

Exercise walk-through

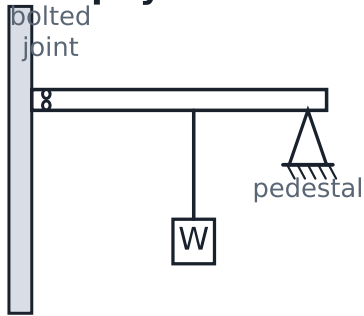
1.2

Free-body diagrams

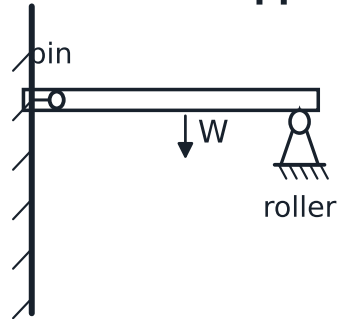
University Mechanical Engineering

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 free-body diagram with three reactions.

Exercises 2.1-2.2

2.1 A cable-pulley system holds a 250 N crate with two vertical cable segments sharing it. Draw (describe) the crate's FBD and give the tension in each segment. [3]

2.2 State the number of unknown reaction components for each support: (a) roller on a horizontal surface, (b) pin, (c) fixed support – and name the extra quantity the fixed support adds. [3]

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2.1

- Forces: weight 250 N down; two cable tensions T_1 , T_2 up.
- Equilibrium: $T_1 + T_2 = 250$ N.
- Sharing equally (symmetric suspension): $T = 125$ N each.

2.2 State the number of unknown reaction components for each support: (a) roller on a horizontal surface, (b) pin, (c) fixed support – and name the extra quantity the fixed support adds. [3]

2.2

- Roller: one unknown (perpendicular to the surface).
- Pin: two unknown components.
- Fixed support: three – two components plus a reaction moment.

Exercise 2.3

2.3 A 100 kg block rests on a smooth (frictionless) 15° incline. List the forces on the block's FBD with magnitudes ($g = 9.81 \text{ m/s}^2$), and state why no friction force appears. [4]

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2.3

- Weight $W = 100 \times 9.81 = 981 \text{ N}$ straight down at the centre of gravity.
- Normal force $N = 981 \cos 15^\circ = 947.6 \text{ N}$ perpendicular to the incline surface.
- Magnitudes: as above; the two forces balance as $981 \sin 15^\circ$ down-slope has nothing to resist –
- A smooth surface is defined as frictionless, so no friction force exists; the block would in fact accelerate down the slope.

Exercise 3.1

3.1 A 5 m cantilever beam is built into a wall at A (fixed support) and carries a vertical 8 kN point load at its free end.

Draw (describe) the complete FBD with every reaction component, compute all three reactions, and verify the moment reaction by taking moments about the free end. Then explain why the wall must supply a moment at all. [6]

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3.1

- FBD: A_x , A_y , reaction moment M_A at the wall; 8 kN down at the free end.
- Horizontally: $A_x = 0$. Vertically: $A_y = 8$ kN up.
- Moments about A: $M_A = 8 \times 5 = 40$ kN · m (counterclockwise, opposing the load's clockwise moment).
- Check, moments about the free end: $M_A - A_y \times 5 = 40 - 40 = 0$. ✓
- The load's line of action passes 5 m from A; a force pair at A alone ($A_x = A_y$ balanced) could not balance its moment – the wall must also supply a pure couple.

Exercise 3.2

3.2 A frame consists of a horizontal member AB pinned to a wall at A, supported by a two-force strut CD from the wall (at C, above A) to point D on AB, carrying a 6 kN load at B, the free end. Distances: A to D is 1.5 m, D to B is 1.5 m, and CD meets AB at 45° .

Explain what makes CD a **two-force member** and what that implies for the direction of its force on AB. Then compute the strut force and the reactions at A by equilibrium of member AB alone, and check the result by moments about A. [7]

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3.2 A frame consists of a horizontal member AB pinned to a wall at A, supported by a two-force strut CD from the wall (at C, above A) to point D on AB, carrying a 6 kN load at B, the free end. Distances: A to D is 1.5 m, D to B is 1.5 m, and CD meets AB at 45° .

Explain what makes CD a **two-force member** and what that implies for the direction of its force on AB. Then compute the strut force and the reactions at A by equilibrium of member AB alone, and check the result by moments about A. [7]

3.2

- CD is loaded only at its two ends (its own weight neglected), so equilibrium of CD itself requires the two forces to be equal, opposite and collinear – along CD.
- Therefore the force on AB at D acts along CD at 45° .
- Member AB FBD: A_x , A_y , force F_{CD} at D at 45° , 6 kN at B.
- Moments about A: $F_{CD} \sin 45^\circ \times 1.5 = 6 \times 3$, so $F_{CD} = 18/1.061 = 16.97 \approx 17.0$ kN compression.
- Horizontally: $A_x = -F_{CD} \cos 45^\circ = -12$ kN (leftward).
- Vertically: $A_y = 6 - F_{CD} \sin 45^\circ = 6 - 12 = -6$ kN (downward).
- Check, ΣM about A already used; ΣM about B: $A_y \times 3 + F_{CD} \sin 45^\circ \times 1.5 = -18 + 18 = 0$. ✓