Rotational Equilibrium

Stefan Bracher

Photo: “Beam on two supports” by Stefan Bracher

Translational equilibrium: $\mathbf{F}_{net}=0 \leftrightarrow \mathbf{a}=0$

If the vector sum of all forces is zero, then the object has no acceleration (and vice-versa)

Rotational equilibrium: $\boldsymbol{\tau}_{net}=0 \leftrightarrow \boldsymbol{\alpha}=0$

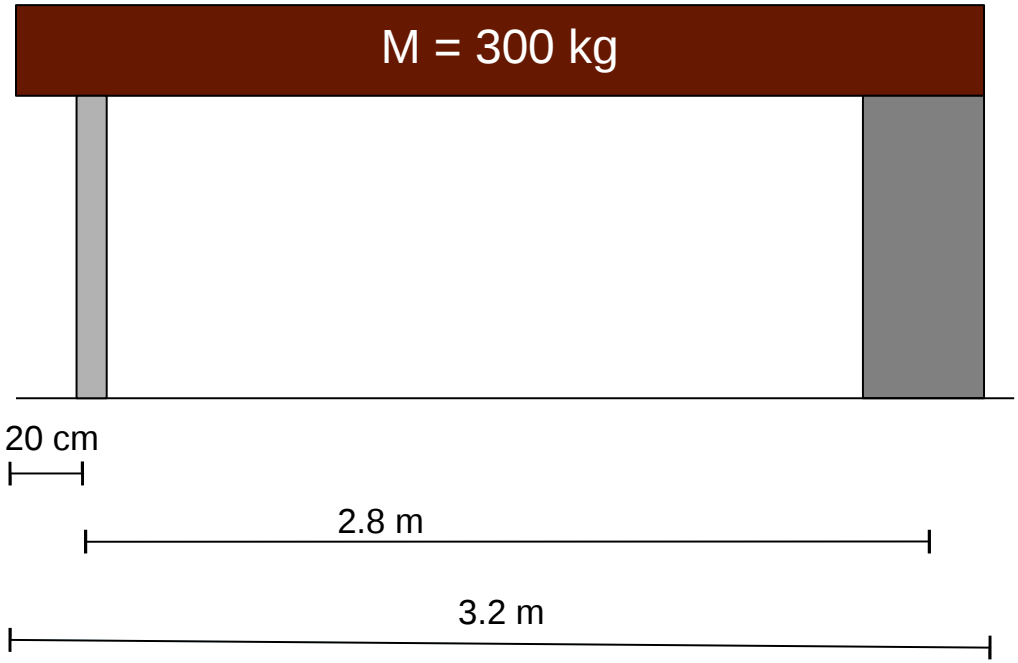
If the vector sum of all torque around any point on an object is zero, then the object has no angular acceleration (and vice-versa)

For an object at rest to remain at rest it has to be both, in translational and rotational equilibrium.

If an object is at rest, it is in rotational equilibrium around ANY point on the object.

Example 1

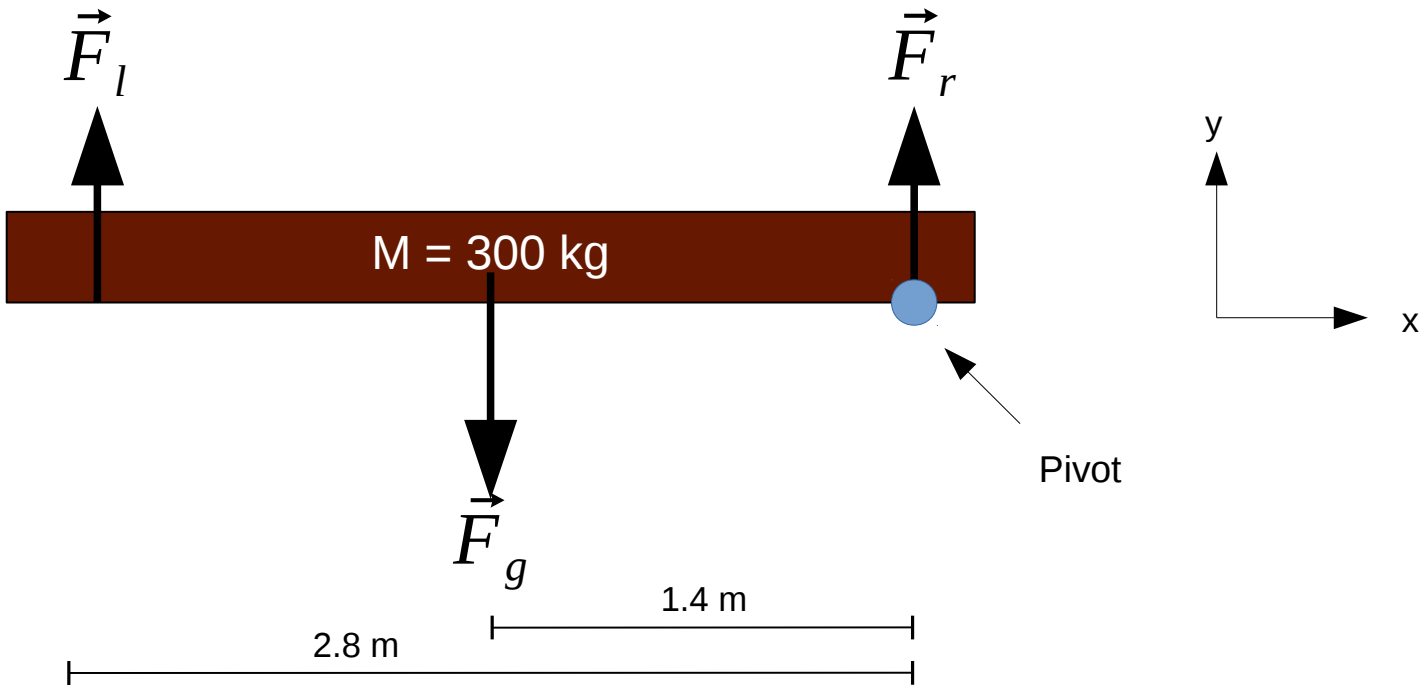
Photo: Stefan Bracher



What is the force in the left support?

Example 1

1. Draw the free body diagram and choose ANY pivot point



2. Rotational equilibrium around z-axis

$$z: \sum \vec{\tau} = 0$$

$$\vec{\tau}_l + \vec{\tau}_g + \vec{\tau}_r = 0$$

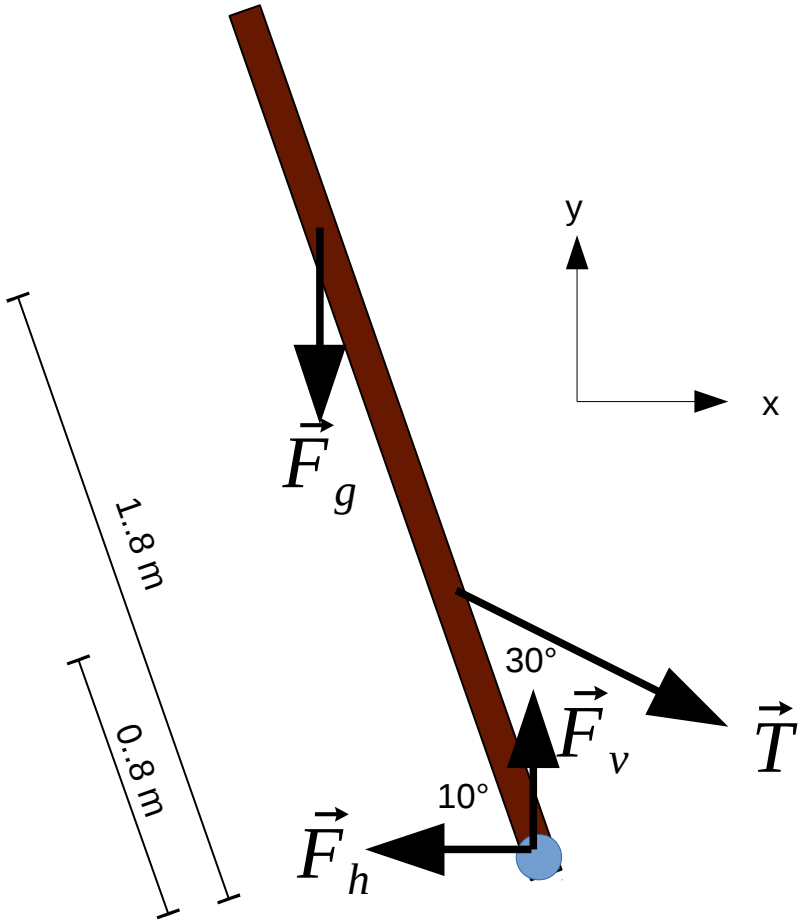
$$-2.8 \cdot F_l + 1.4 \cdot m \cdot g + 0 = 0 \longrightarrow F_l = \frac{1.4 \cdot m \cdot g}{2.8} = 1470\ N$$

Example 2

What is the tension in the string?

Photo: Stefan Bracher

M=200.kg



$$z: \sum \vec{\tau} = 0$$

$$\vec{\tau}_g + \vec{\tau}_T = 0$$

$$+1.8 \cdot M \cdot g \cdot \sin(10°) - 0.8 \cdot T \cdot \sin(30°) = 0$$

$$+613 - 0.4 \cdot T = 0 \longrightarrow T = 1532\,N$$

More Examples

Photo: Stefan Bracher

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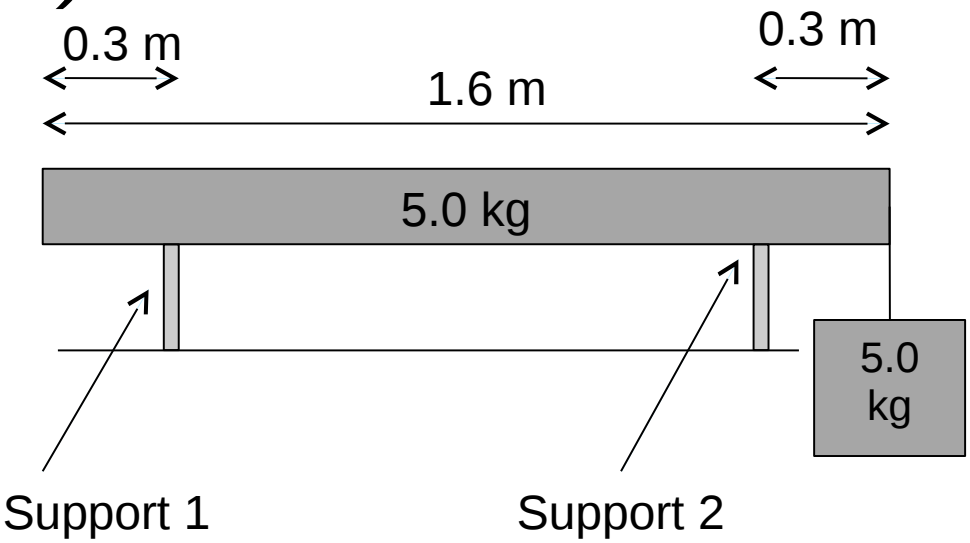
→ Problems B09-B13

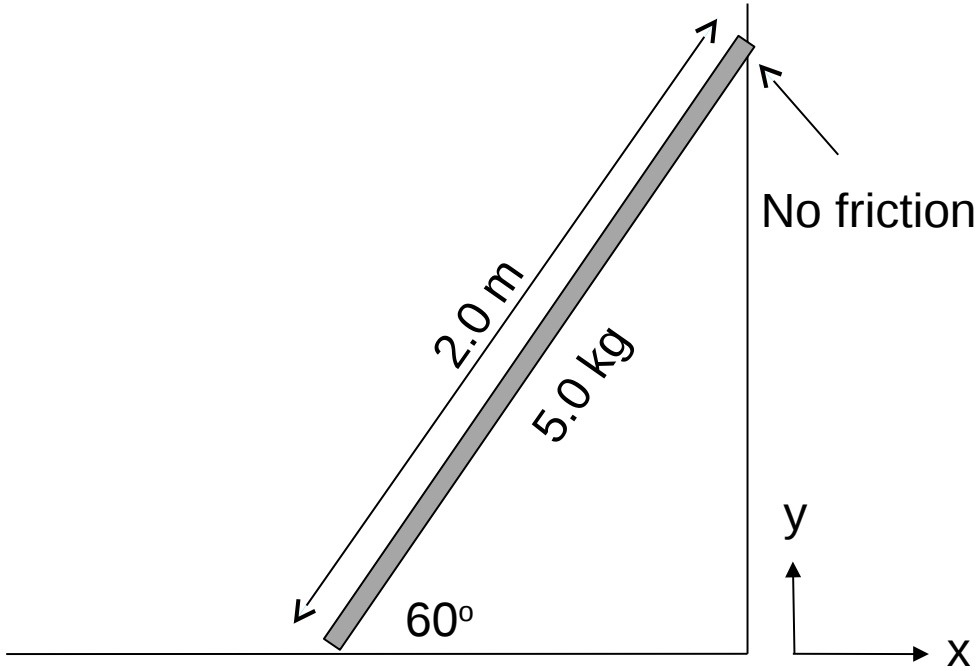
a)



Calculate the normal force exerted by each of the two supports.

Solution: F_{N1}=10 N, F_{N2}=90 N

b)



Calculate the reaction force of the floor on the ladder.

Solution: F_N= 14.4 N, f=50 N

More Examples

→ WebWork

→ Problems B14-B24

Additional Resources

Online Textbook

- The Second Condition for Equilibrium, OpenStax „College Physics“
  http://cnx.org/contents/Ax2o07Ul@9.94:EarCWlUd@4/The-Second-Condition-for-Equil

Simulations

- Balancing Act, University of Colorado “Phet Simulations”
  https://phet.colorado.edu/en/simulation/balancing-act