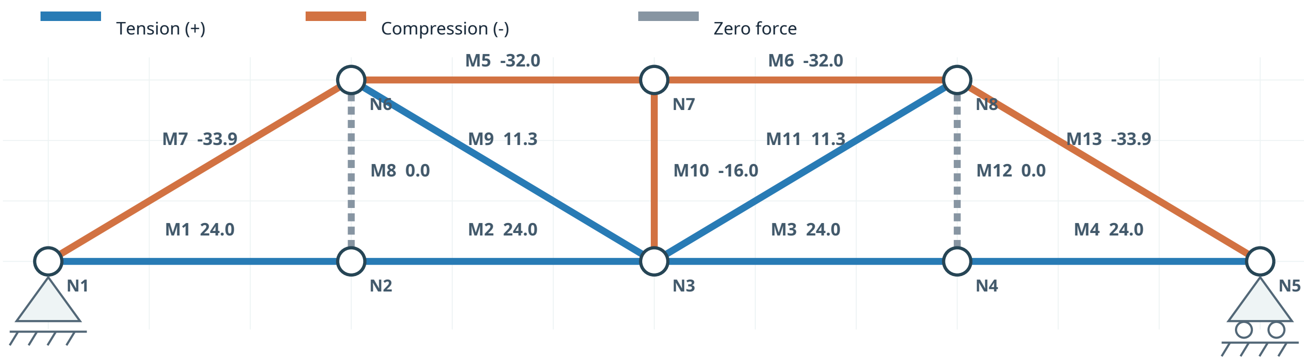
Unit-load contributions at N7

Members	Real N (kN)	Virtual n	L (m)	Subtotal (mm)
M1-M4	+24.000	+0.500000	3.000	0.144000
M5-M6	-32.000	-1.000000	3.000	0.192000
M7, M13	-33.941	-0.707107	4.243	0.203647
M8, M12	0.000	0.000000	3.000	0.000000
M9, M11	+11.314	+0.707107	4.243	0.067882
M10	-16.000	-1.000000	3.000	0.048000
Total				**0.655529**

04 OPTIMAL BEAM 2D SOLVER RESULTS

Axial-force results from Optimal Beam 2D

The axial forces below come directly from the analyzed result snapshot produced by the Optimal Beam 2D Structural Analysis Solver for this exact benchmark model. This sheet is a focused comparison summary; the separate 29-sheet calculation package is the complete browser-generated solver export.



Optimal Beam 2D Solver member results

Member	Connectivity	Axial force (kN)	State
M1	N1 to N2	24.000	Tension
M2	N2 to N3	24.000	Tension
M3	N3 to N4	24.000	Tension
M4	N4 to N5	24.000	Tension
M5	N6 to N7	-32.000	Compression
M6	N7 to N8	-32.000	Compression
M7	N1 to N6	-33.941	Compression
M8	N6 to N2	0.000	Zero
M9	N6 to N3	11.314	Tension
M10	N7 to N3	-16.000	Compression
M11	N8 to N3	11.314	Tension
M12	N8 to N4	0.000	Zero
M13	N8 to N5	-33.941	Compression

Full Optimal Beam 2D Solver output: Download the separate 29-sheet calculation package generated from the 2D Structural Analysis workspace: four-panel-pratt-truss-calculation-report.pdf.

05 INDEPENDENT VERIFICATION

Hand checks compared with Optimal Beam

Declared comparison checks

Check	Hand	Optimal Beam	Difference	Status
Left vertical reaction R_Ay	24.000000 kN	24.000000 kN	0.000%	**PASS**
Right vertical reaction R_By	24.000000 kN	24.000000 kN	0.000%	**PASS**
Bottom chord M2	24.000000 kN	24.000000 kN	0.000%	**PASS**
Top chord M5	-32.000000 kN	-32.000000 kN	0.000%	**PASS**
Diagonal M9	11.313708 kN	11.313708 kN	0.000%	**PASS**
Centre vertical displacement N7	-0.655529 mm	-0.655529 mm	0.000%	**PASS**
Vertical equilibrium	48.000 kN load	48.000 kN reaction	0.000%	**PASS**

Verification result: All declared checks passed. Relative equilibrium residual: 2.910e-11. Last model verification: 2026-07-26.

Solver package traceability

Package field	Report value
Generated by	Optimal Beam 2D Structural Analysis PDF export
Model / scenario	Four-panel Pratt truss · All applied loads
Contents	29 sheets: model, inputs, diagnostics, reactions, displacements, diagrams and member results
Download	https://optimalbeam.com/output/pdf/four-panel-pratt-truss-calculation-report.pdf

Internal file paths and code fingerprints are retained in automated release tests, not shown as user-facing engineering report content.

06 MODELING REVIEW

Common mistakes and responsibility boundary

The following changes alter the analytical problem rather than merely changing presentation.

01 Applying a distributed load directly to an ideal truss member instead of converting it to panel-point loads.	02 Using moment-resisting member behavior when an axial-only pin-jointed idealization is intended.
03 Drawing crossing members without creating a shared node at the intersection.	04 Restraining both supports horizontally and unintentionally introducing an extra reaction.
05 Treating a negative axial-force result as an error instead of compression.	06 Using the solver result as a strength or buckling design check.

Analysis statement

This report documents an ideal pin-jointed truss benchmark. It calculates reactions, member axial forces and elastic displacement. It does not design members, connections or bracing and does not evaluate yielding, fracture, buckling or code compliance.

Prepared and reviewed by: Tamer Hijjawi, P.Eng.
Analysis scope: First-order linear elastic 2D analysis
Editable model: optimalbeam.com/2d-structural-analysis/?example=pratt-truss
Full solver package: https://optimalbeam.com/output/pdf/four-panel-pratt-truss-calculation-report.pdf