April 15, Week 13

Today: Chapter 10, Torque

Homework Assignment #10 - Due April 19.

Mastering Physics: 7 problems from chapter 9

Written Question: 10.86

Help sessions with Jonathan:

M: 1000-1100, RH 111
T: 1000-1100, RH 114
Th: 0900-1000, RH 114

General Torque

The direction of the force also determines the torque. When $\overrightarrow{\mathbf{F}}$ is not perpendicular to the lever arm ($\overrightarrow{\mathbf{r}}$), only the component of $\overrightarrow{\mathbf{F}}$ which is perpendicular to $\overrightarrow{\mathbf{r}}$ causes torque.

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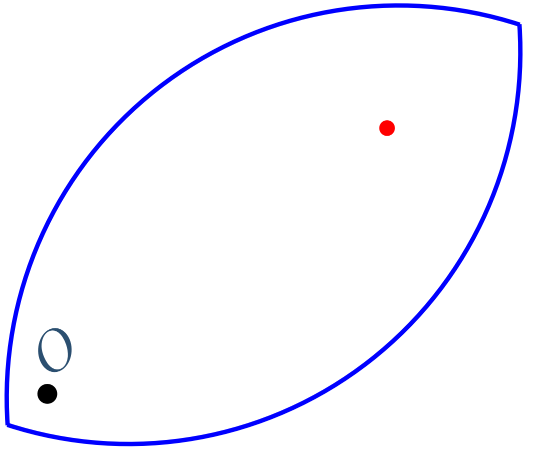

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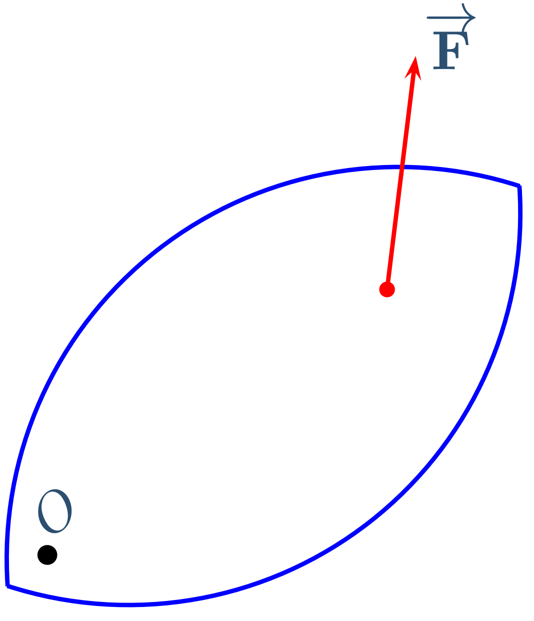

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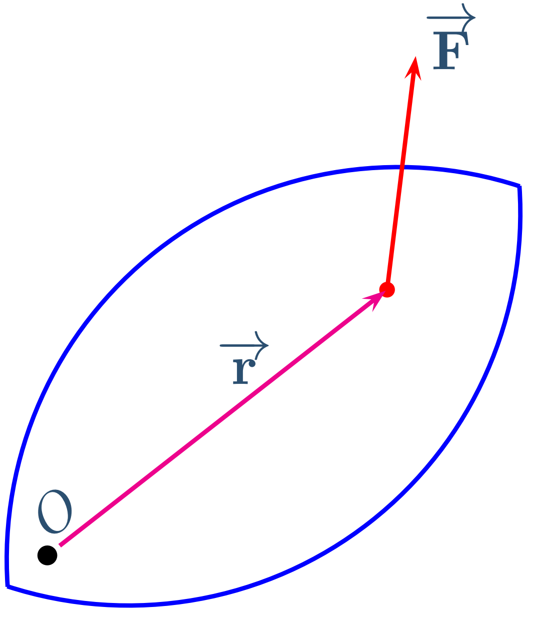

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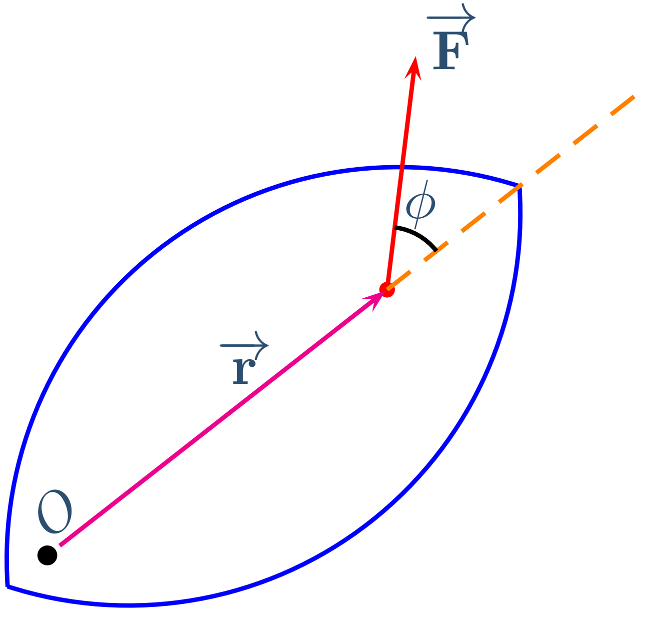

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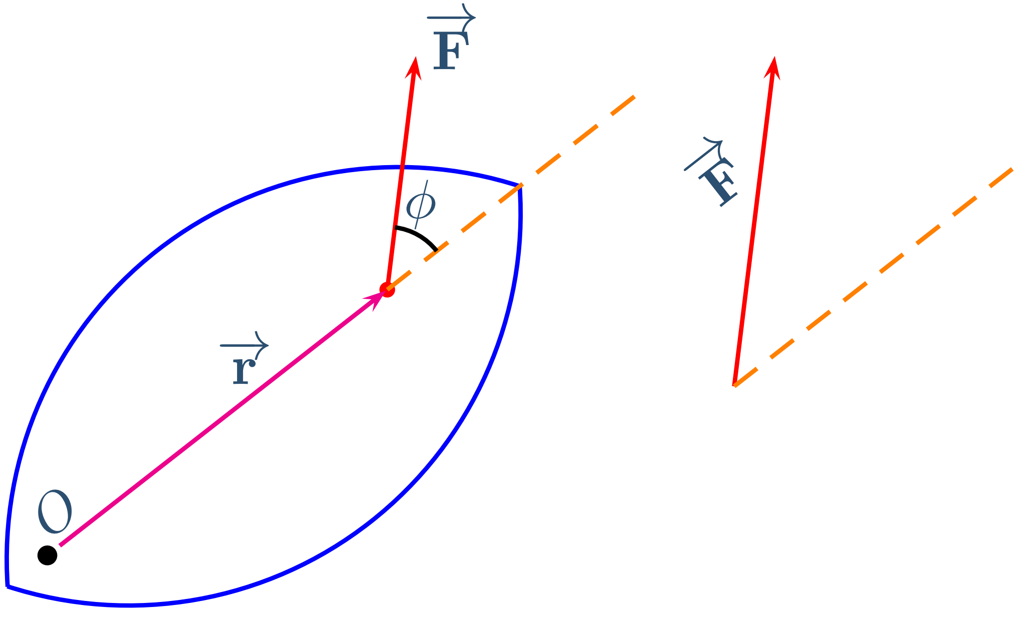

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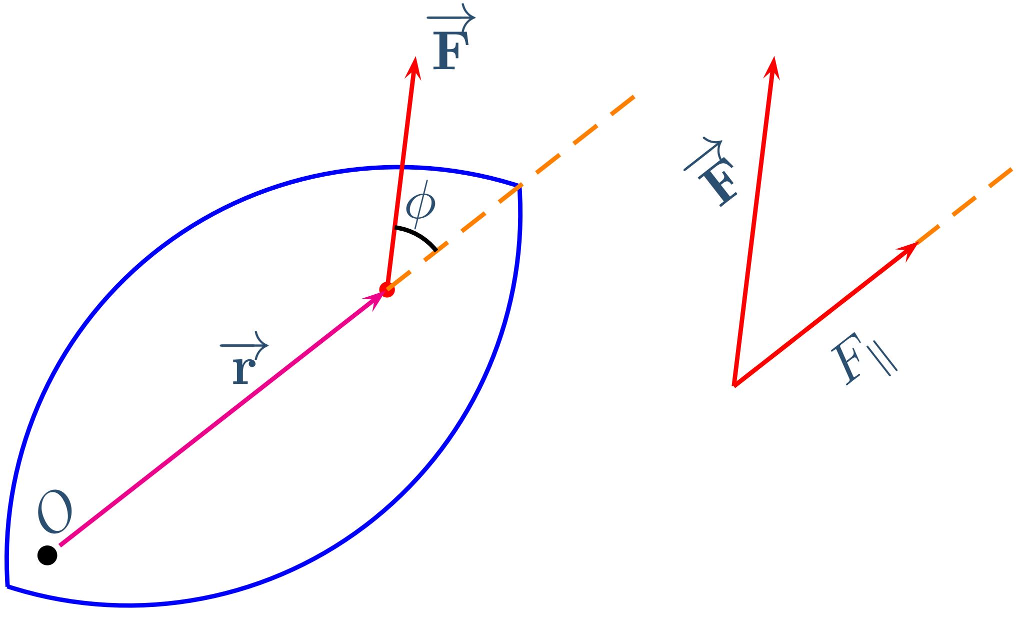

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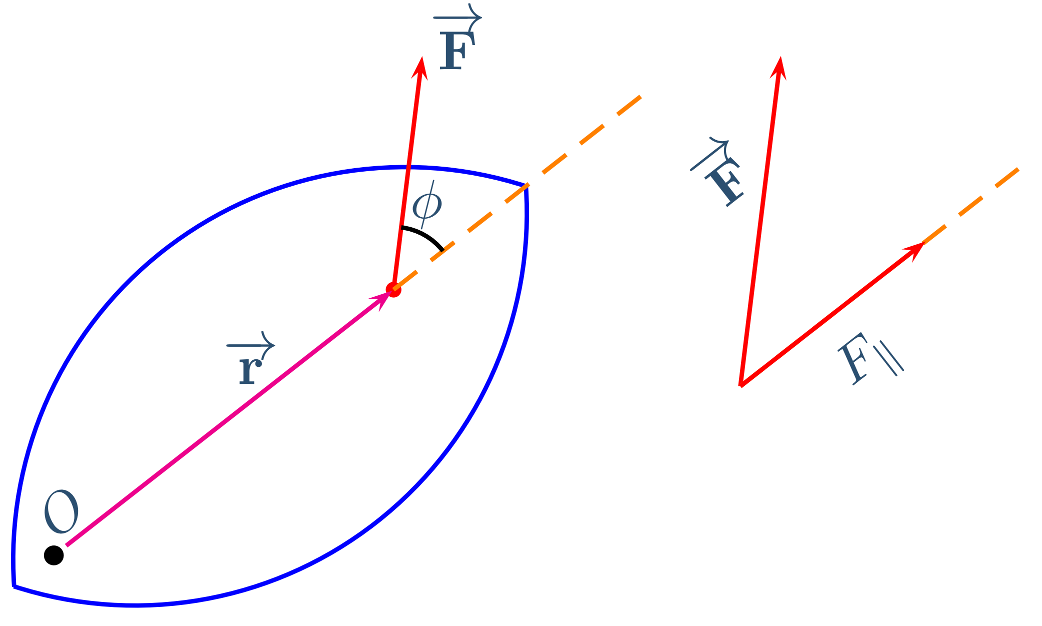

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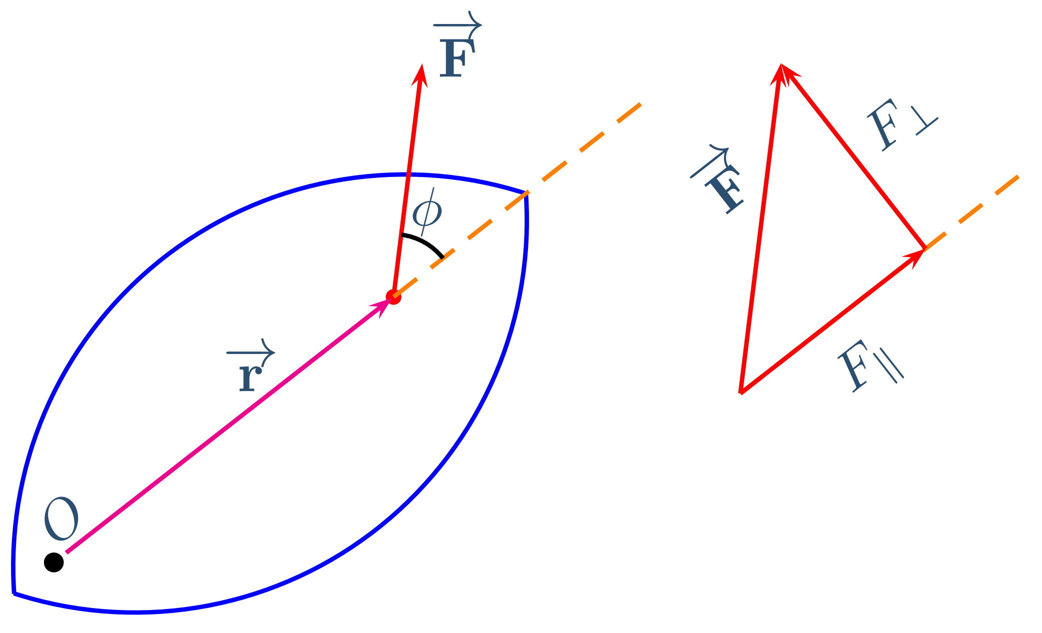

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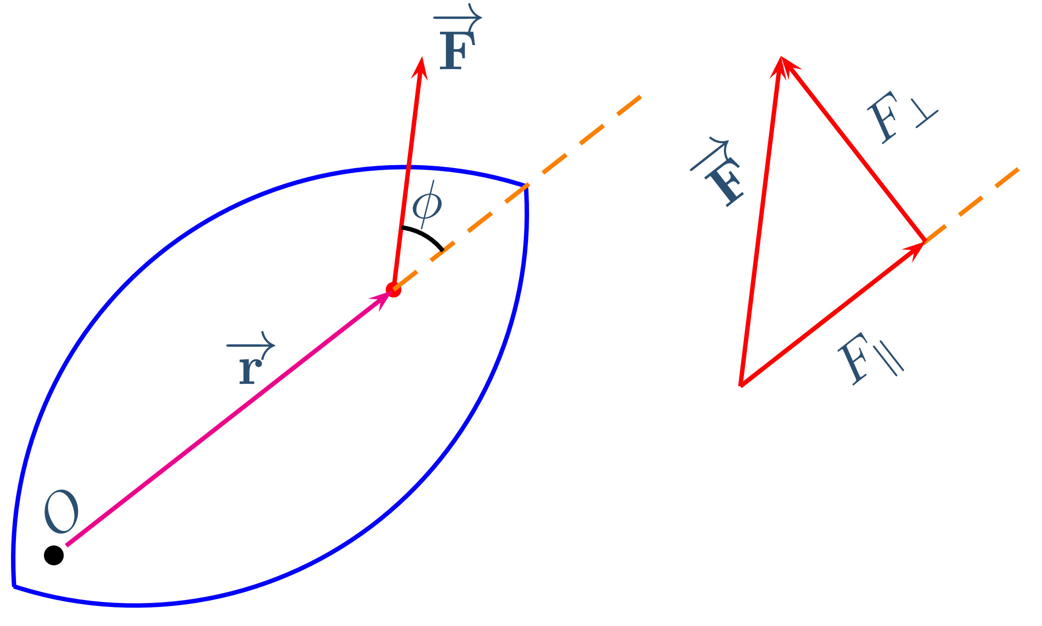

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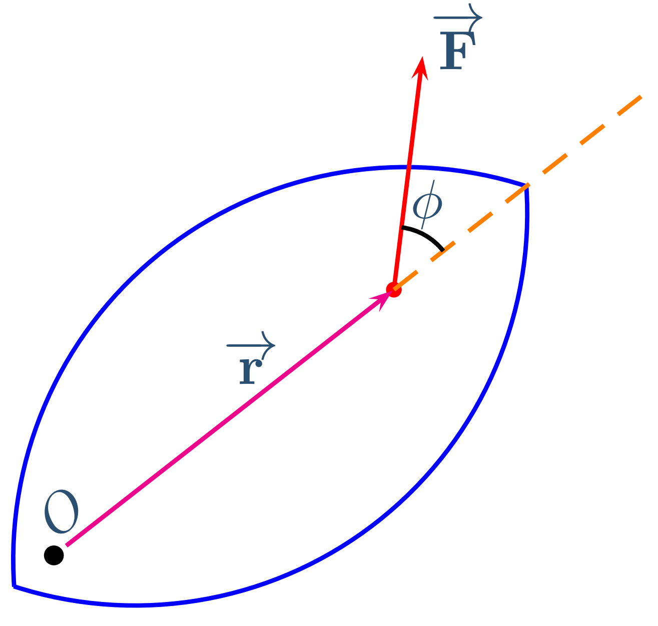

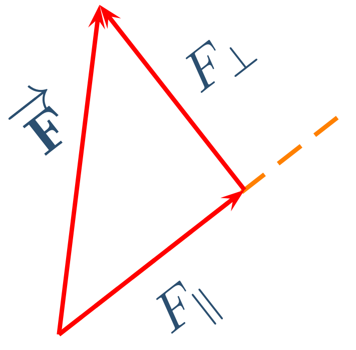

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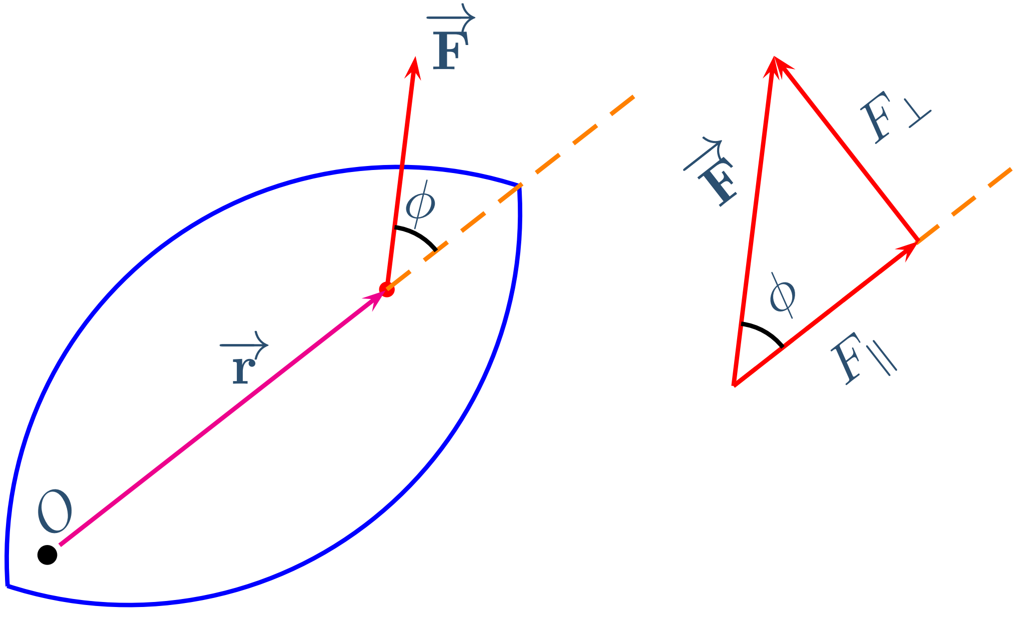

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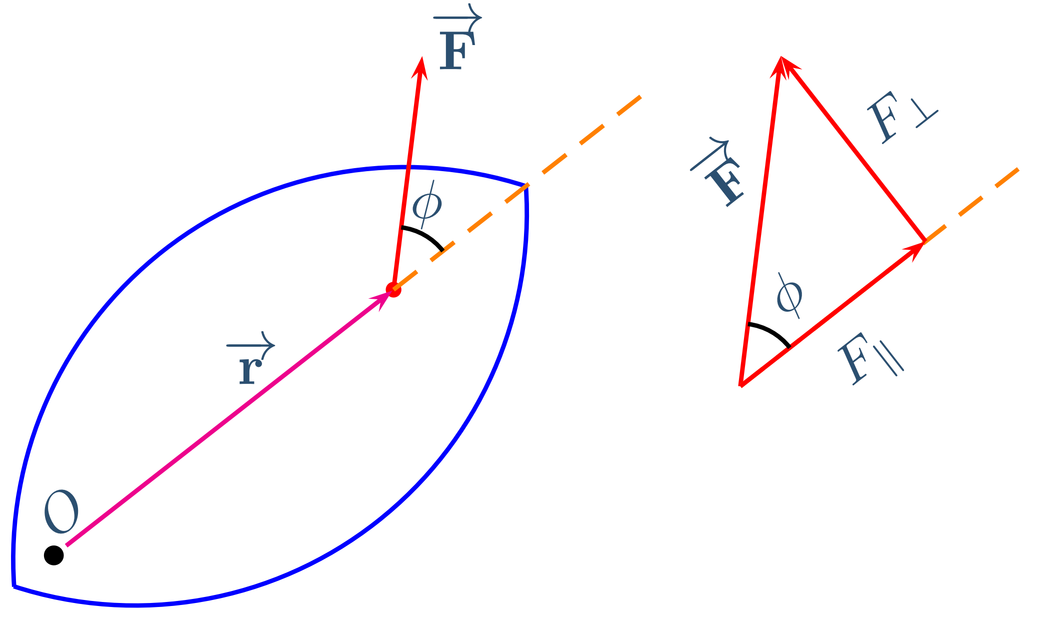

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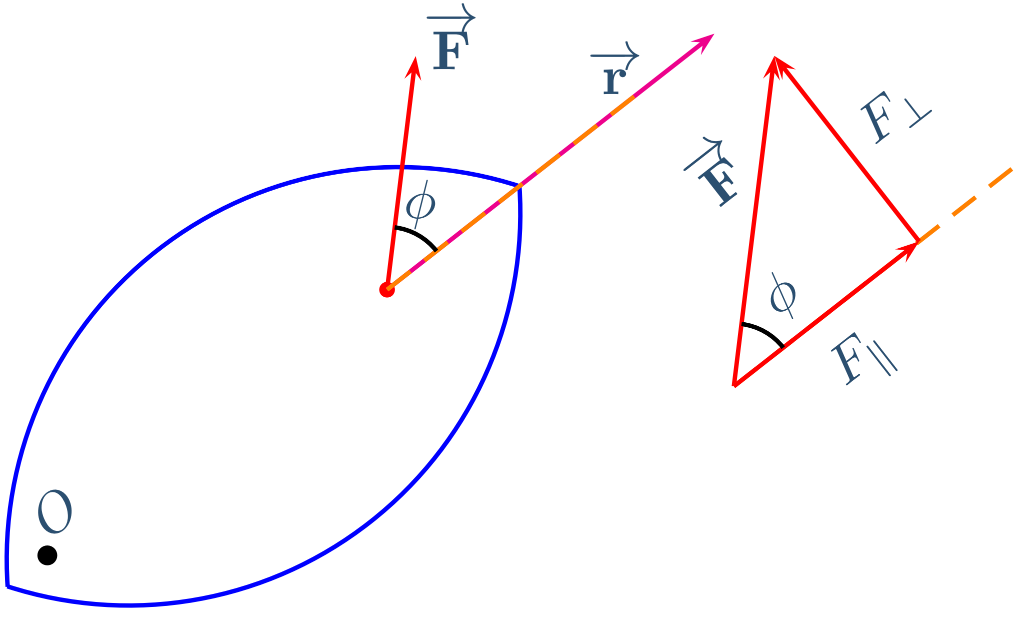

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ϕ is angle between $\overrightarrow{\mathbf{r}}$ and $\overrightarrow{\mathbf{F}}$

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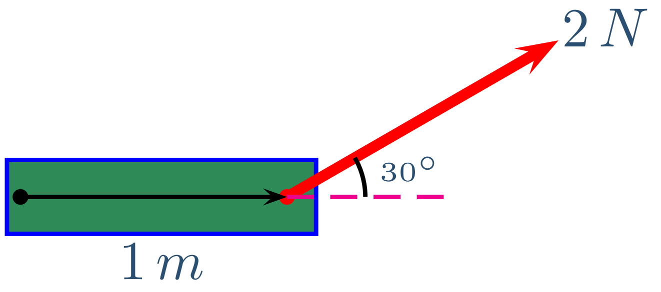

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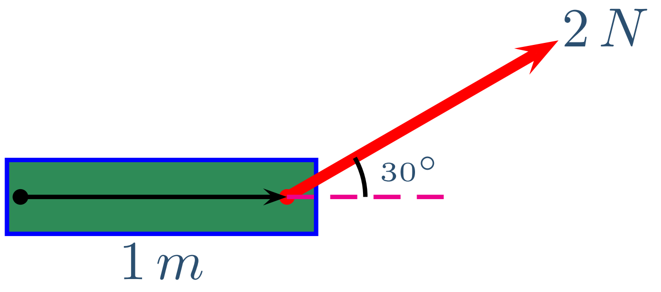

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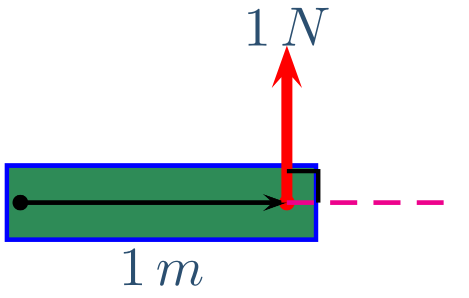

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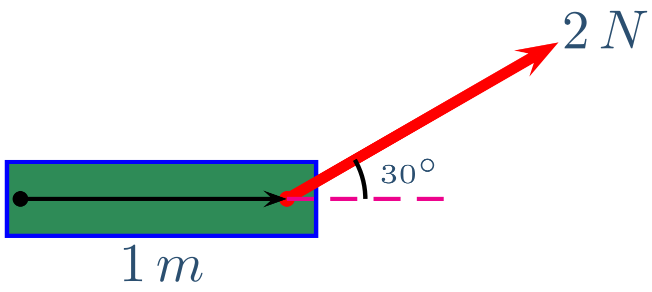

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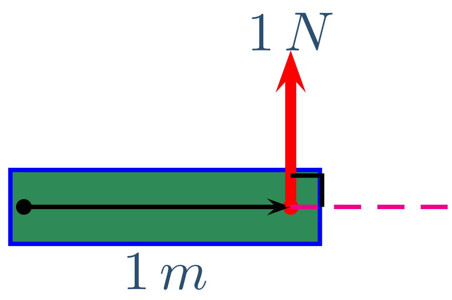

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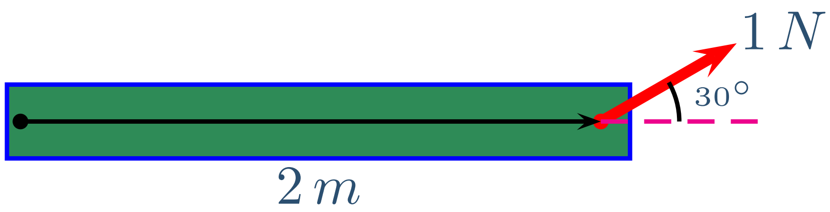

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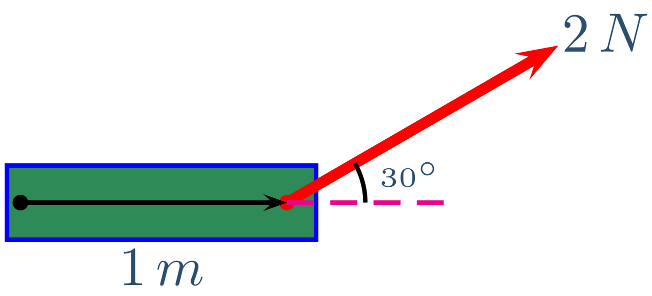

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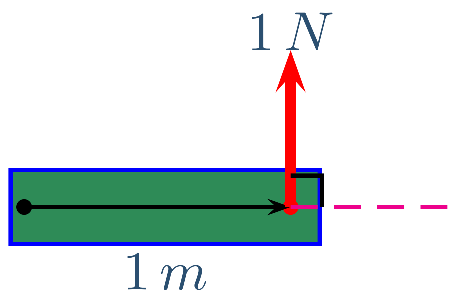

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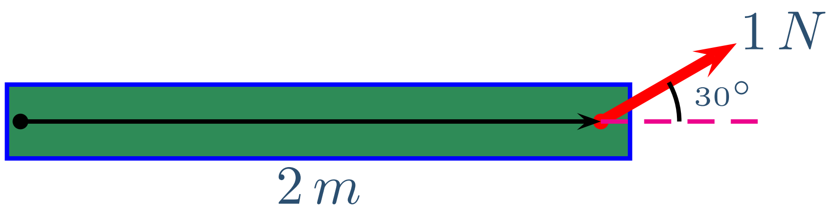

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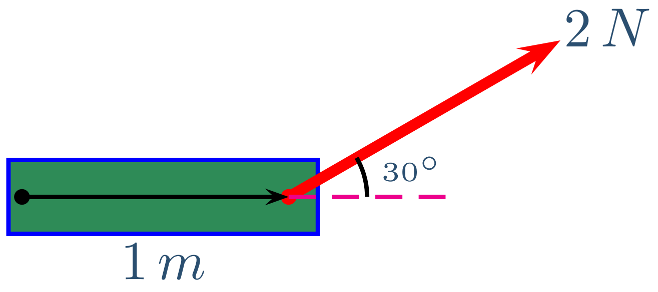

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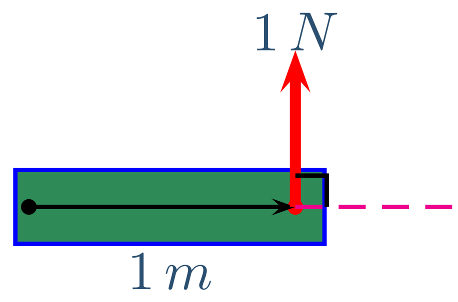

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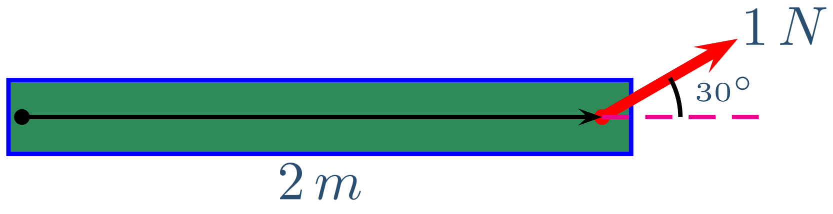

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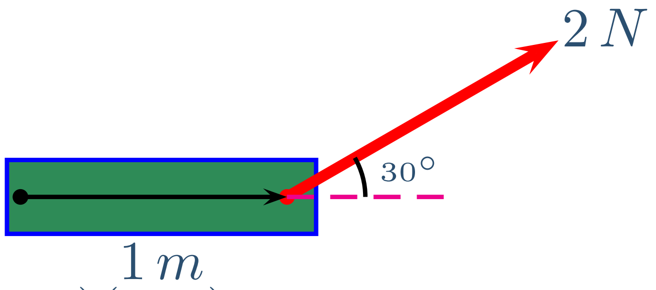

$$\tau_1 = (1\,m)(2\,N)\sin 30^\circ = 1\,N\cdot m$$

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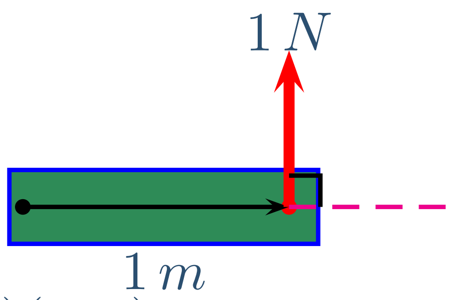

$$\tau_2 = (1\,m)(1\,N) = 1\,N\cdot m$$

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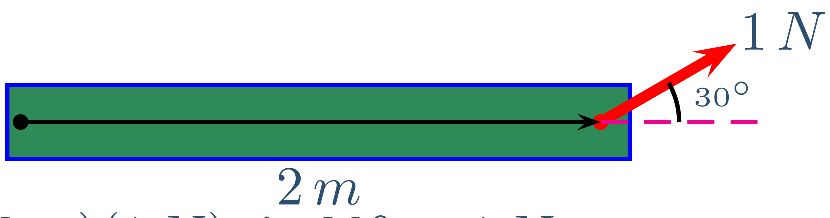

$$\tau_3 = (2\,m)(1\,N)\sin 30^\circ = 1\,N\cdot m$$

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The Torque Vector

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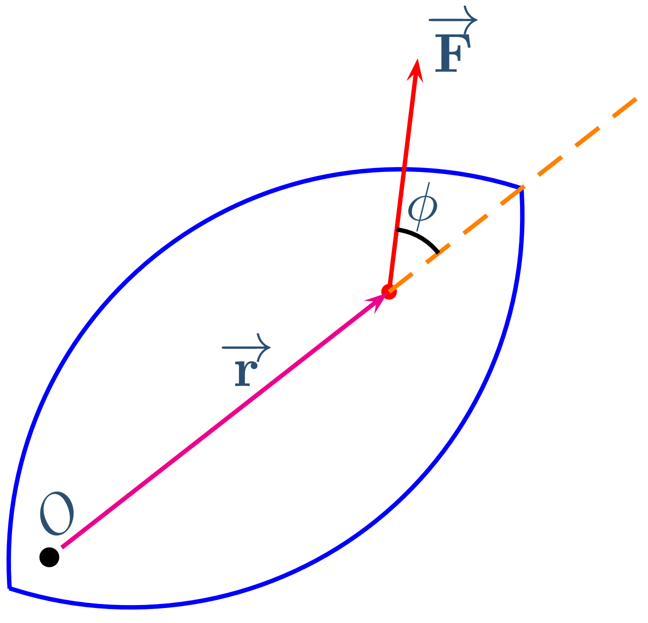

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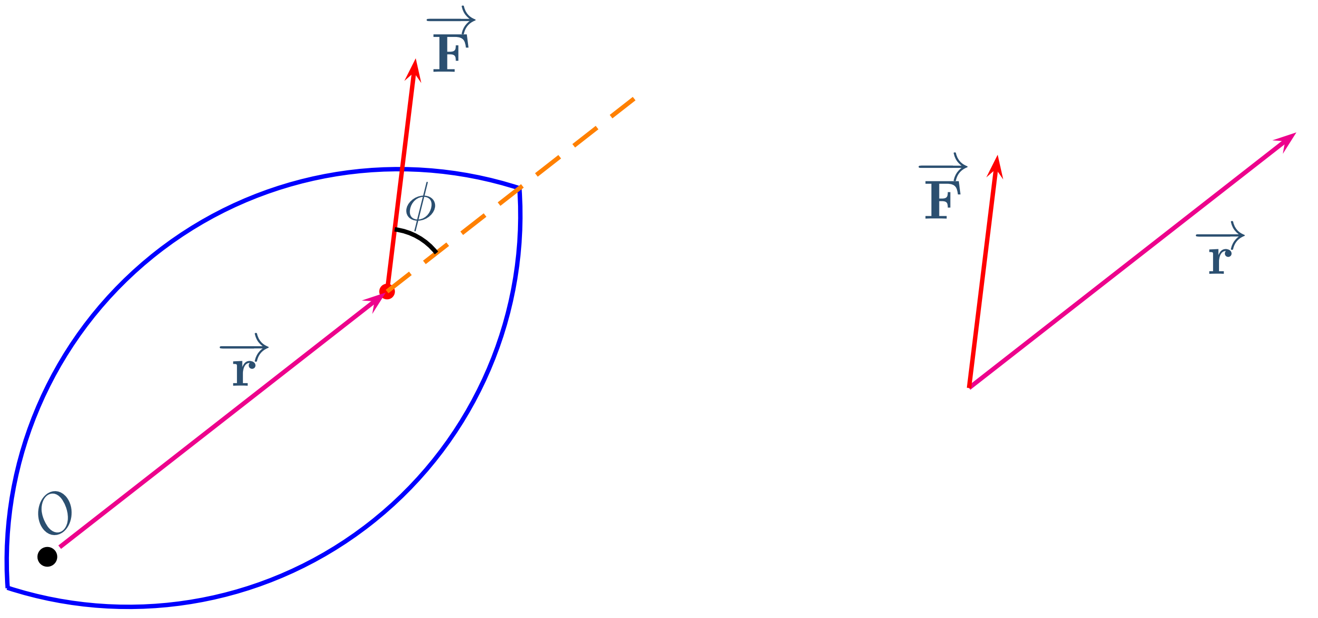

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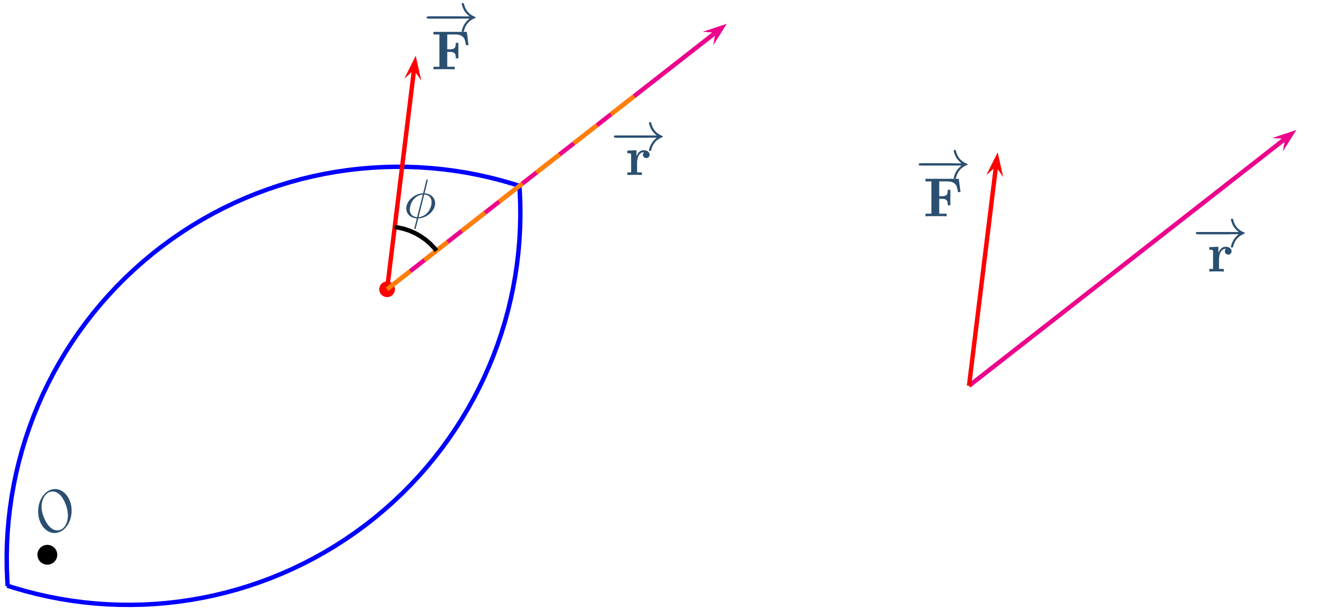

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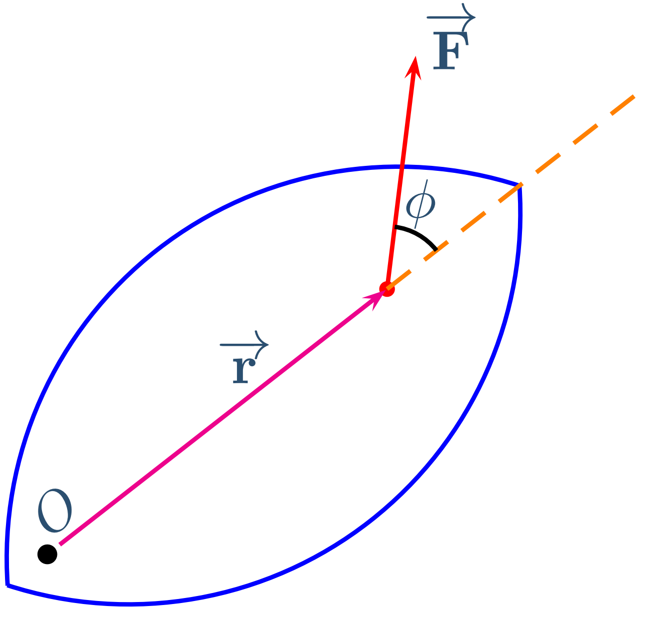

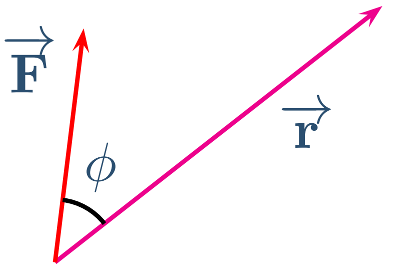

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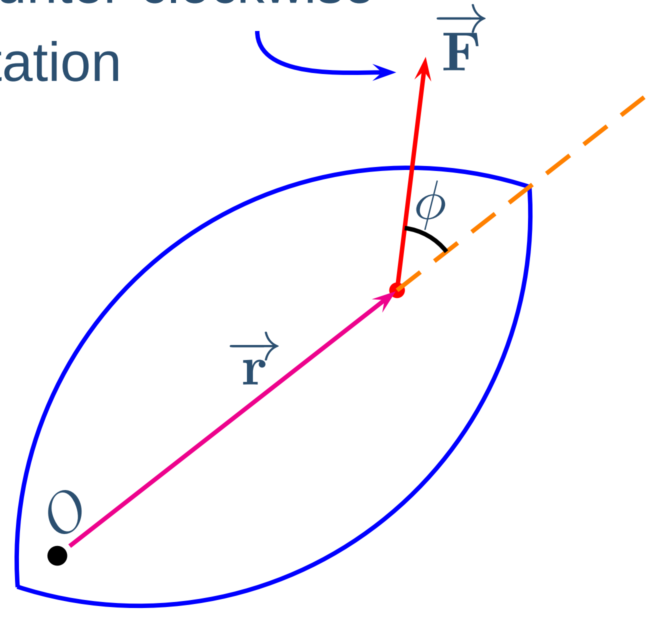

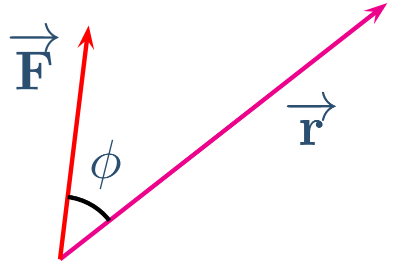

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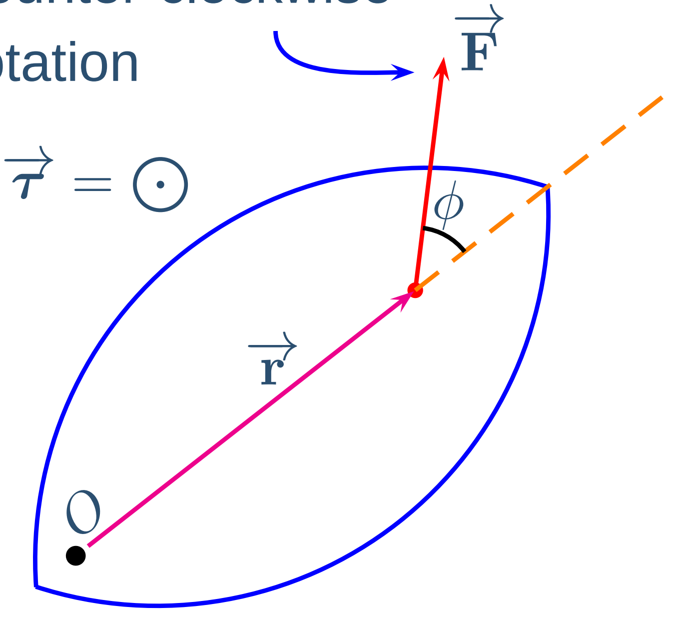
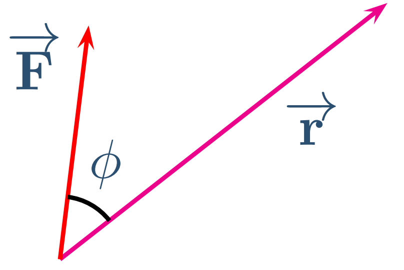
$\vec{\boldsymbol{\tau}} = \odot$





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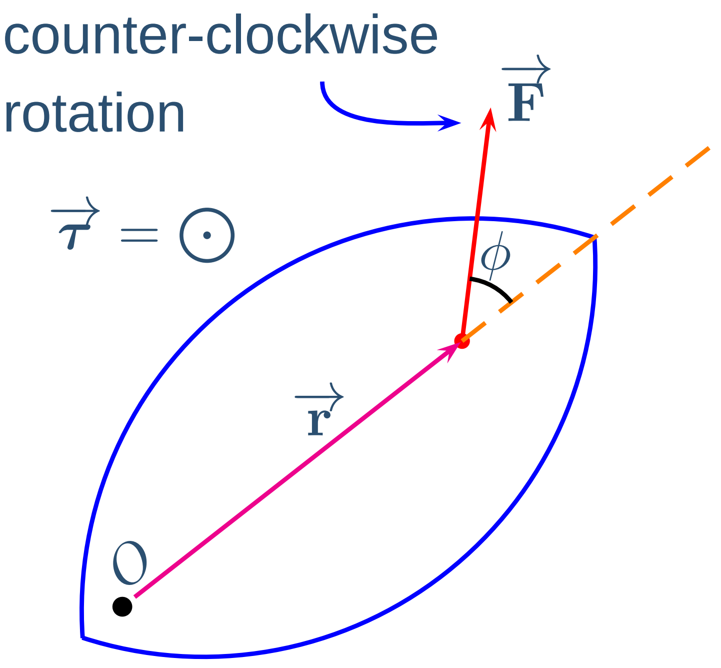

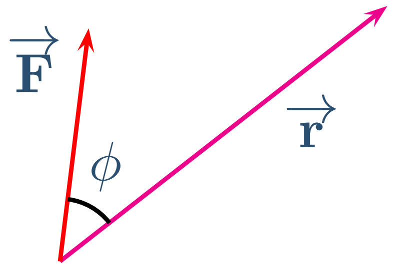

$$\vec{\boldsymbol{\tau}} = \vec{\mathbf{r}} \times \vec{\mathbf{F}}$$

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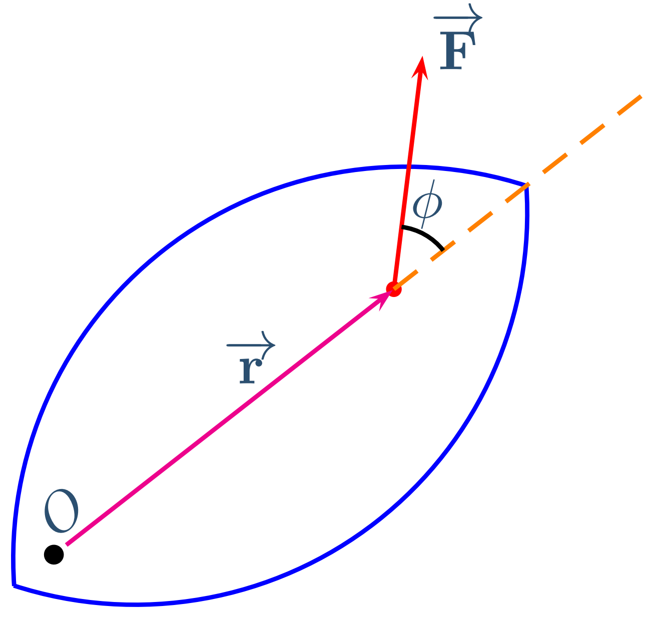

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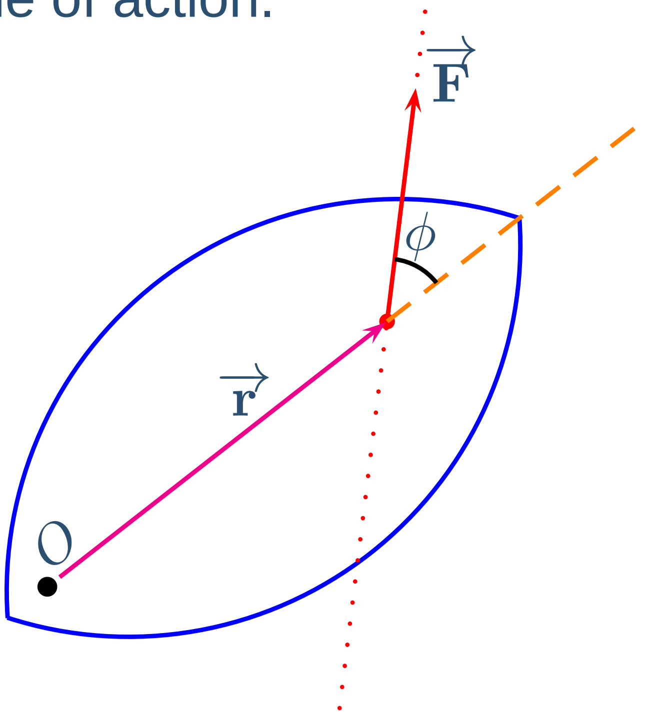

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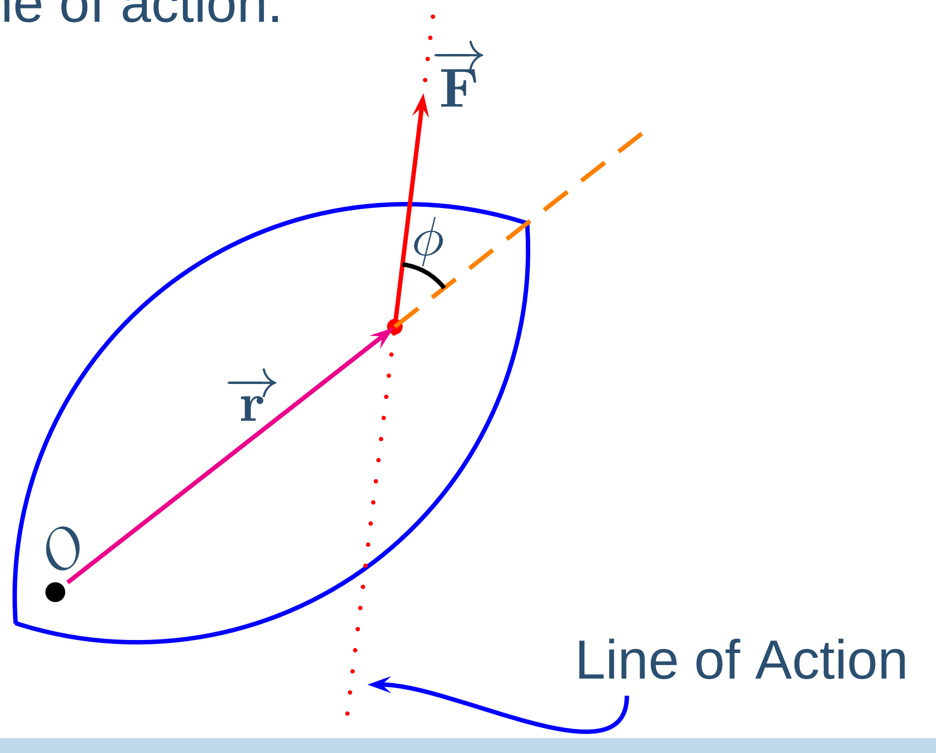

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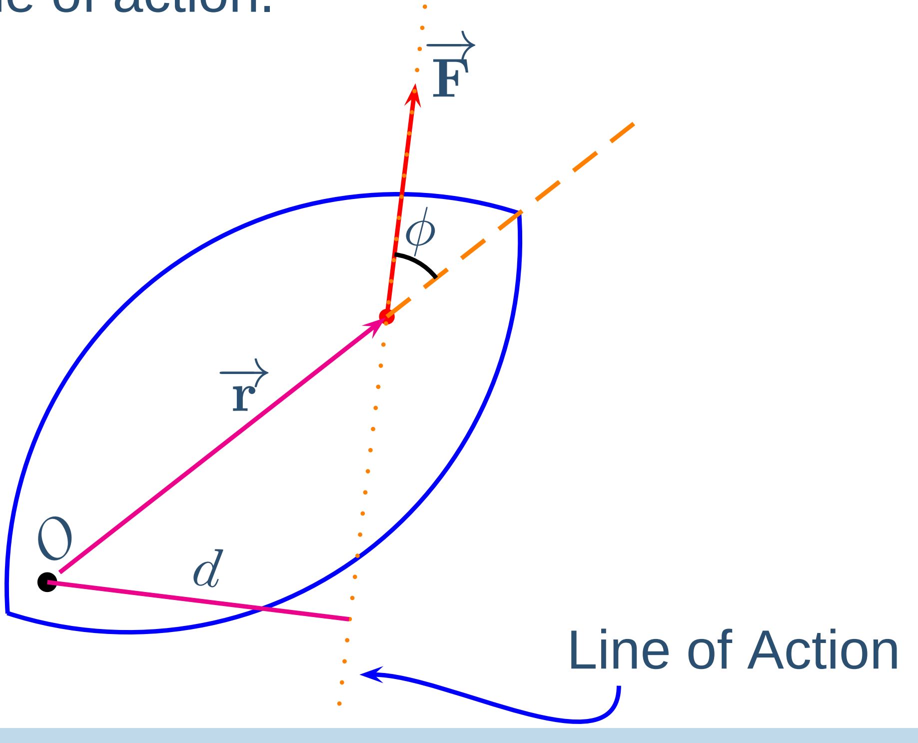

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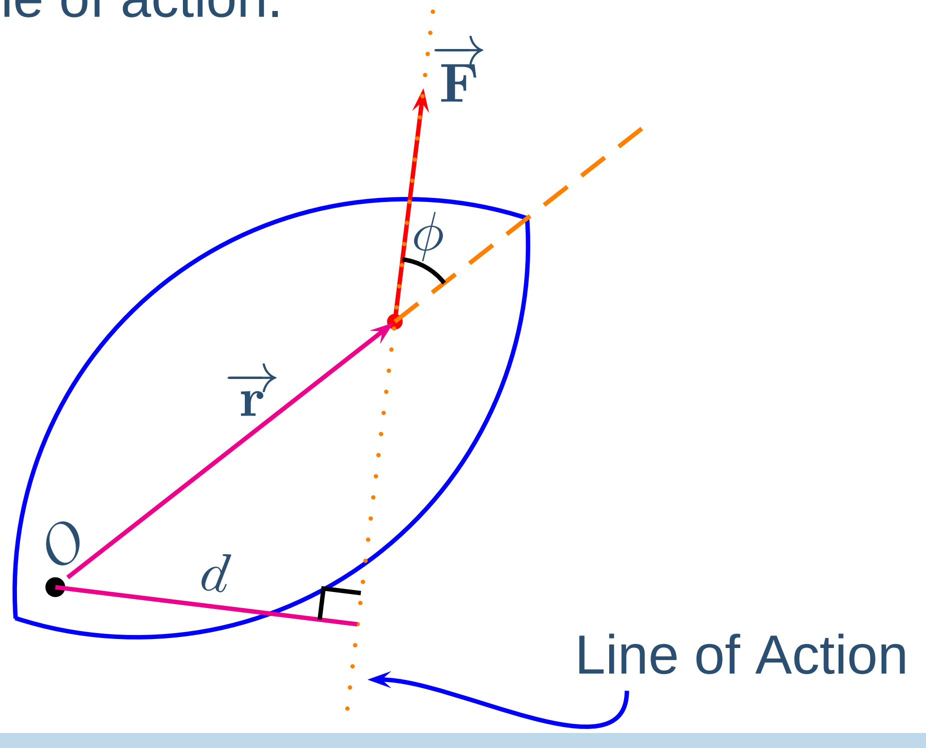

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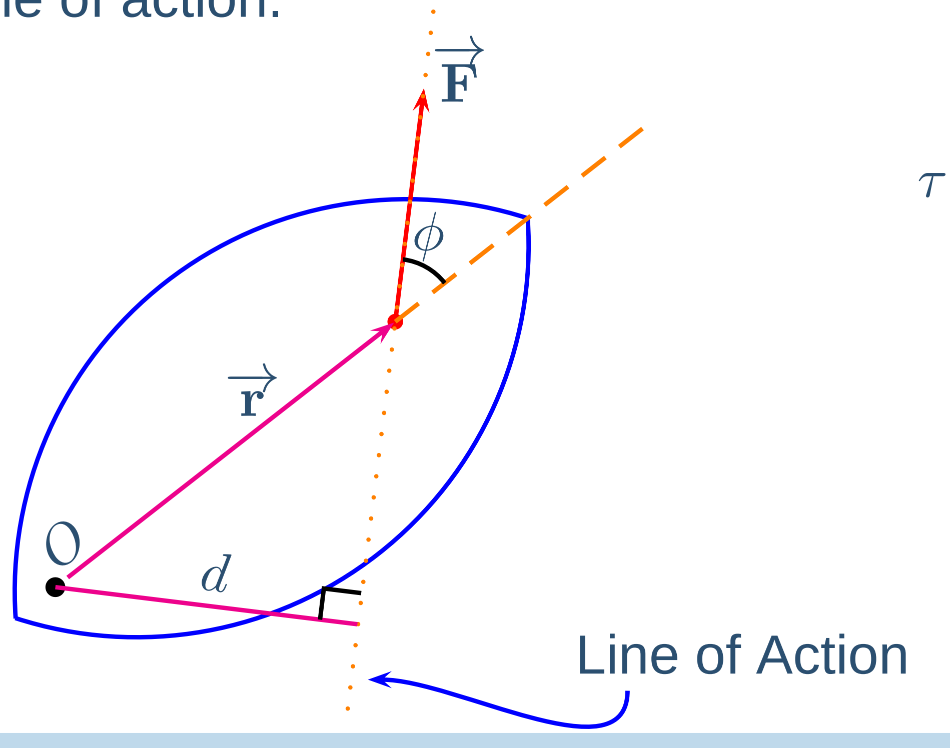

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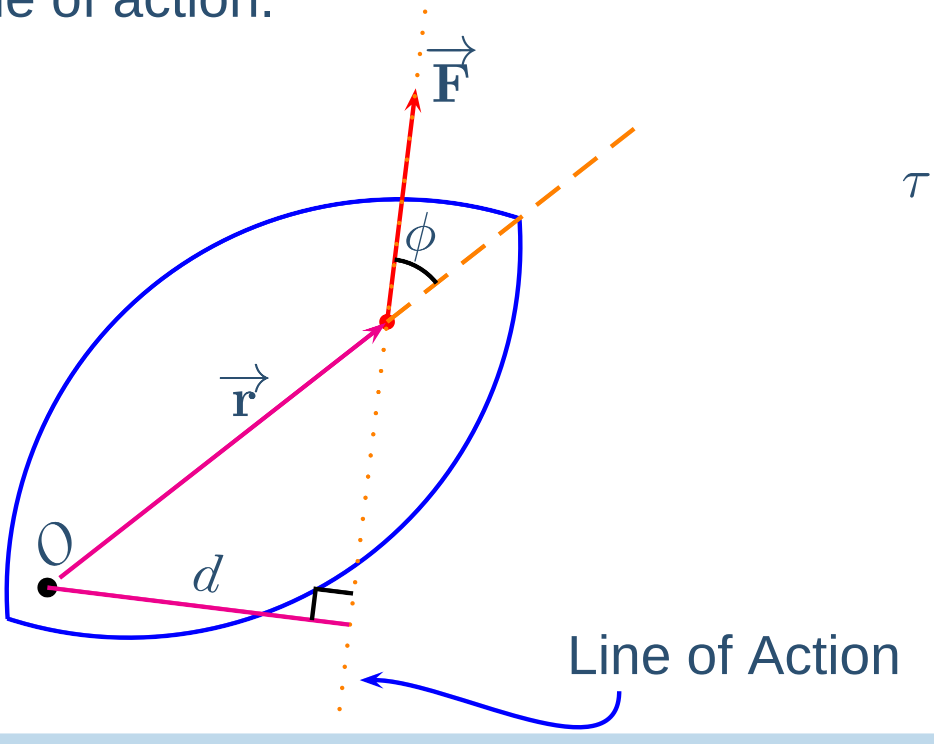

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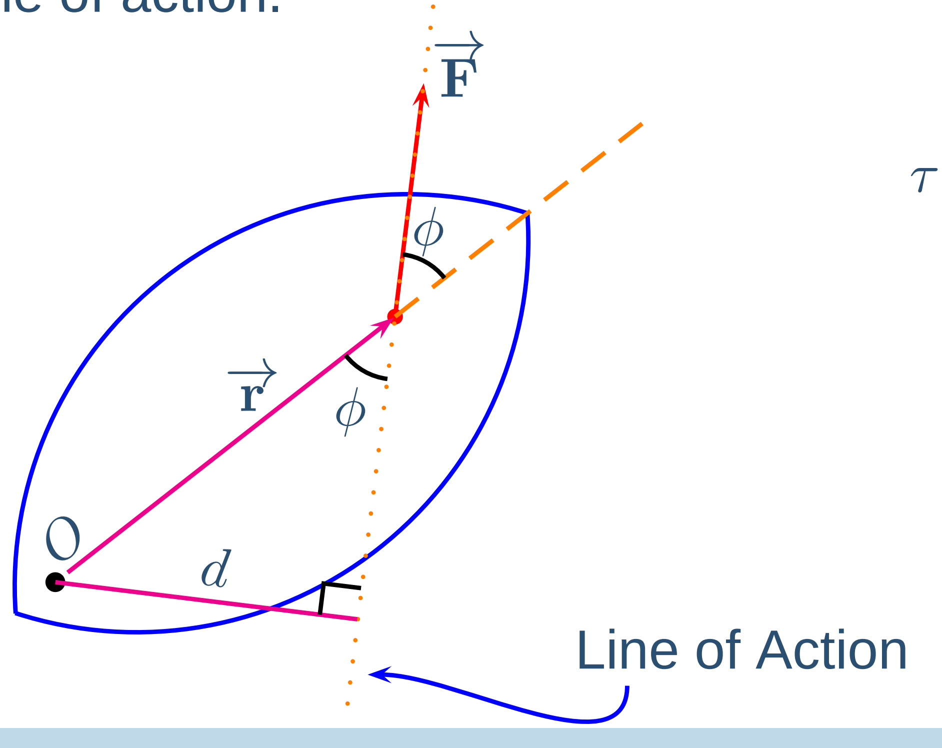

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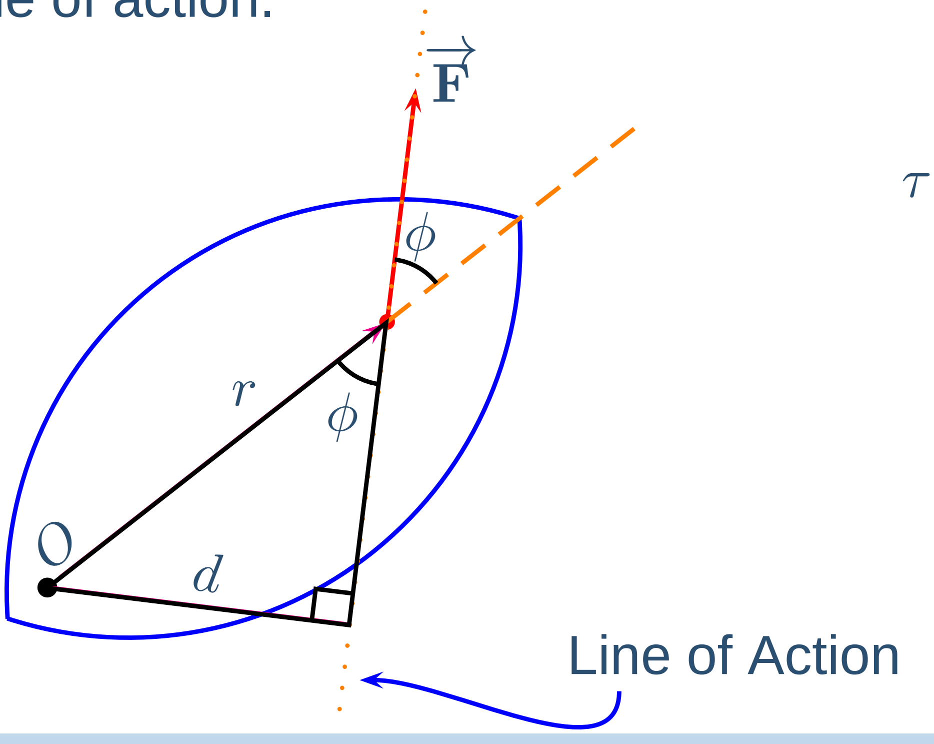

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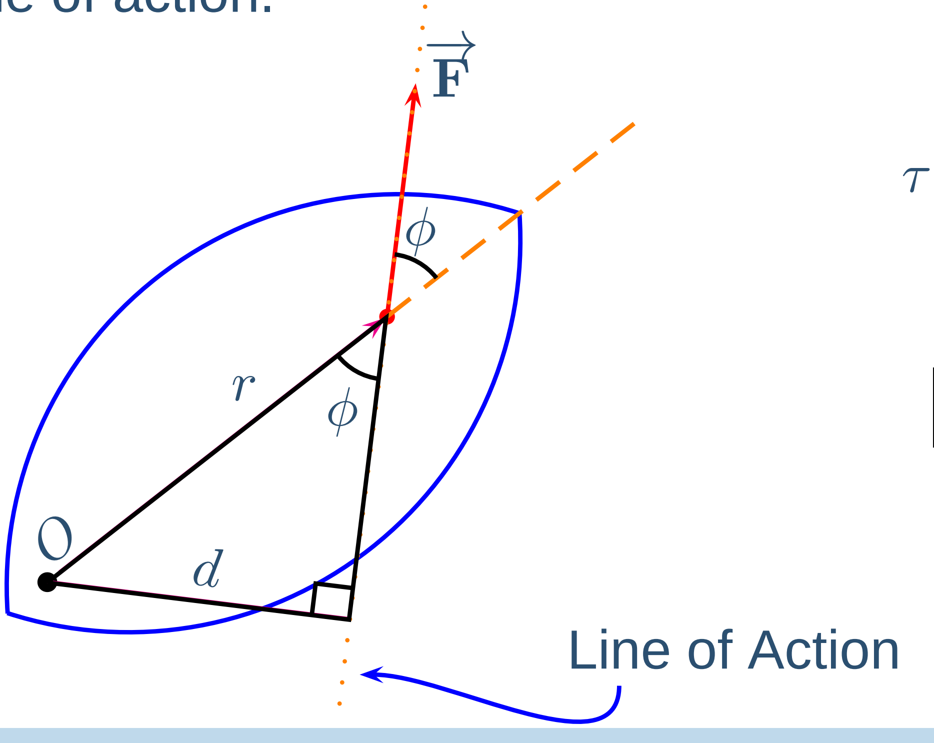

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$$\boxed{\tau = dF}$$

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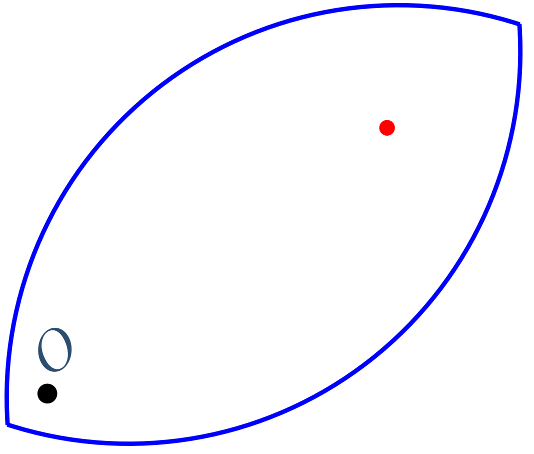

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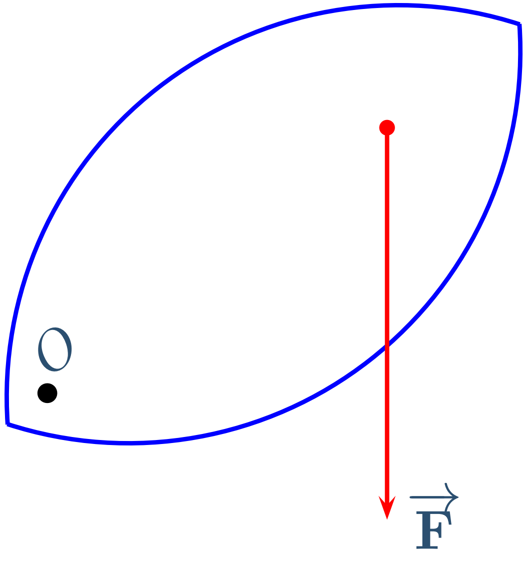

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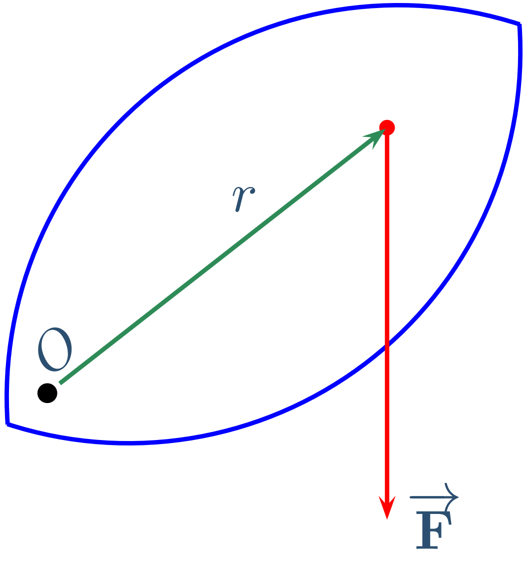
The perpendicular distance is particularly useful in finding the torque exerted by vertical forces.



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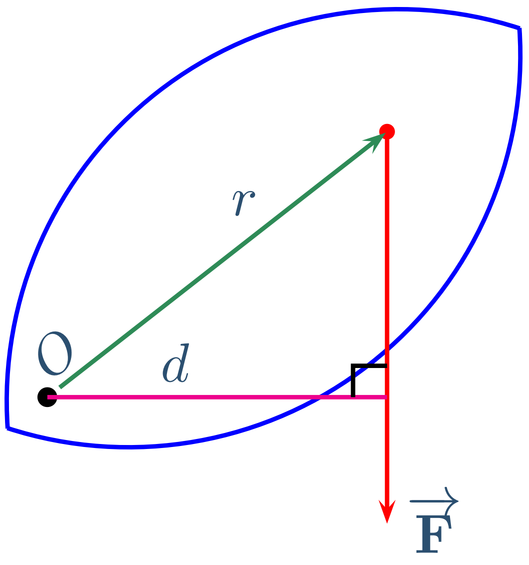

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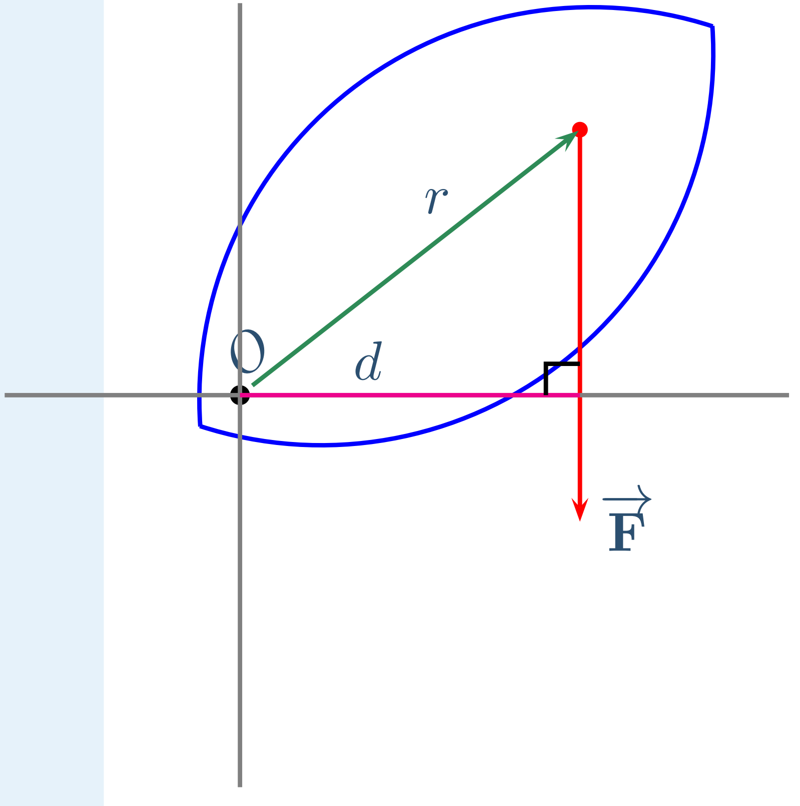

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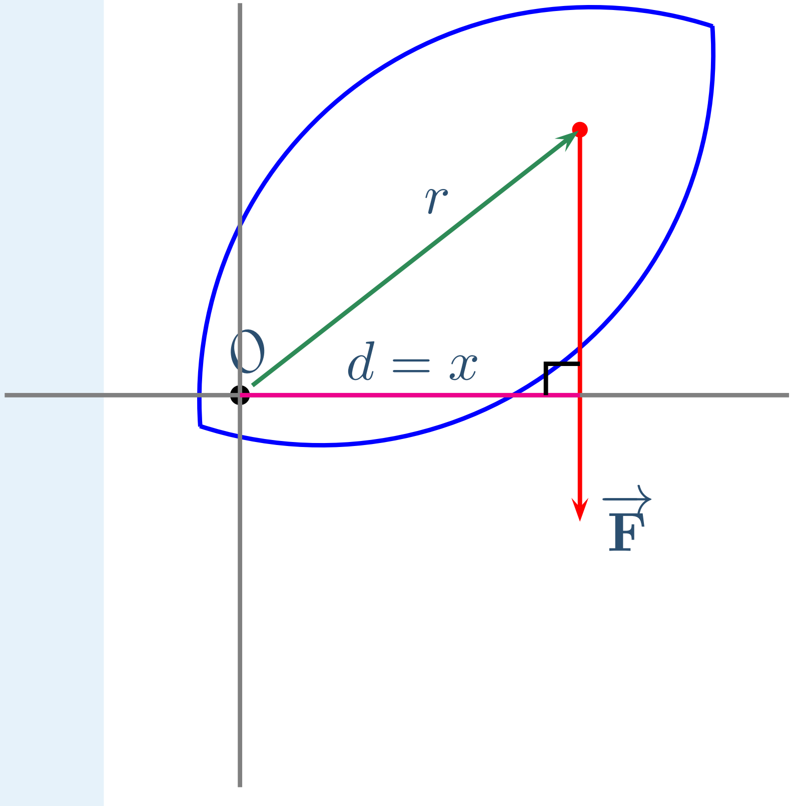

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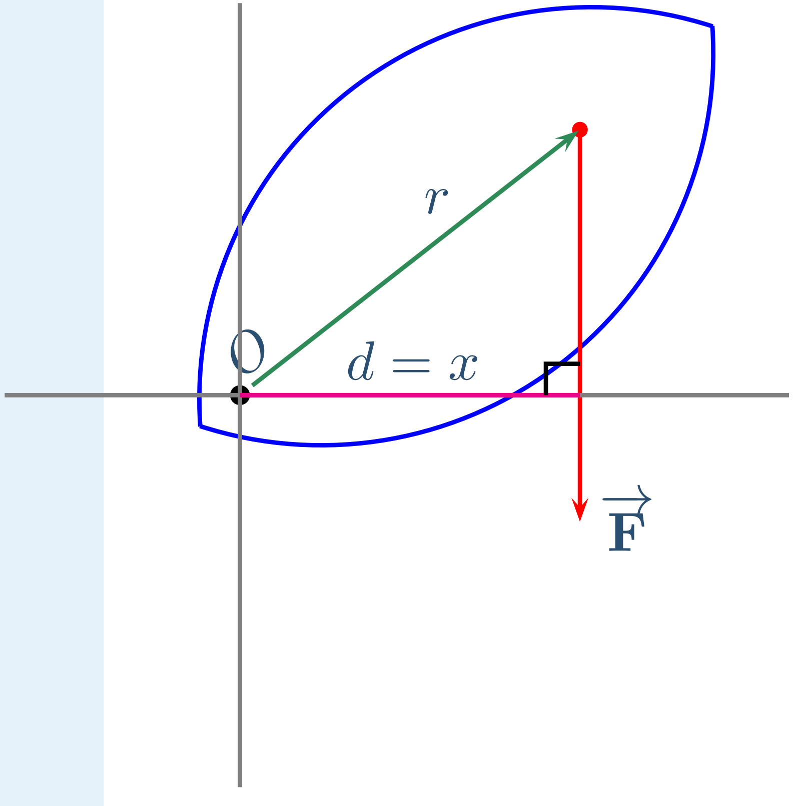

For vertical forces:

$$\tau = xF$$

Center of Gravity

Real objects consist of many particles. When experiencing a gravitational torque, each individual particle experiences a torque.

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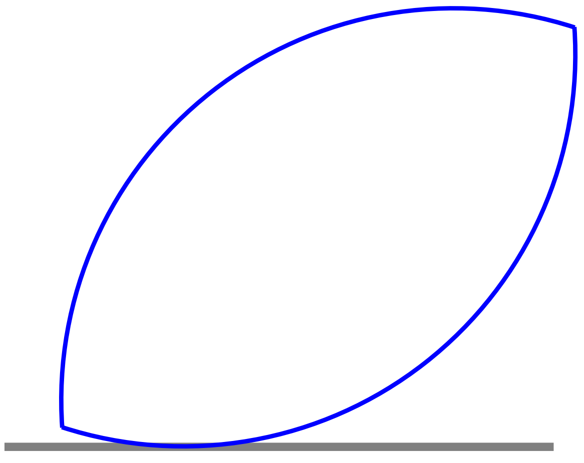

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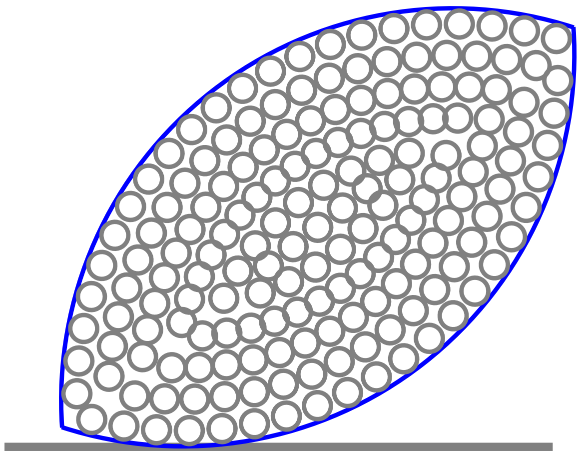

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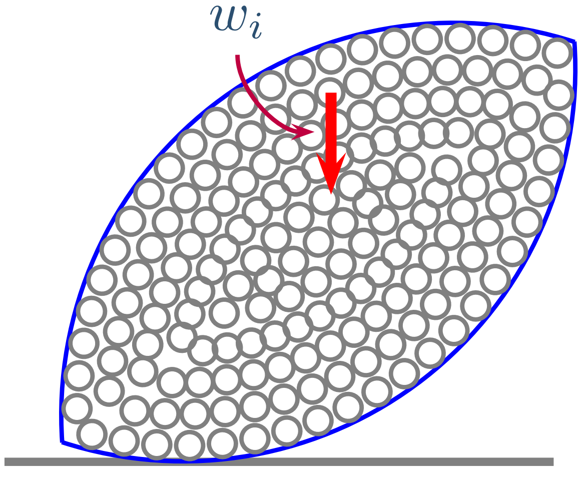

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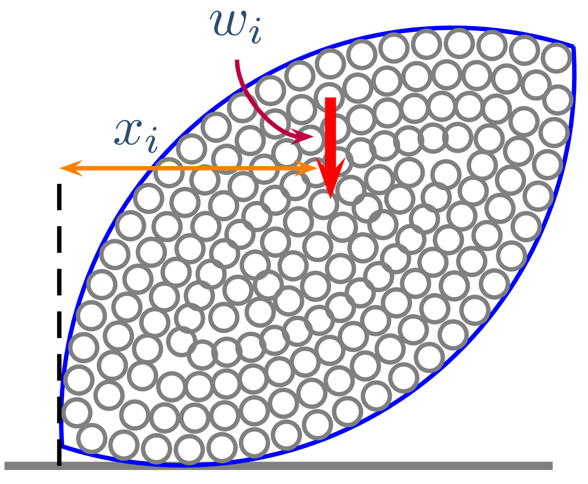

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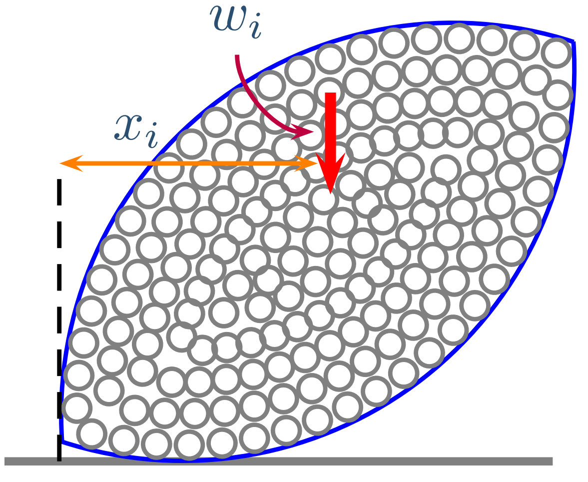

Each particle has

$$\tau_i = x_i w_i$$

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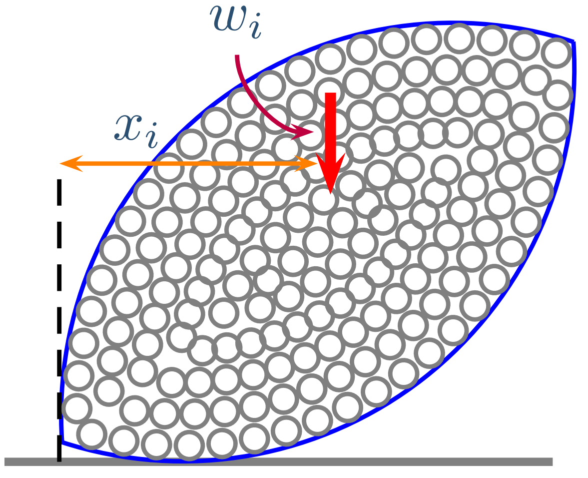

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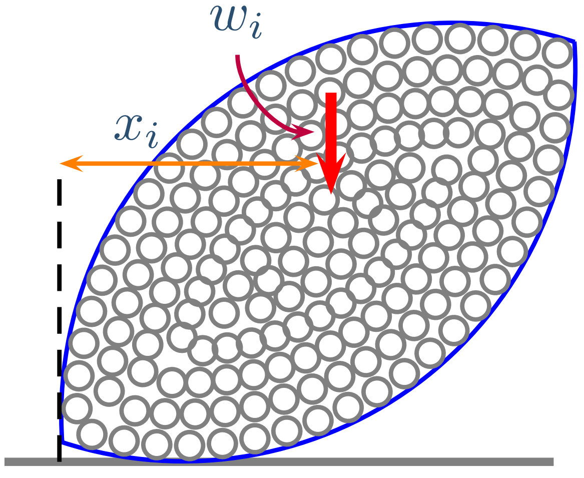

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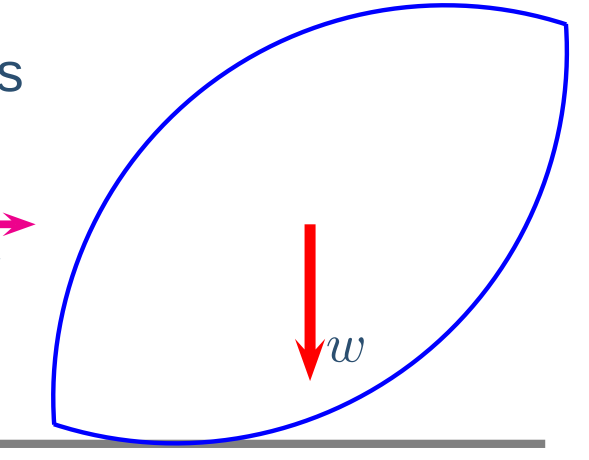

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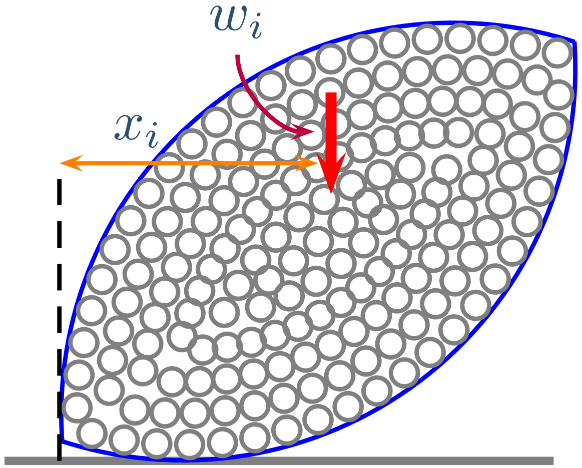
$$\tau_g = x_{cg} w$$



Each particle has

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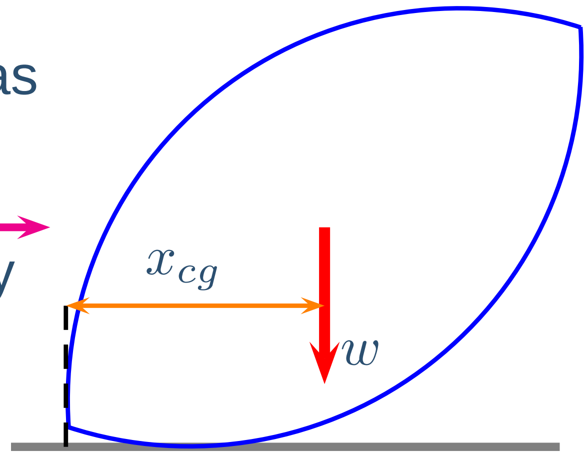
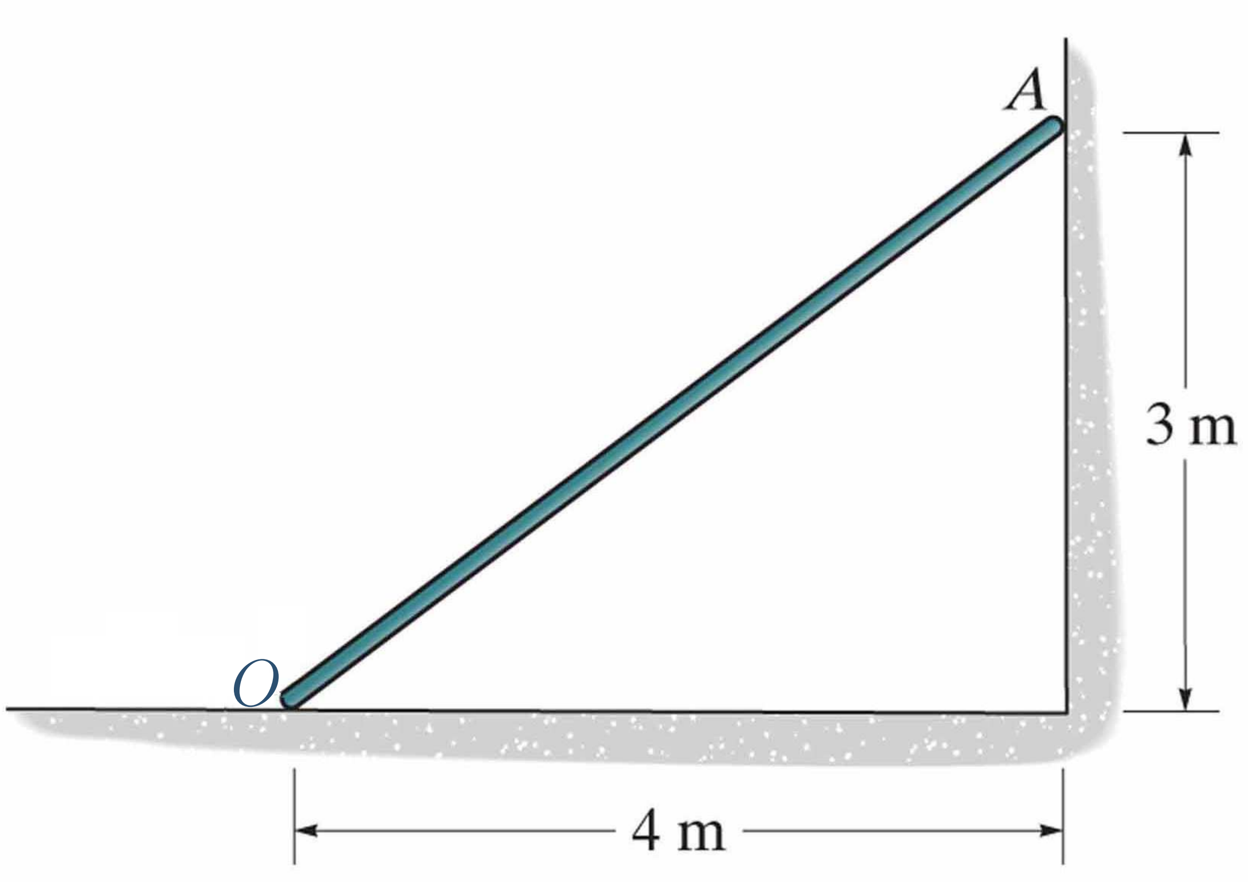


Center of Gravity Exercise

A 300-N *uniform* bar is leaning against a wall as shown. What is the gravitational torque magnitude about the point O?



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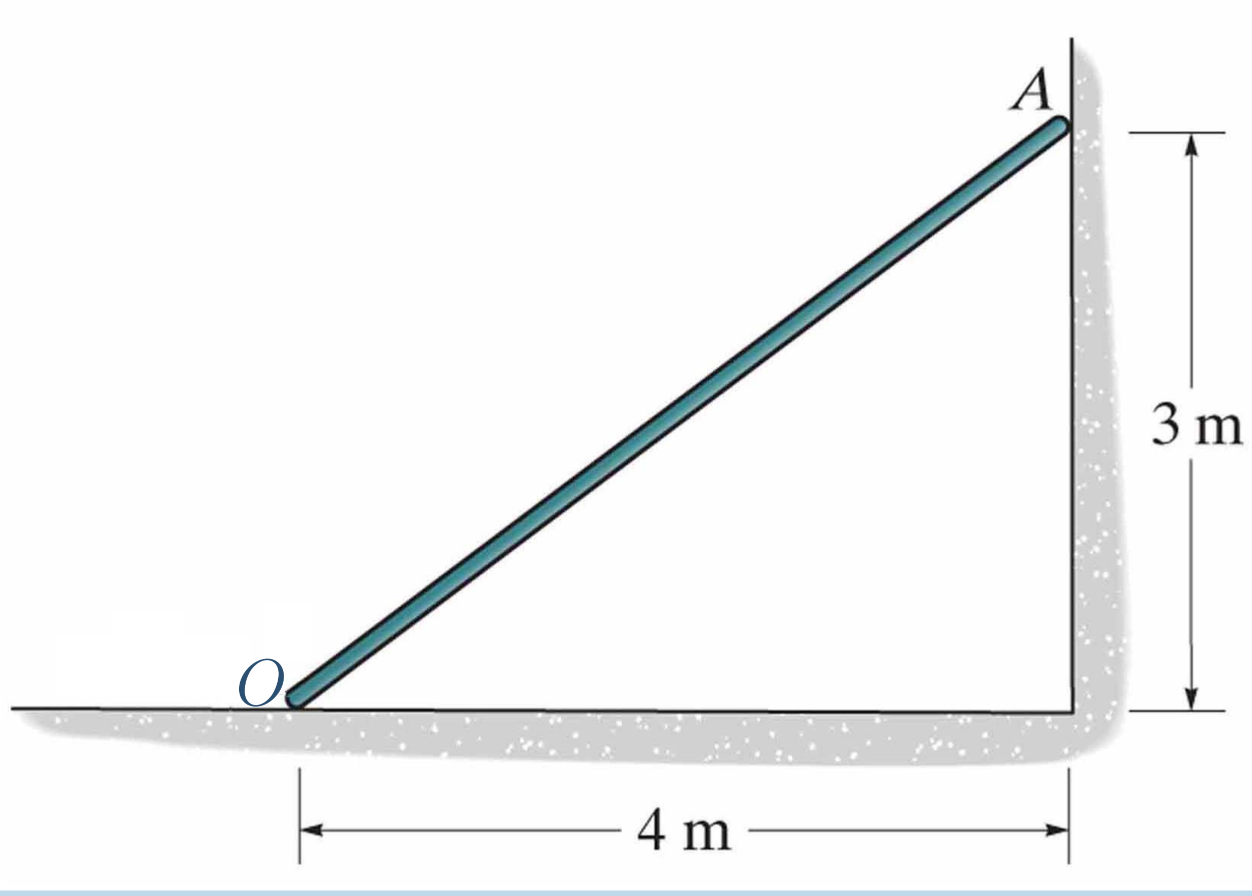
A 300-N *uniform* bar is leaning against a wall as shown. What is the gravitational torque magnitude about the point O?

(a) $300\, N \cdot m$



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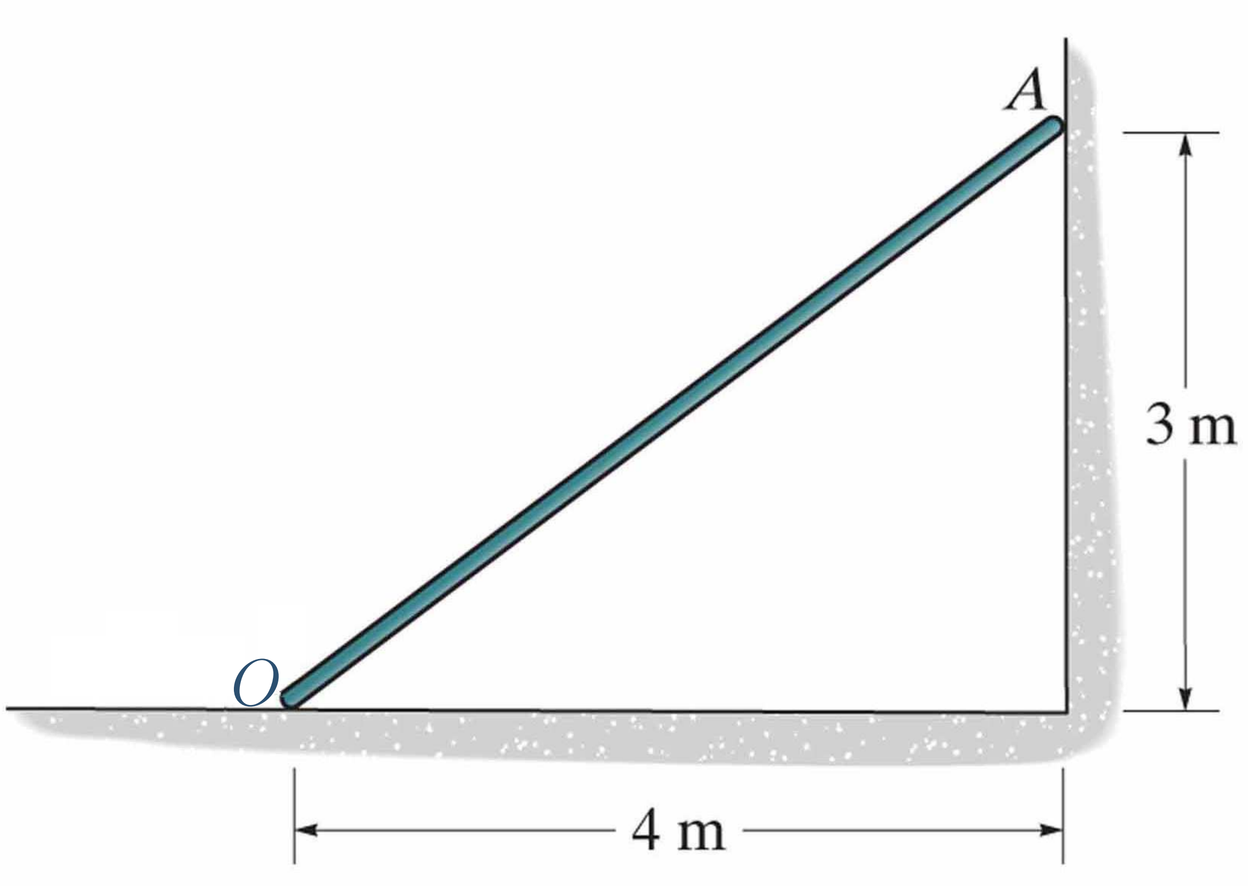

(a) $300\ N \cdot m$

(b) $450\ N \cdot m$

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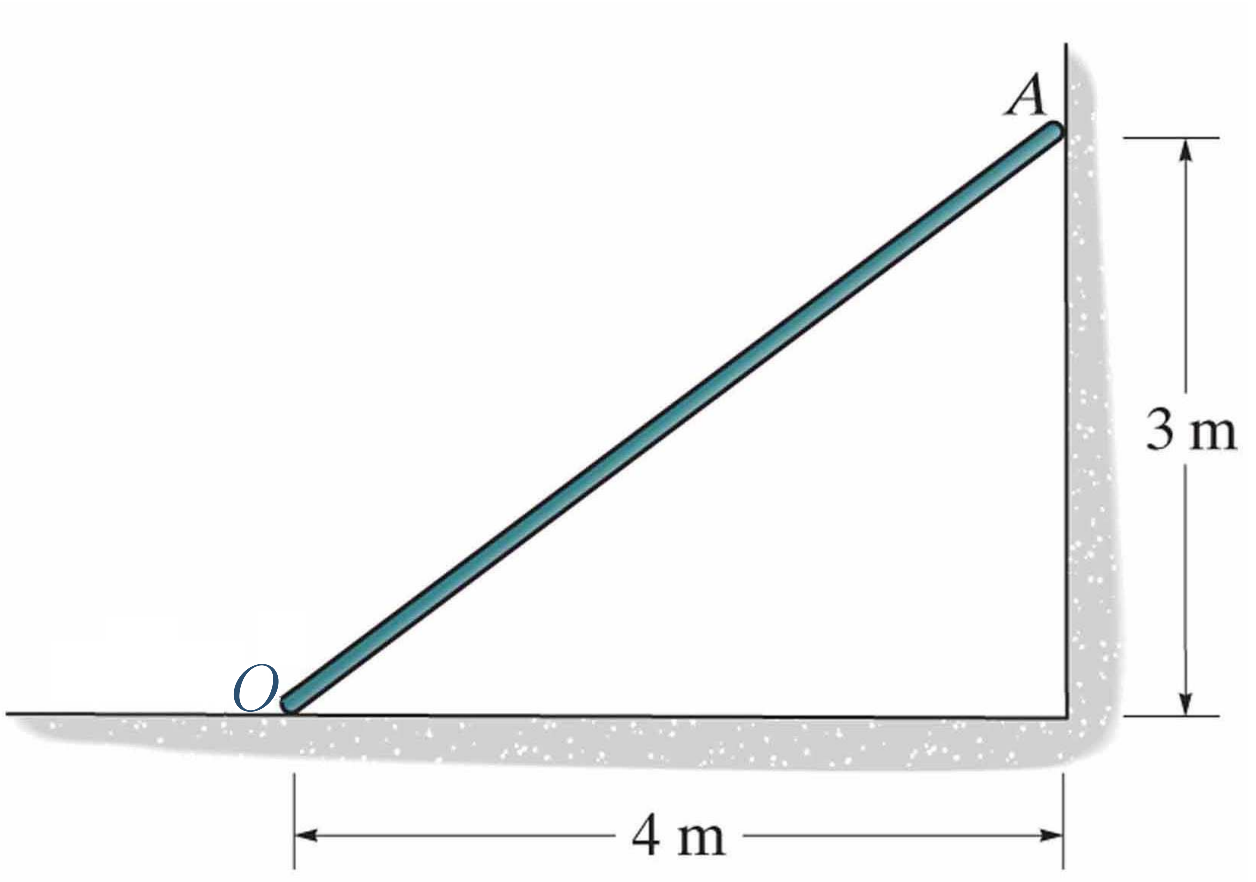

(a) $300\,N \cdot m$

(b) $450\,N \cdot m$

(c) $600\,N \cdot m$

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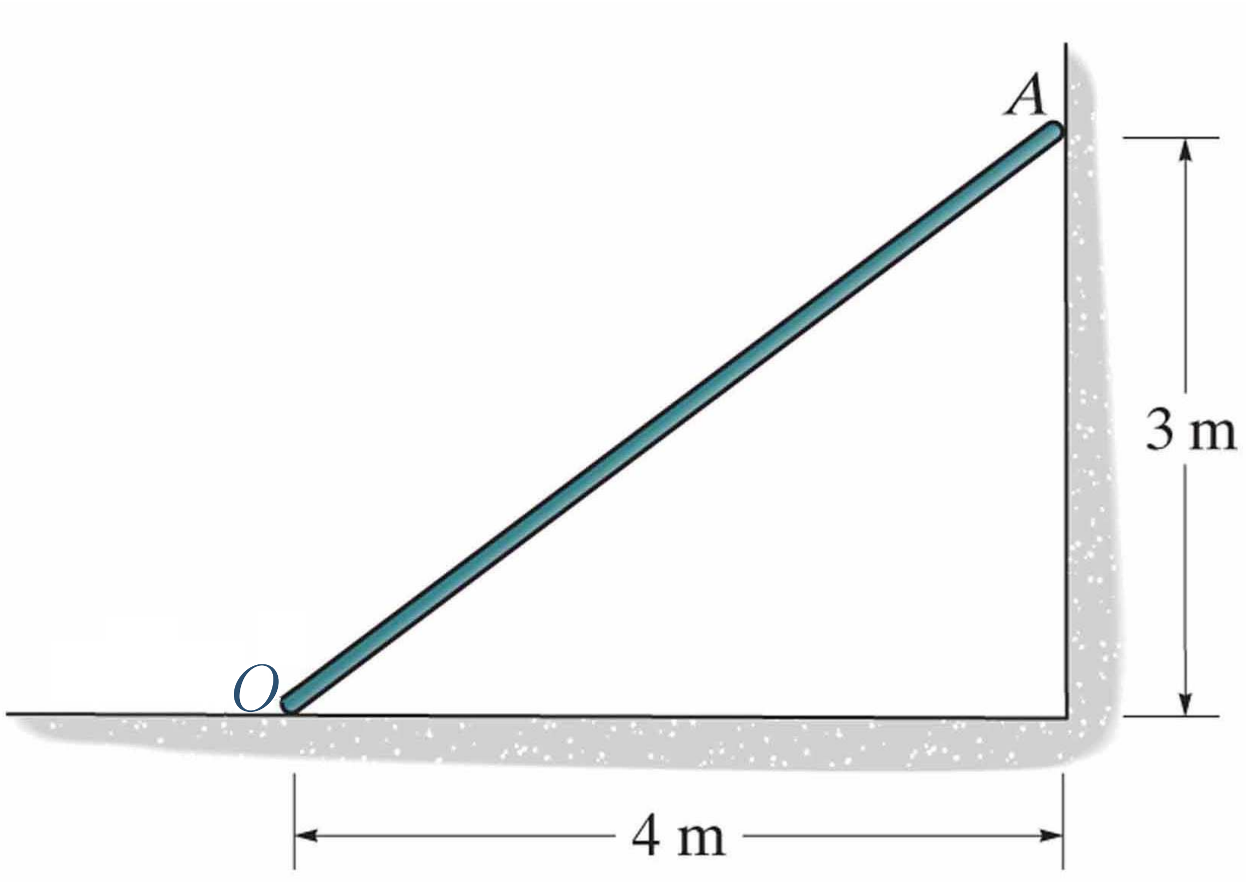

(a) $300\, N \cdot m$

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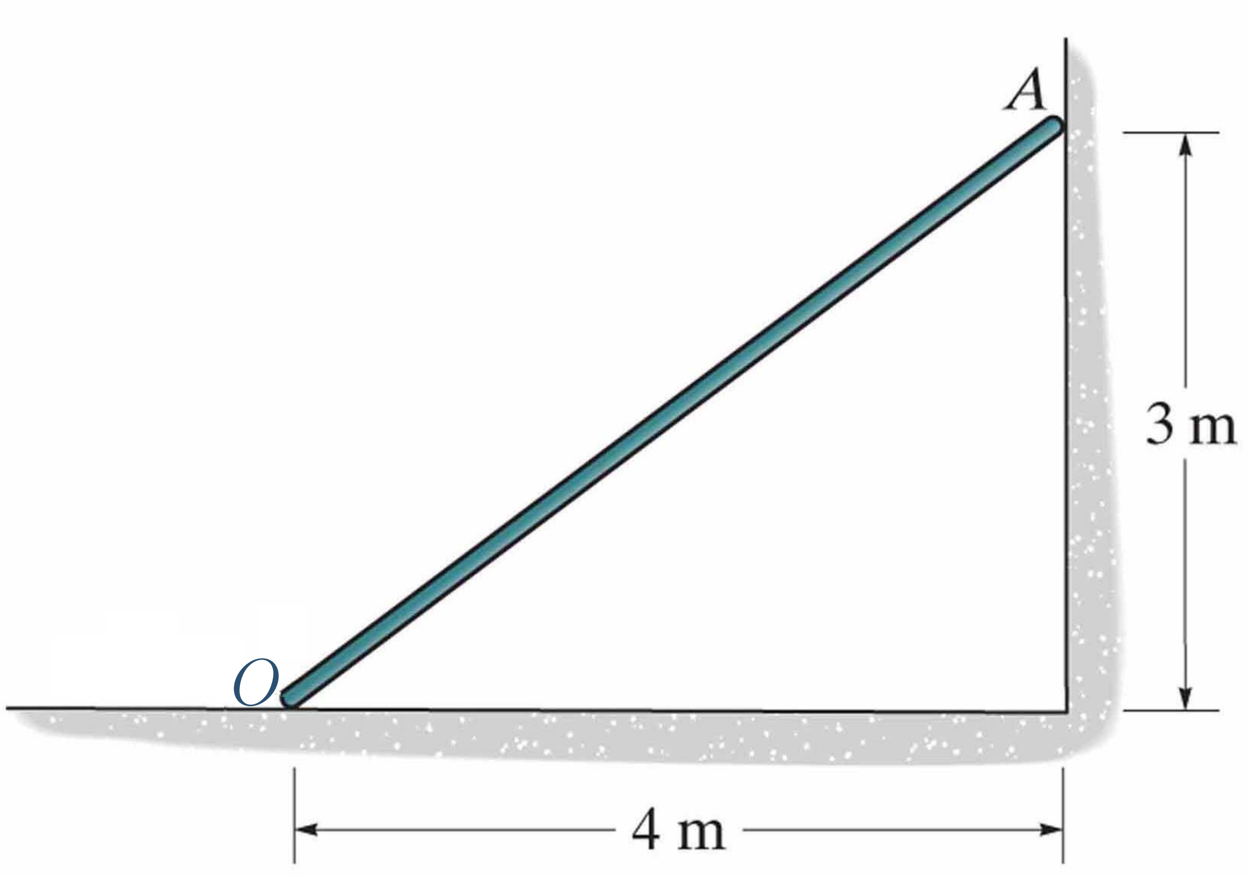

(a) $300\,N \cdot m$

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(e) $1200\,N \cdot m$

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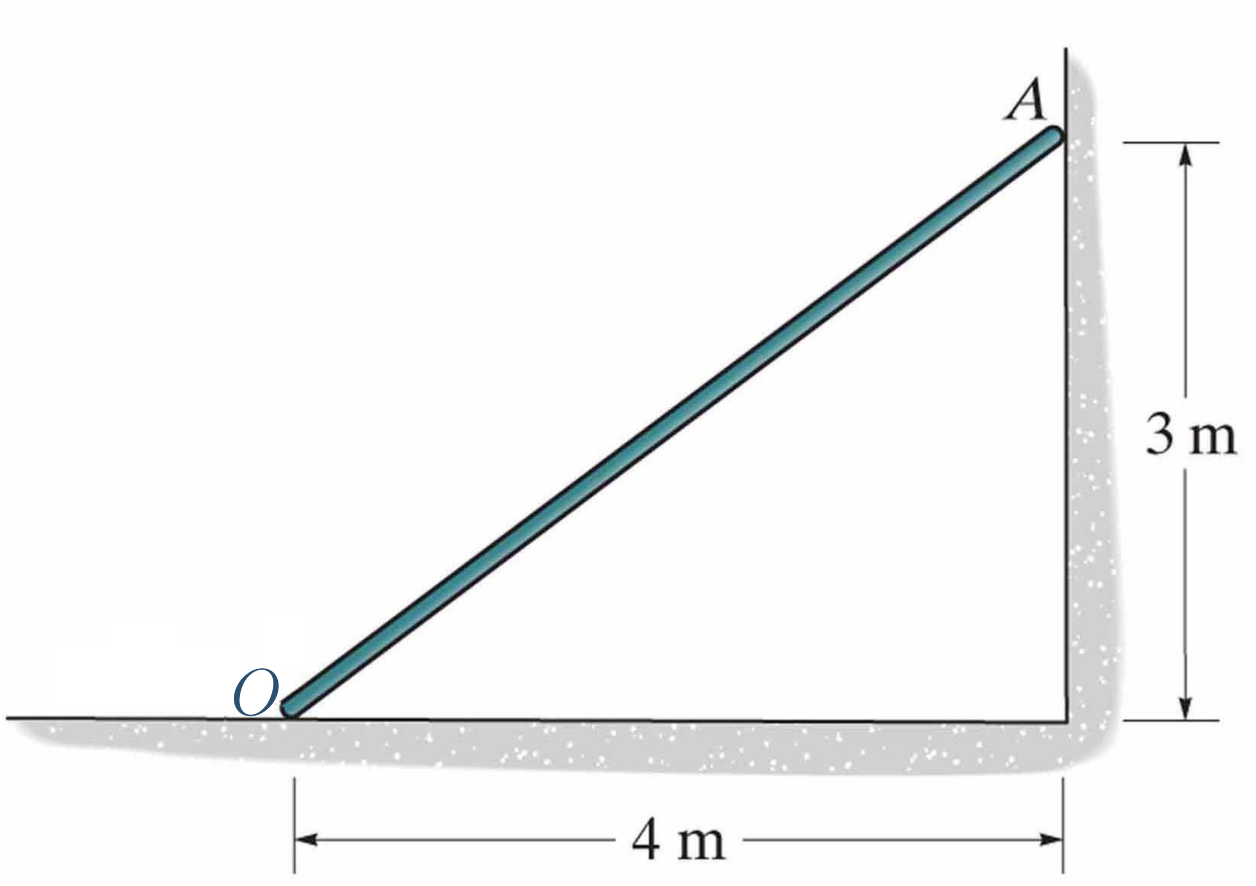

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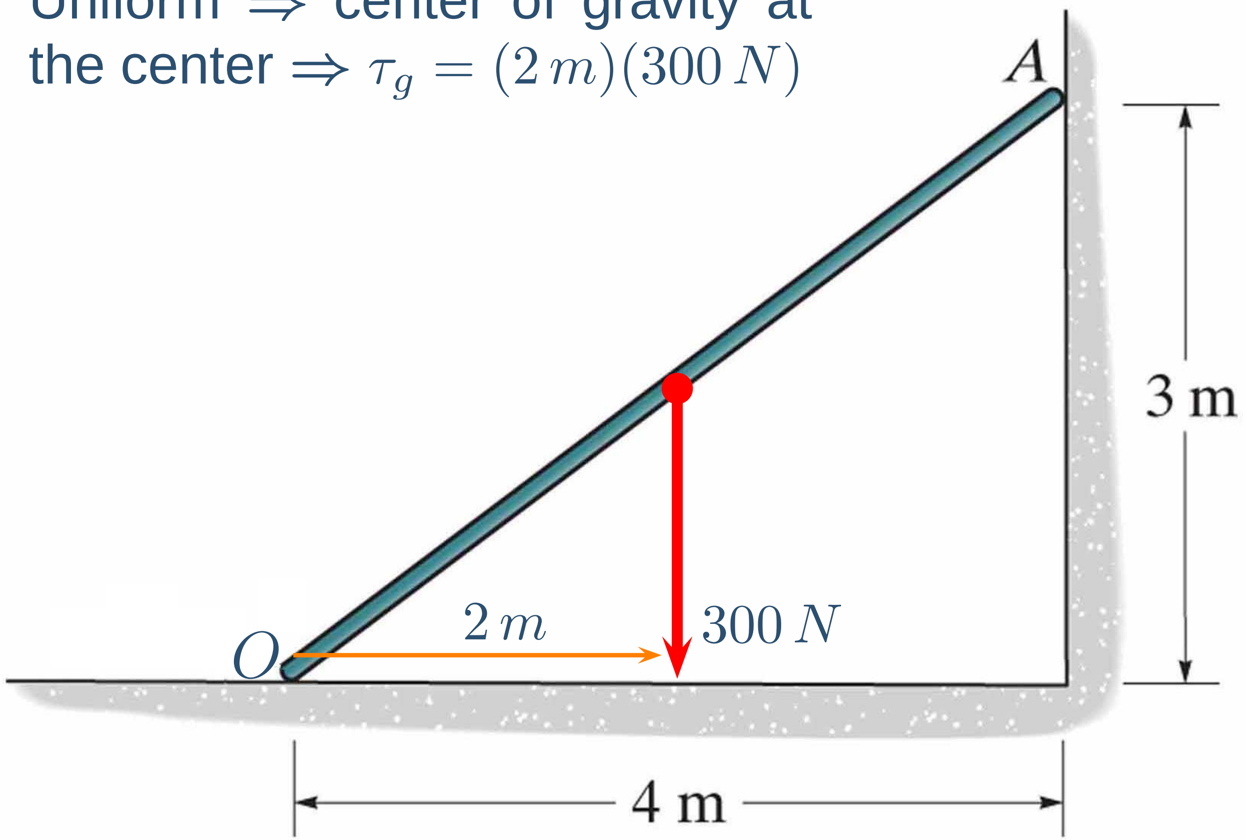
A 300-N *uniform* bar is leaning against a wall as shown. What is the gravitational torque magnitude about the point O?

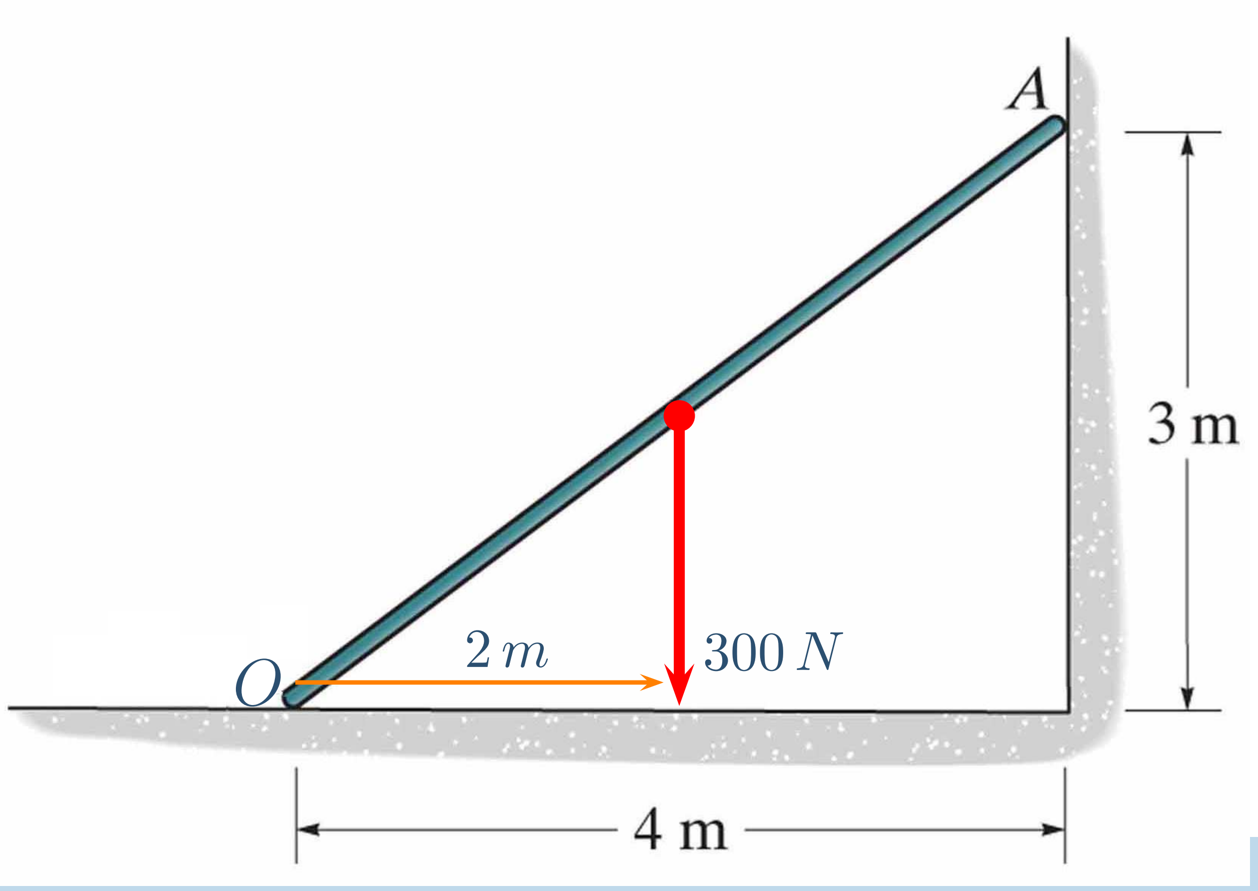
Uniform $\Rightarrow$ center of gravity at the center $\Rightarrow \tau_g = (2\,m)(300\,N)$



(c) $600\,N \cdot m$

Perpendicular Distance Exercise

What normal force must the wall exert on the bar at point A to keep it from rotating? Ignore any friction between the bar and the wall.



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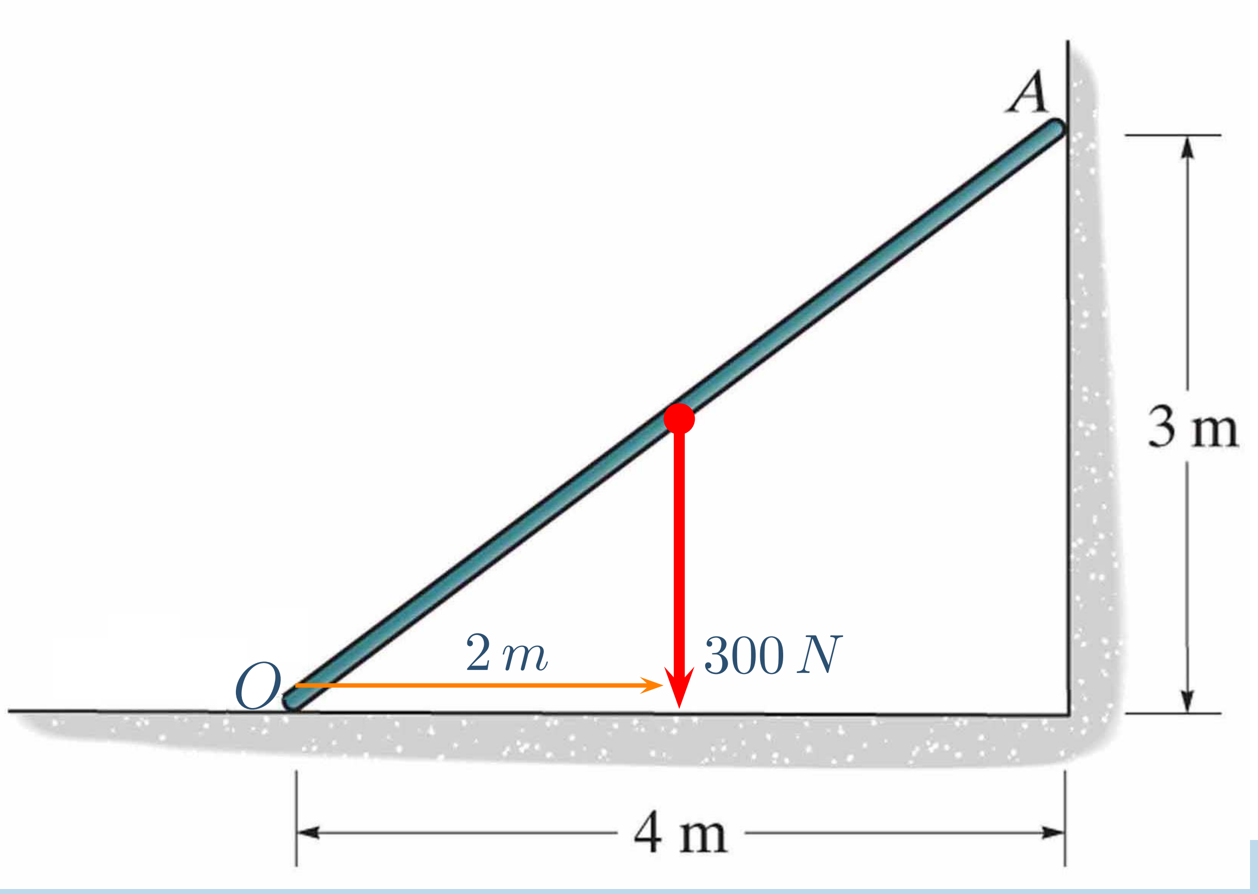
What normal force must the wall exert on the bar at point A to keep it from rotating? Ignore any friction between the bar and the wall.

(a) $150\,N$



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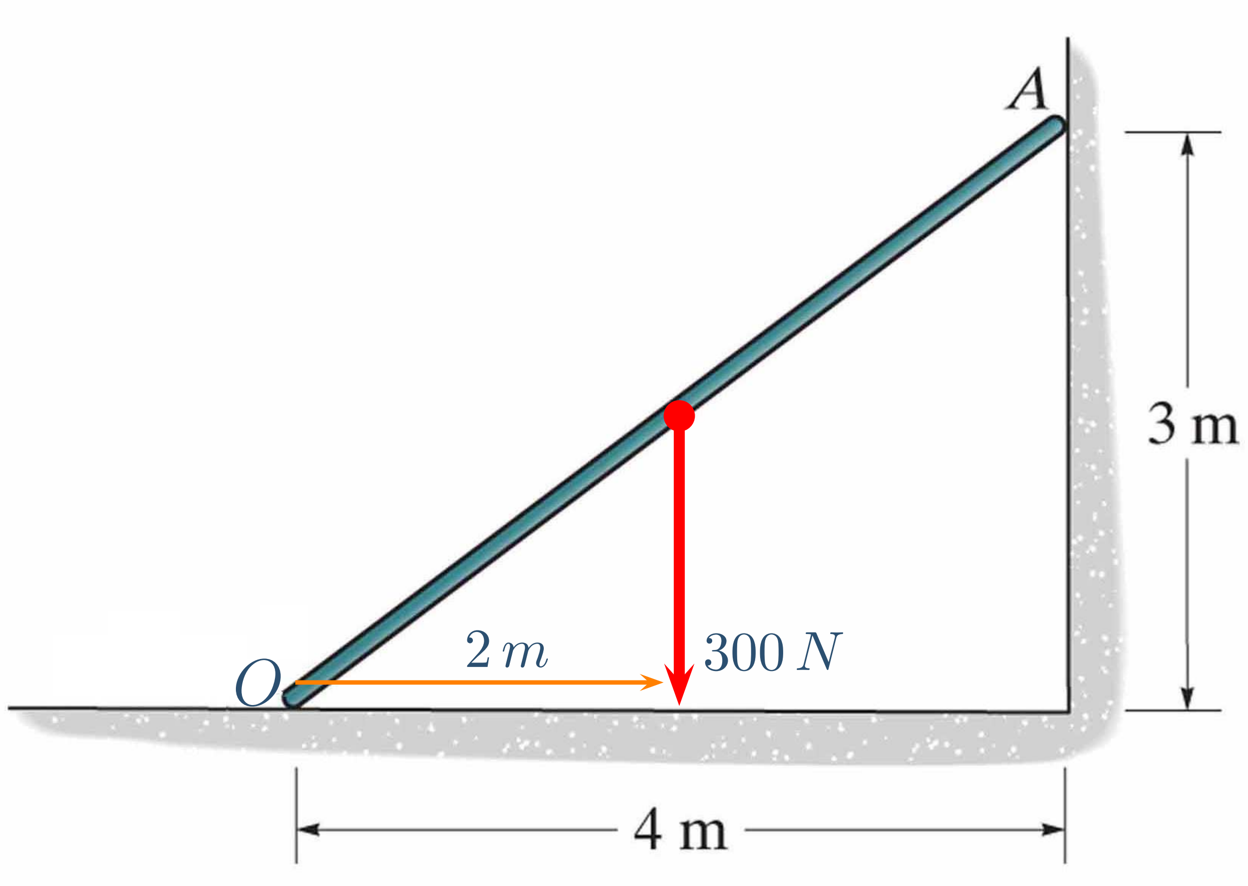

(a) $150\,N$

(b) $200\,N$

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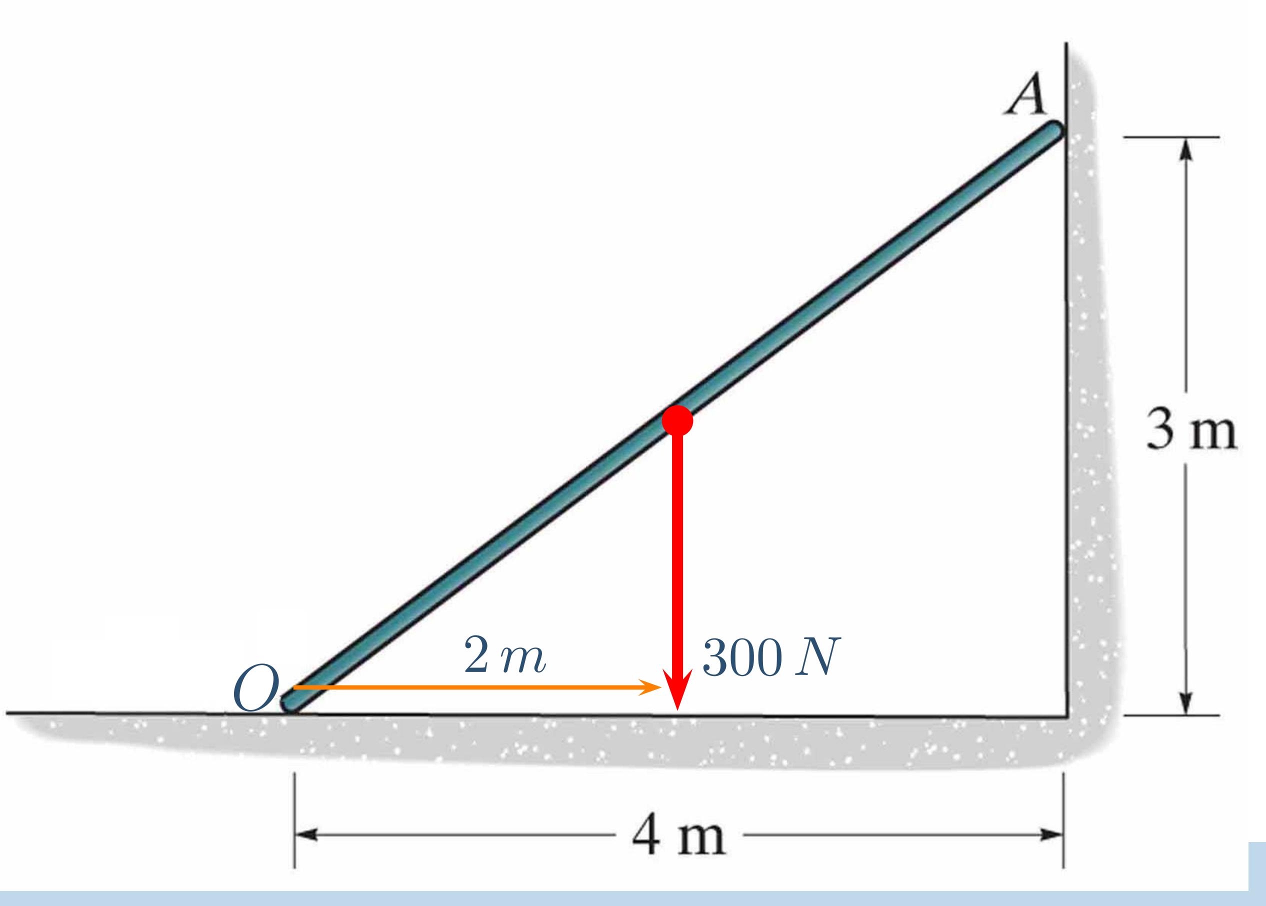

(a) $150\ N$

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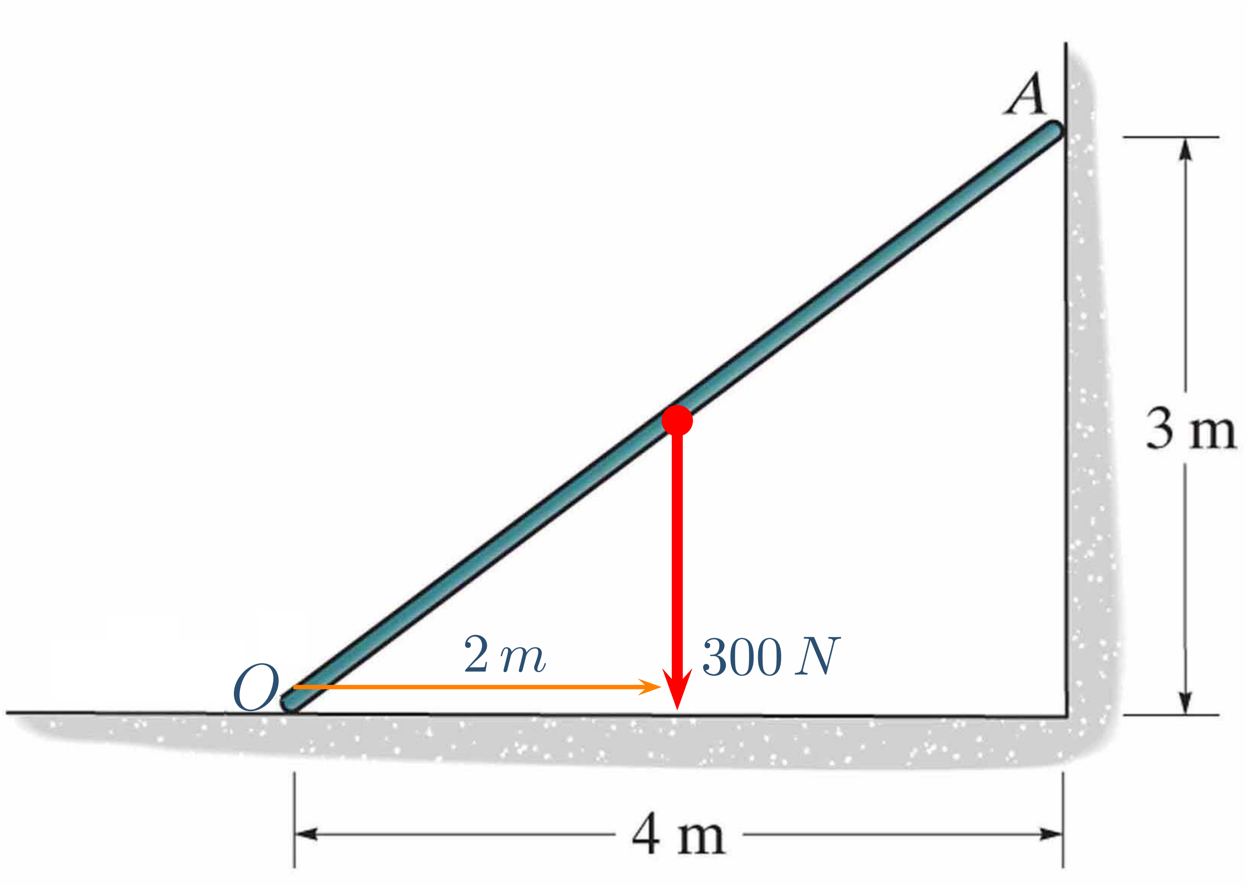

(a) $150\,N$

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(c) $300\,N$

(d) $400\,N$

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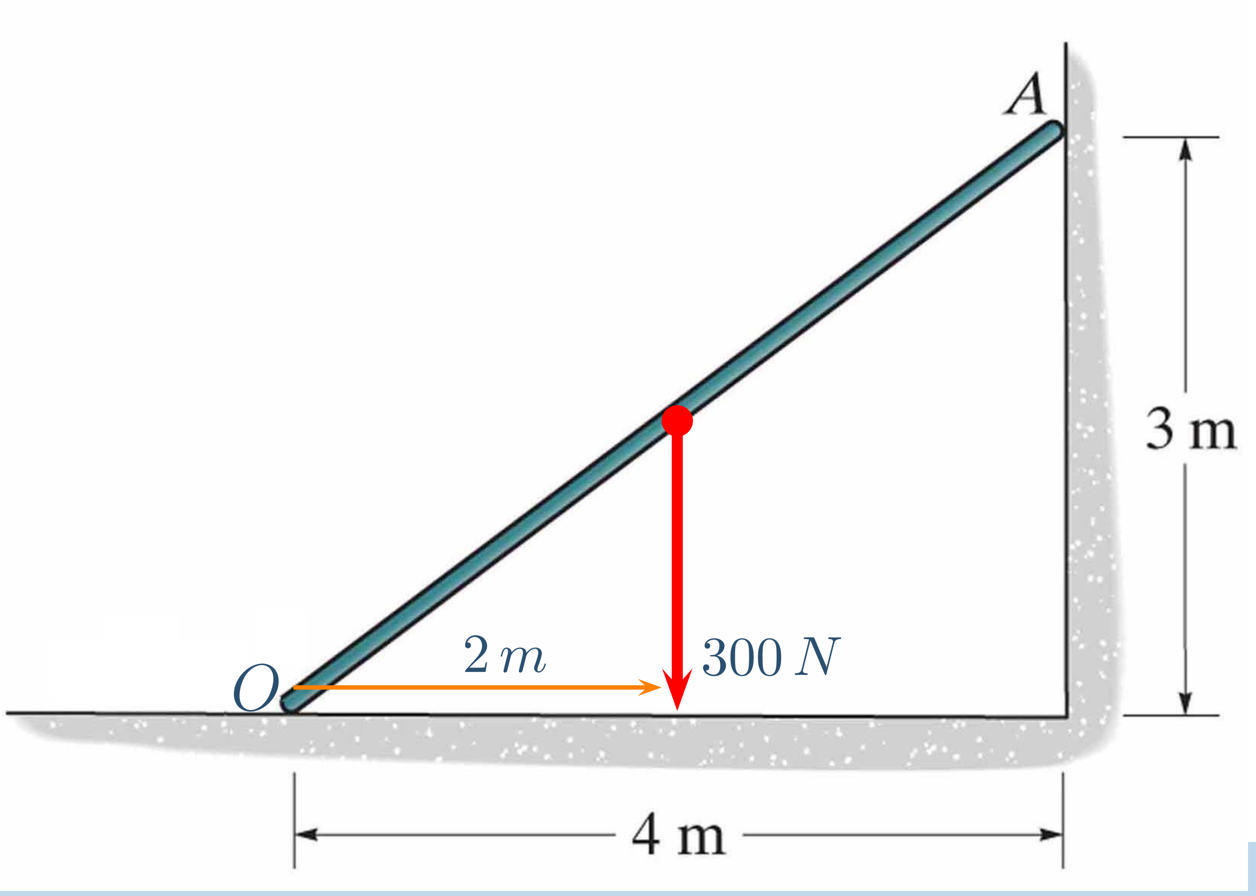

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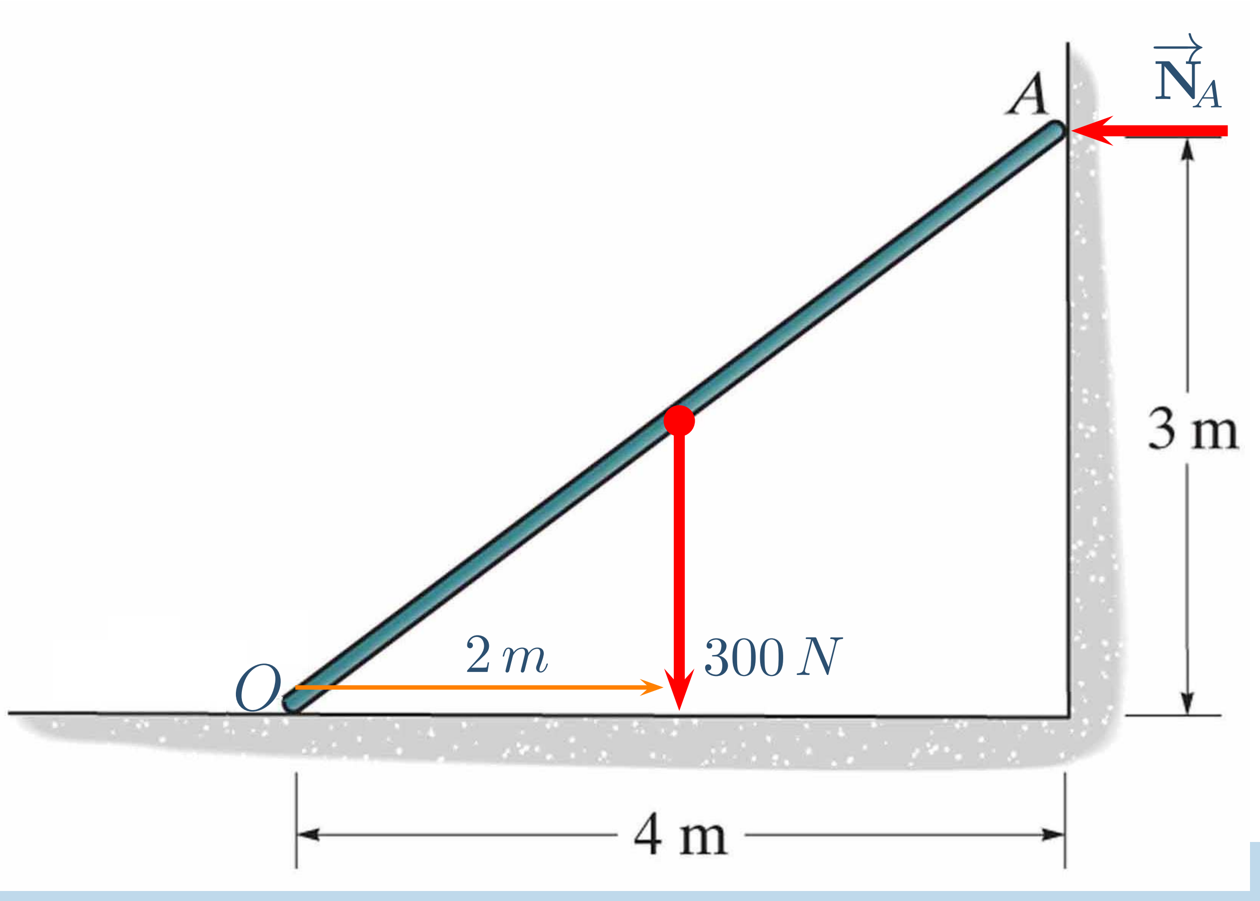

(a) $150\ N$

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(c) $300\ N$

(d) $400\ N$

(e) $900\ N$

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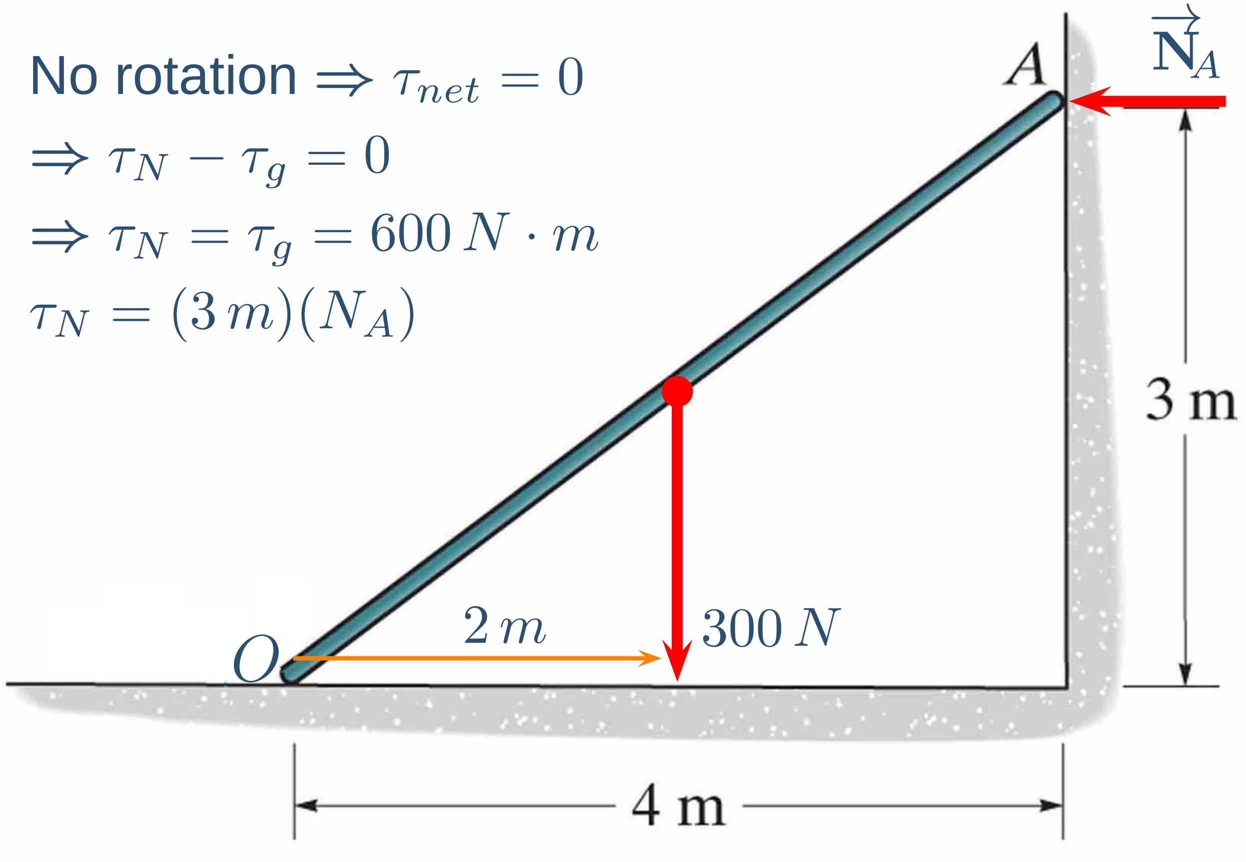
What normal force must the wall exert on the bar at point A to keep it from rotating? Ignore any friction between the bar and the wall.

No rotation $\Rightarrow \tau_{net} = 0$

$\Rightarrow \tau_N - \tau_g = 0$

$\Rightarrow \tau_N = \tau_g = 600\,N \cdot m$

$\tau_N = (3\,m)(N_A)$



(a) $150\,N$

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Newton’s Second Law for Rotation

Newton’s Second law can be modified for rotation.

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