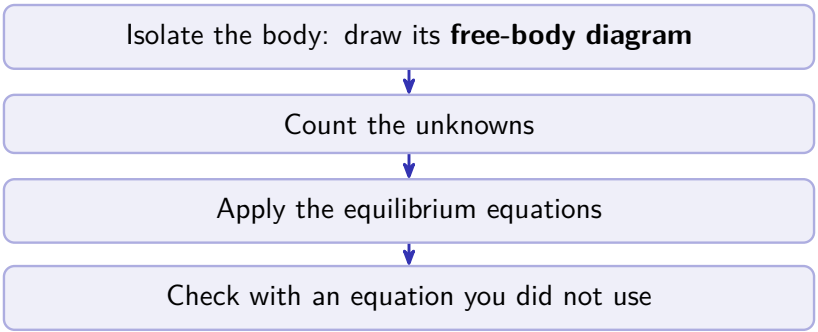
Engineering Mechanics — Statics

Curated undergraduate study track (not accredited, no external exam). Original explanations and practice only, following the reviewed course handout.

One method wearing eight costumes



> Every later unit is this loop with new geometry.

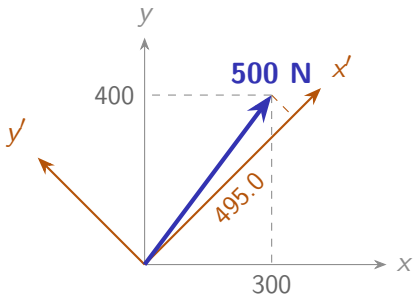
Resolve, combine, and always rebuild

1. **Resolve** 100 N at 30 degrees: the x-component is 86.6 N, the y-component 50 N.
2. **Check** $\sqrt{(86.6^2 + 50^2)} = 100$ N exactly.
3. **Combine** 30 N + 40 N perpendicular: 50 N on the 3-4-5 diagonal.

$$F_x = F\cos\theta \qquad F_y = F\sin\theta$$

then rebuild the **magnitude** as a free check

The tilted frame proves you understood nothing changed

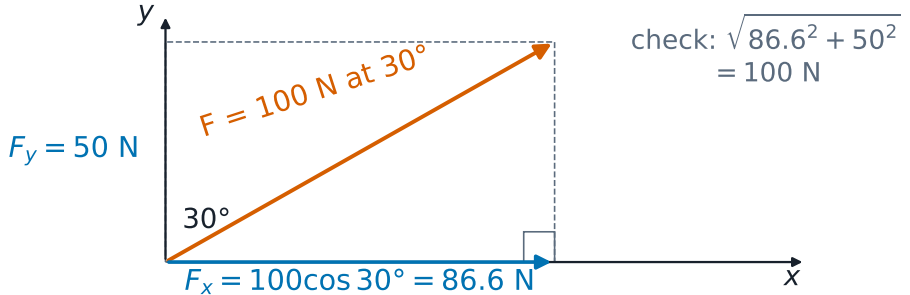


- Components depend on the axes; the force does not.
- Resolving 300 N + 400 N at 45° axes gives (495.0, 70.7) N — still 500 N.

$\sqrt{(495.0^2 + 70.7^2)} = 500$ N in either frame.

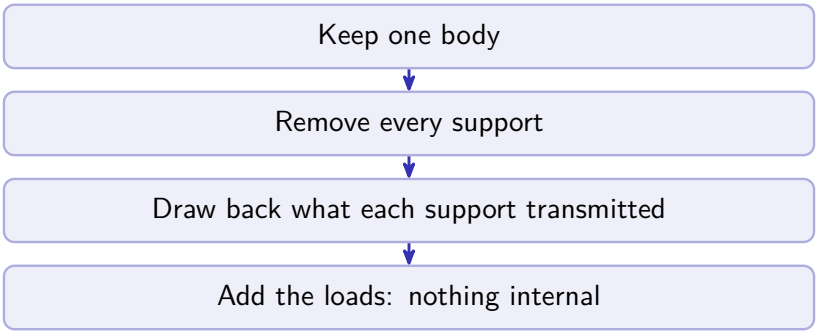
Components are the rectangle sides

Components are the sides; the force is the diagonal



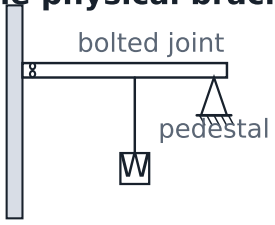
100 N at 30 degrees: 86.6 N along x, 50 N along y; the components rebuild it.

Isolate, then draw the world back on

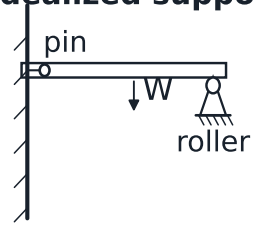


Layout: the bracket becomes a beam

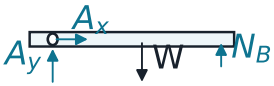
the physical bracket



idealized supports



free-body diagram

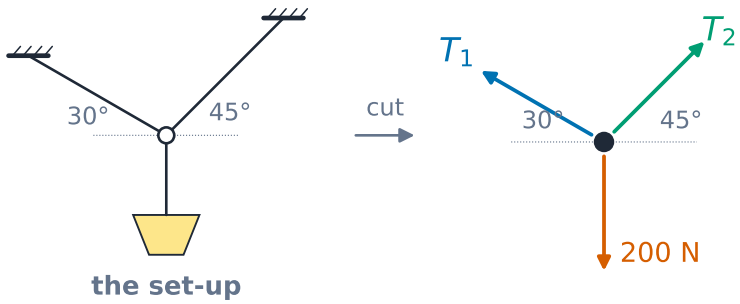


unknowns: A_x, A_y, N_B
equations: ΣF_x, ΣF_y, ΣM

Physical bracket, idealized pin-and-roller model, and the complete cut drawing with three **reactions**.

The ring cut free: three forces, two unknowns

FBD of the ring: three forces, two unknowns



Cut the cables: the 200 N weight and two tensions along the cables.

Particle equilibrium: two equations, chosen axes

1. **Cables** 400 N sign, two cables at 30°: 2T sin 30° = 400 gives T = 400 N.
2. **Angle** At 60° the same load needs only 231 N; at 10° it needs 1152 N.
3. **Geometry** Three balancing forces are **concurrent** - their lines meet at one point.

$$T = \frac{W}{2\sin\theta}$$

two symmetric cables at θ above horizontal

Moments - choose the centre, delete an unknown

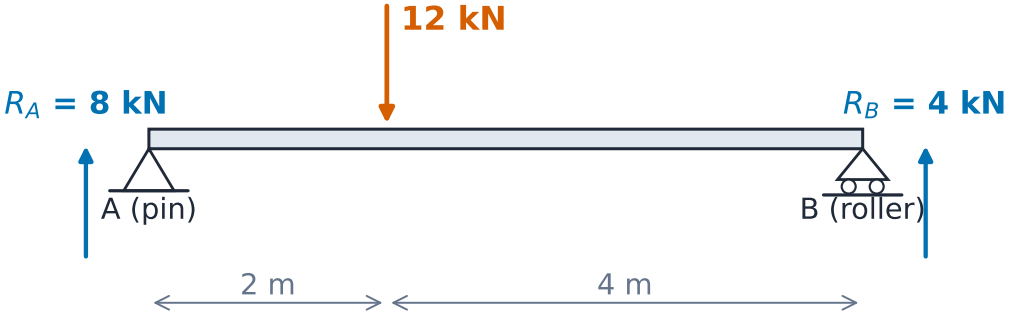
1. **Direct** 300 N at 40° on a 1.2 m arm: $300 \sin 40° \times 1.2 = 231.2$ N · m.
2. **Beam** Moments about A solve the **roller** force; about B the **pin**; the vertical equation checks.
3. **Couple** Two 150 N forces 0.8 m apart: 120 N · m about every point in the plane.

$$M = F\,d_{\perp}$$

d is the perpendicular arm; counterclockwise positive

Moments about A, sum about B

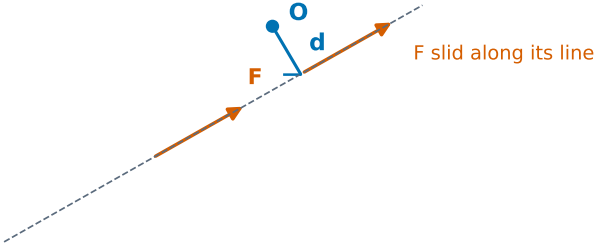
moments about A: $R_B \times 6 = 12 \times 2$



Moments about A give RB = 4 kN; the vertical sum gives RA = 8 kN.

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The arm is the perpendicular, always



M about O = F · d for both positions — the perpendicular never changed

d is the perpendicular from the point to the **line of action**; sliding the force along its line leaves d unchanged.

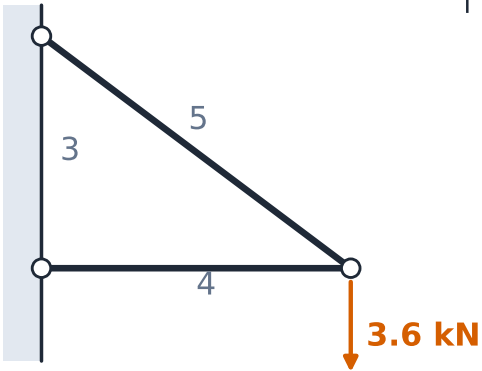
Rigid-body equilibrium: three equations, three supports

1. **Beam** 6 m, **pin** A, **roller** B, 12 kN at 2 m: roller 4 kN, pin 8 kN.
2. **Check** Moments about B: $8 \times 6 = 12 \times 4$. ✓
3. **Overhang** Roller at 4 m, 10 kN at the 6 m tip: roller 15 kN, pin -5 kN - the pin pulls down.

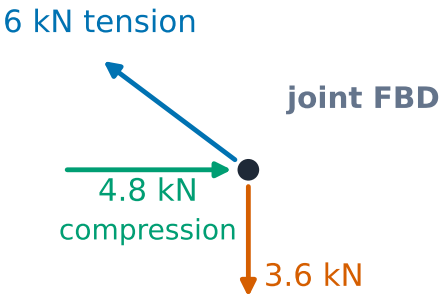
$$\sum F_x = 0 \qquad \sum F_y = 0 \qquad \sum M = 0$$

three equations: at most three unknown **reactions**

Every joint is two equations



$\uparrow: F \times 3/5 = 3.6 \rightarrow F = 6$ kN

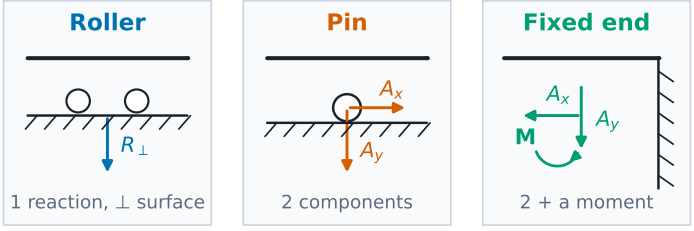


The 3-4-5 joint: 6 kN **tension** in the incline, 4.8 kN **compression** in the horizon-

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Supports priced by what they prevent

One, two, or two-plus-a-moment: supports priced by what they prevent



Roller one reaction, **pin** two, fixed end two plus a **moment**: the count is the design.

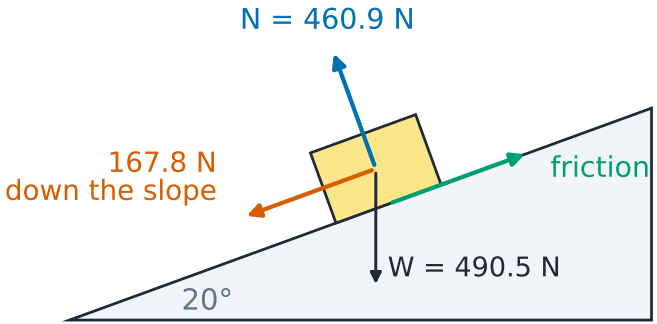
Trusses - joints, sections, and the free members

1. **Joint** 3.6 kN hanging, one member at 3-4-5: F = 6 kN **tension**; partner 4.8 kN **compression**.
2. **Zero-force** Unloaded joint: two non-collinear members both carry zero; with two collinear of three, the third does - find them first.
3. **Frames** Multi-force members: dismember, equal-and-opposite **pin** pairs, solve the two-force member first.

$$F = \tfrac{5}{3} \times 3.6 = 6\ \mathrm{kN}$$

vertical balance at the joint, member at 3-4-5

Needed versus available



can friction hold it?

needed: 167.8 N

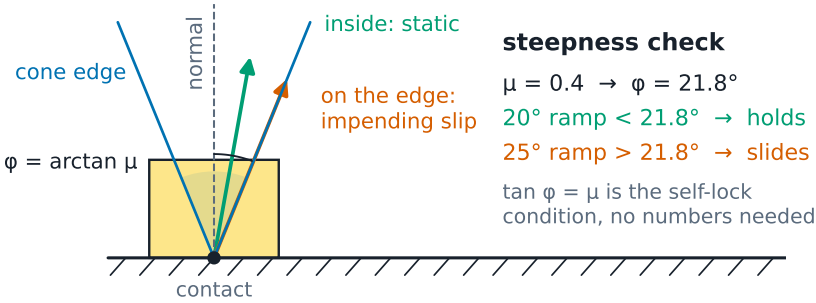
available: $0.4 \times 460.9 = 184.4$ N

$167.8 < 184.4$: it stays; friction supplies only 167.8 N

Friction needed 167.8 N, available 184.4 N: the block stays.

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The reaction lives inside the cone



steepness check

$\mu = 0.4 \rightarrow \varphi = 21.8°$

$20°$ ramp $< 21.8° \rightarrow$ holds

$25°$ ramp $> 21.8° \rightarrow$ slides

$\tan\varphi = \mu$ is the self-lock condition, no numbers needed

Reaction within arctan μ of the normal; at **impending slip**, on the edge.

Friction takes what it needs

1. **Incline** 50 kg on 20° ($\mu = 0.4$): needs 167.8 N, ceiling 184.4 N - it stays, with 167.8 N acting.
2. **Pull** W = 400 N, b = 0.8 m, h = 1.2 m: slips at 160 N, tips at 133.3 N - it tips.
3. **Direction Friction** opposes the would-be motion - state it in words first.

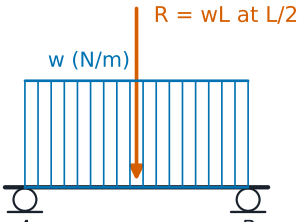
$$F \le \mu N \qquad P_{\text{tip}} = \frac{Wb}{2h}$$

slip ceiling and tipping threshold: the smaller happens first

Each shape becomes one arrow

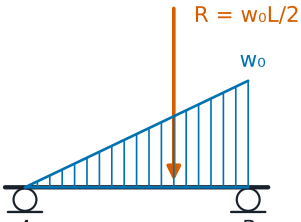
Each shape becomes one arrow: total at the balance point

Uniform: rectangle



area = wL · centroid at mid-length

Triangular: peak w_0



at L/3 from the peak end

Uniform: wL at mid-length; triangular: $w_0 L/2$ a third from the peak end.

Centroids and distributed loads: resultants in disguise

1. **Triangle** 0 to 6 kN/m over 4 m: R = 12 kN at 1.333 m from the high end.
2. **Composite** T-section: $(2400\times10 + 1600\times60)/4000 = 30$ mm from the top.
3. **Close** Resultants enter FBDs; the three equations finish - the course loops.

$$\bar{y} = \frac{\sum A_i \bar{y}_i}{\sum A_i}$$

composite **centroid**

Check yourself

- Vectors: 250 N at 40° - horizontal component? (191.5 N.)
- Supports: 6 m beam, 12 kN at 2 m - the **roller** force? (4 kN.)
- **Friction**: 40 kg block, $\mu = 0.35$, pushed 100 N - does it move? (No; 100 N friction acts.)