July 10, Week 6

Today: Finish Chapter 10, Begin Chapter 7, Rotational Motion

Homework #6 due tomorrow

General Energy Conservation III

$$\boxed{\frac{1}{2}mv_i^2 + mgy_i + \frac{1}{2}ks_i^2 + W_{other} = \frac{1}{2}mv_f^2 + mgy_f + \frac{1}{2}ks_f^2}$$

Example: An $80\,kg$ man jumps onto a spring platform ($k = 18000\,N/m$) going $9\,m/s$. How far does he compress the spring?

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Example: An $80\,kg$ man skydives from a plane $1600\,m$ above the ground. If he lands with a speed of $10\,m/s$ (and was essentially at rest when he jumped), how much work did his parachute do?

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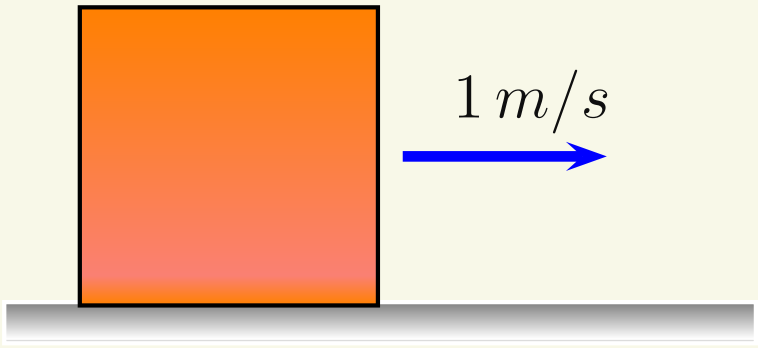
Thermal Energy Exercise

A 10-kg mass sliding to the right, initially with speed $3\,m/s$, is stopped by friction. How much thermal energy will be created by this process?



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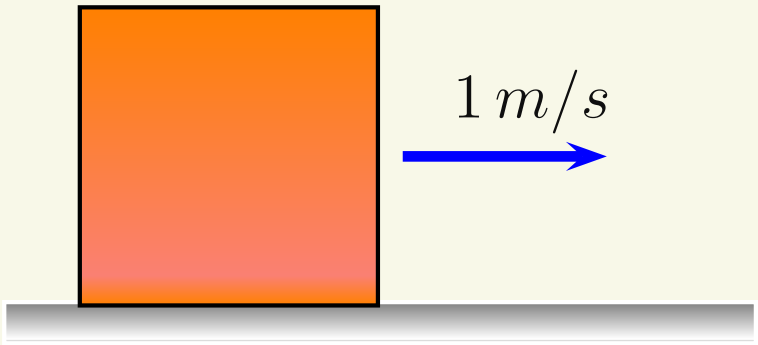

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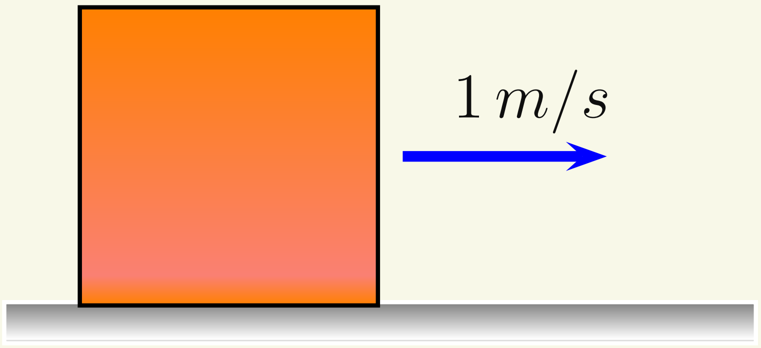

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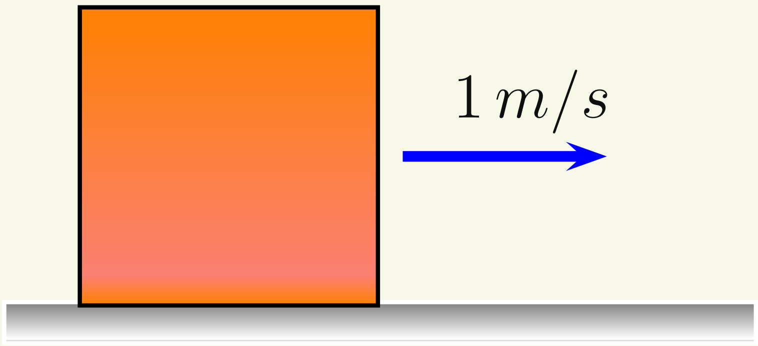

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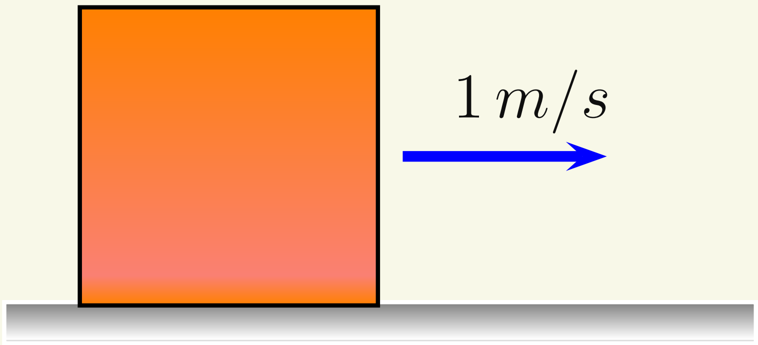

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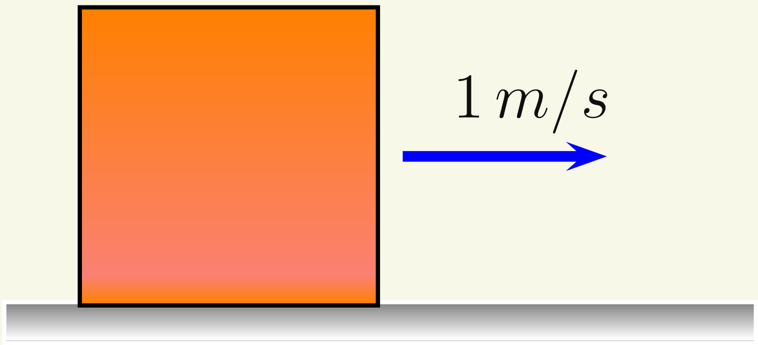

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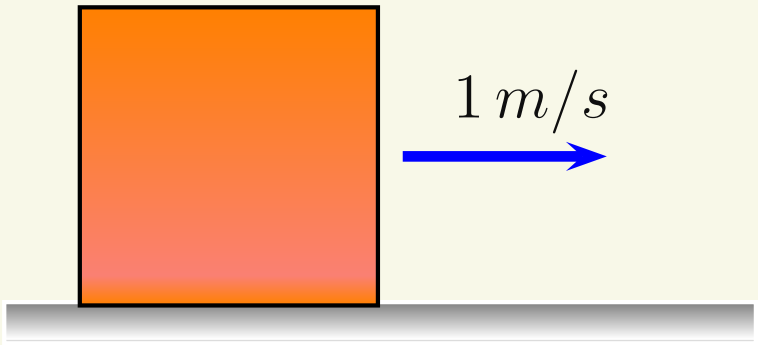

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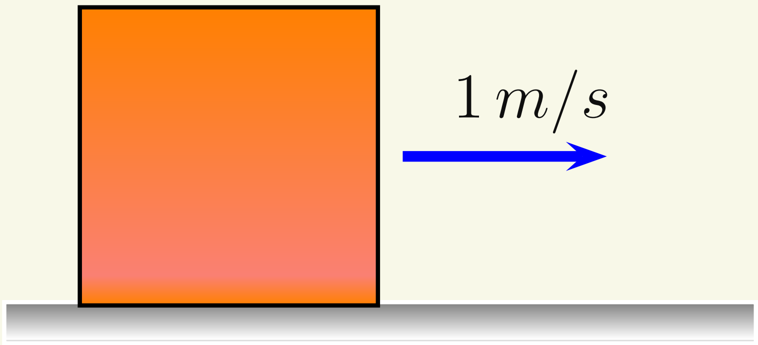

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No springs or gravity $\Rightarrow \frac{1}{2}mv_i^2 = \frac{1}{2}mv_f^2 + \Delta E_{th}$

$$v_i = 3\,m/s,\ v_f = 0 \Rightarrow 45\,J = 0 + \Delta E_{th}$$

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$$\boxed{1\,hp = 550\,lb \cdot ft/s = 746\,Watt}$$

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Non-negligible size, *i.e*, can’t be treated as a particle

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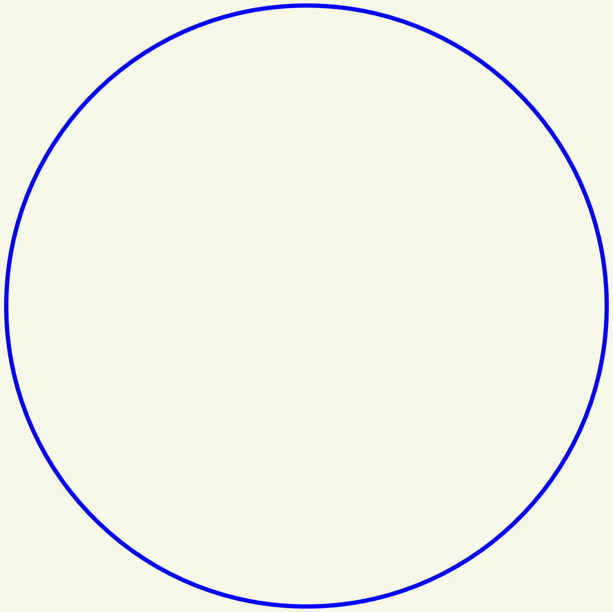

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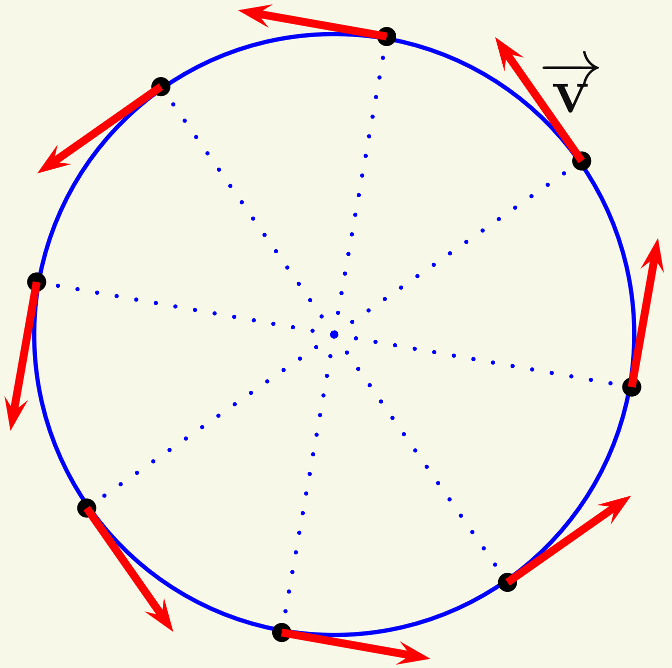

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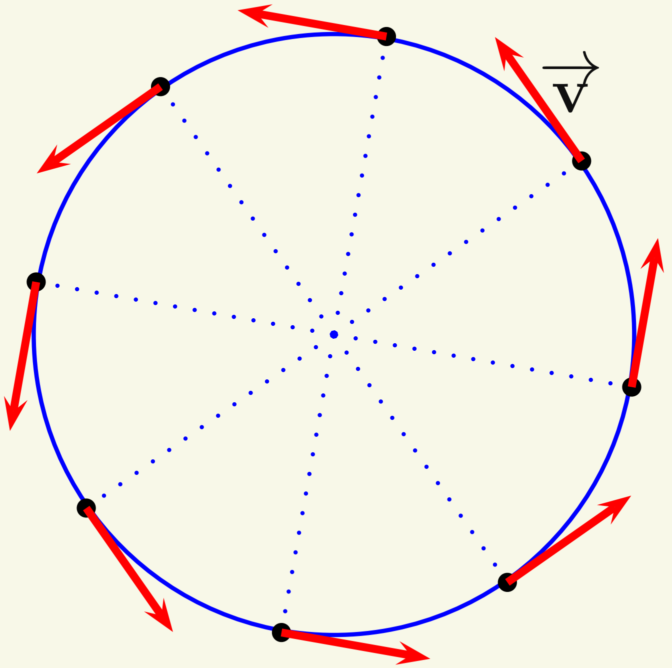

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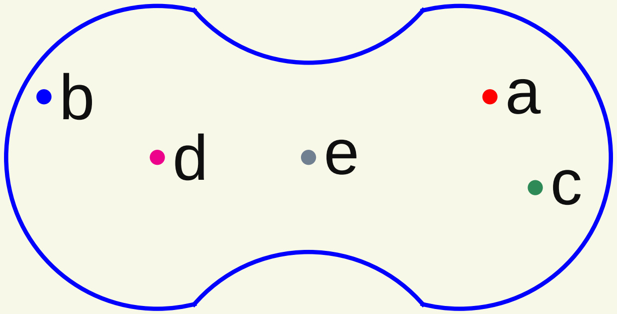
The rotational axis is along the z-axis, *i.e.*, into and out of the page

Axis Exercise

For the following motion, through which of the points shown is the axis of rotation passing?



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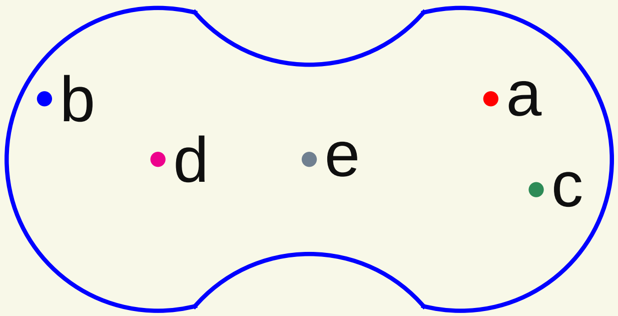

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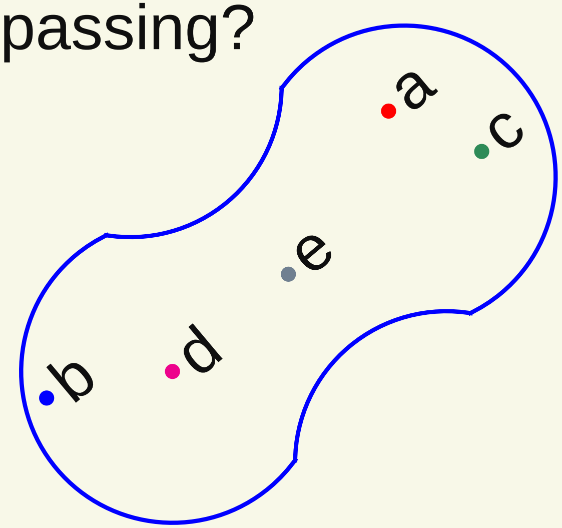

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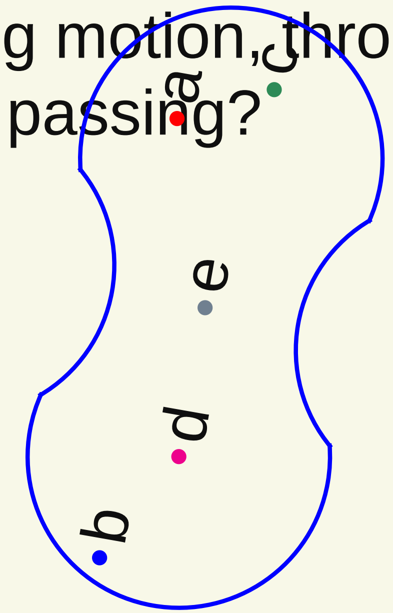

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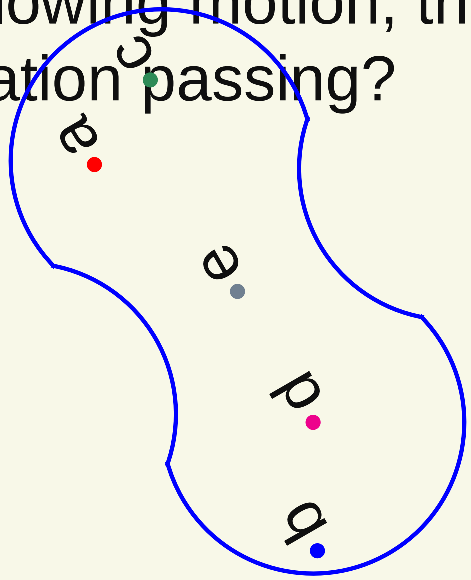

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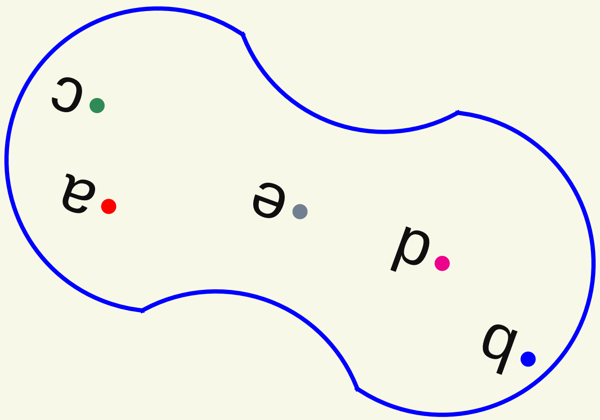

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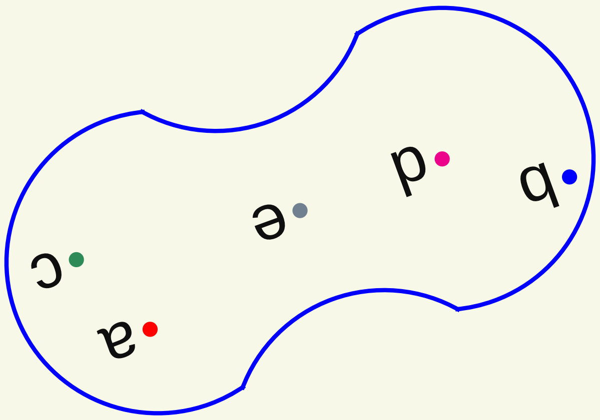

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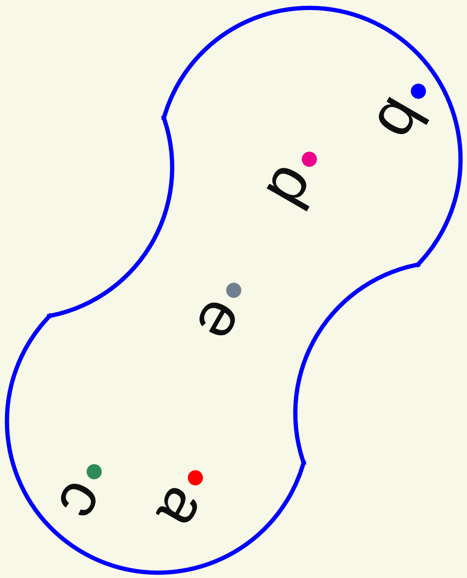

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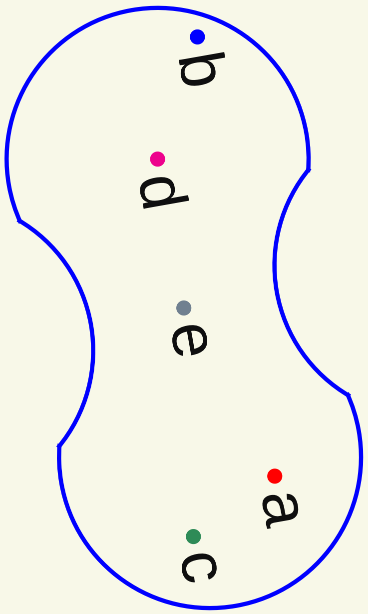

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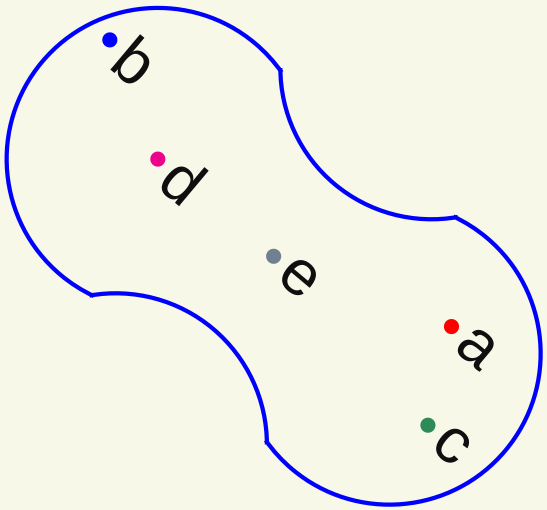

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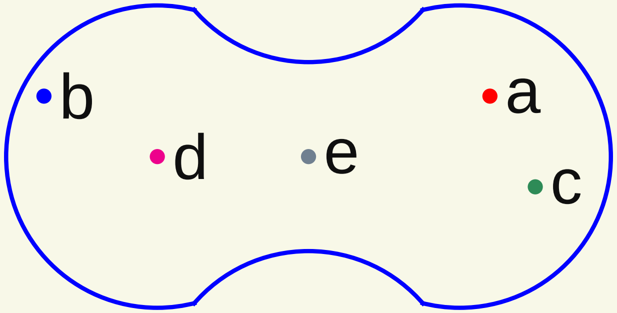

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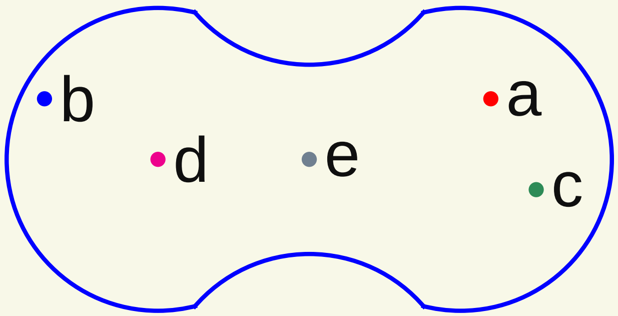

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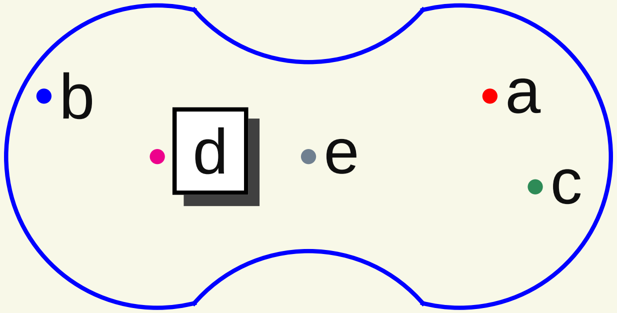

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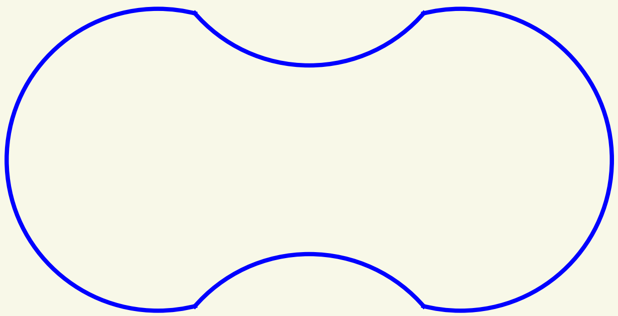
Non-Circular Objects

Putting the origin of the coordinate system at the axis of rotation allows us to still discuss circular motion.



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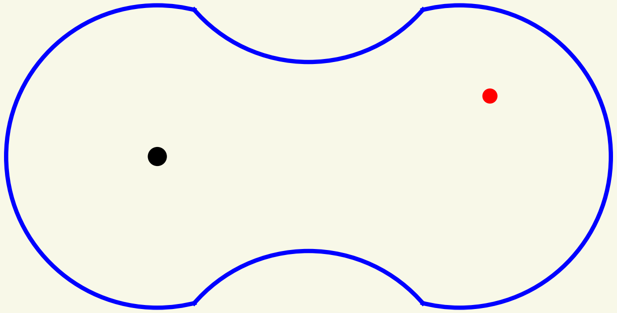

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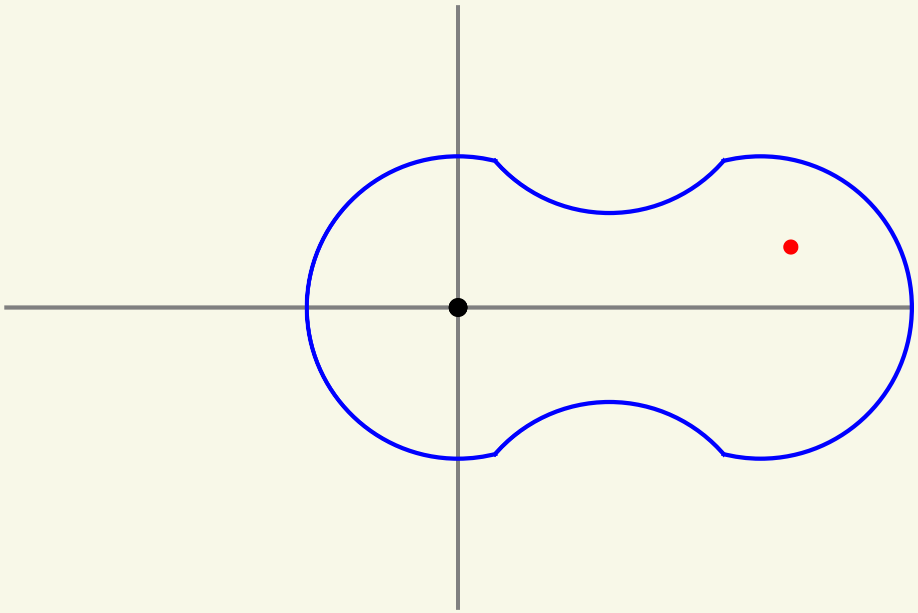

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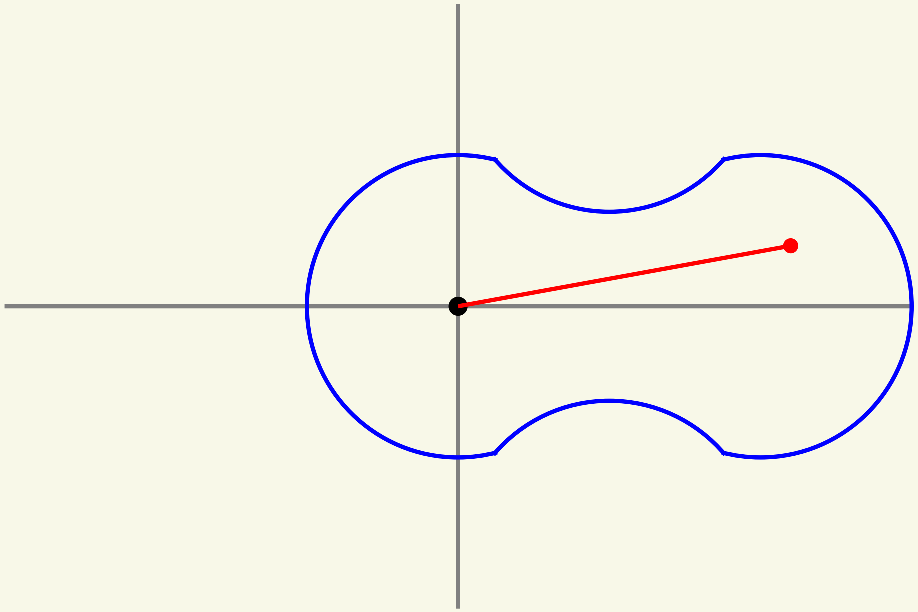

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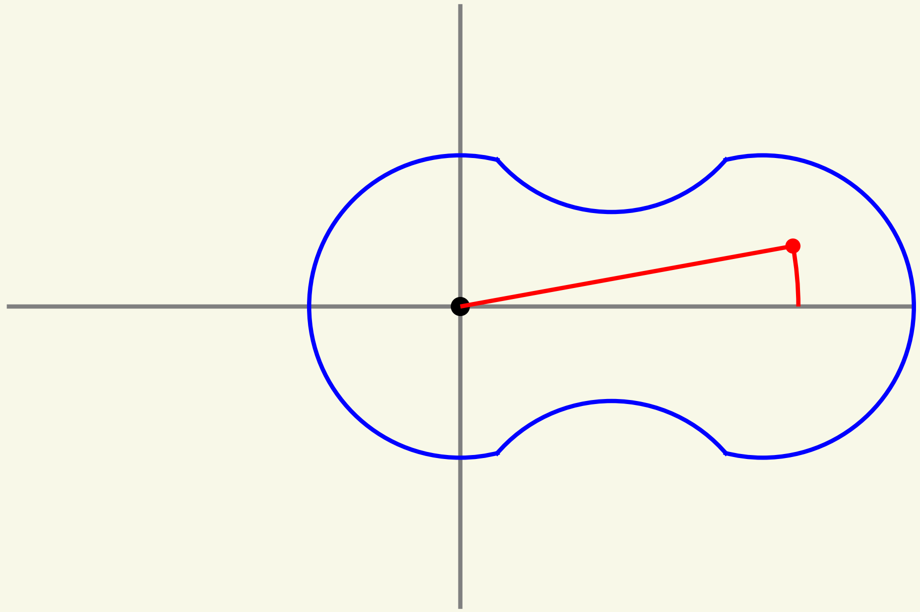

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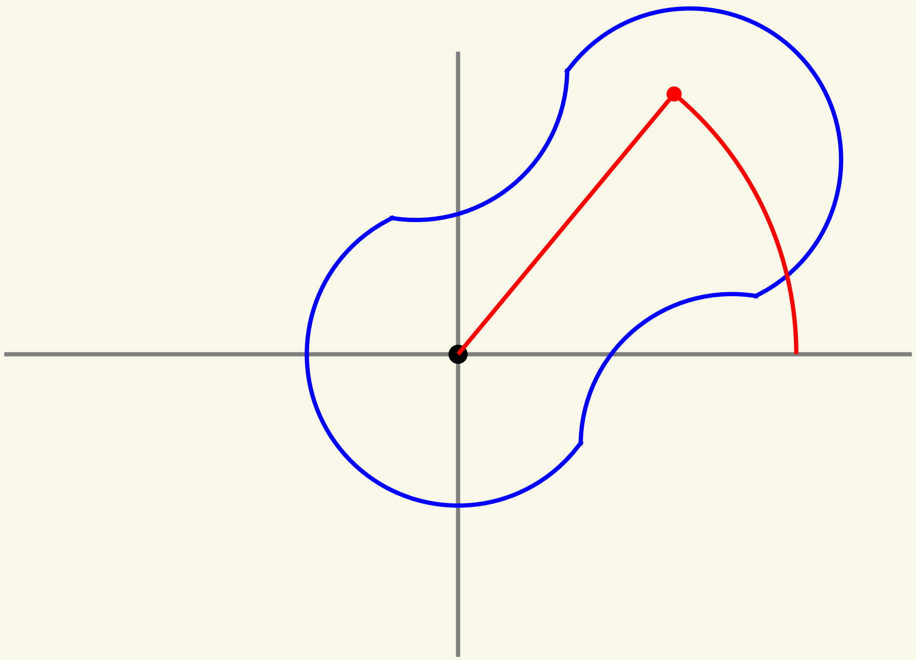

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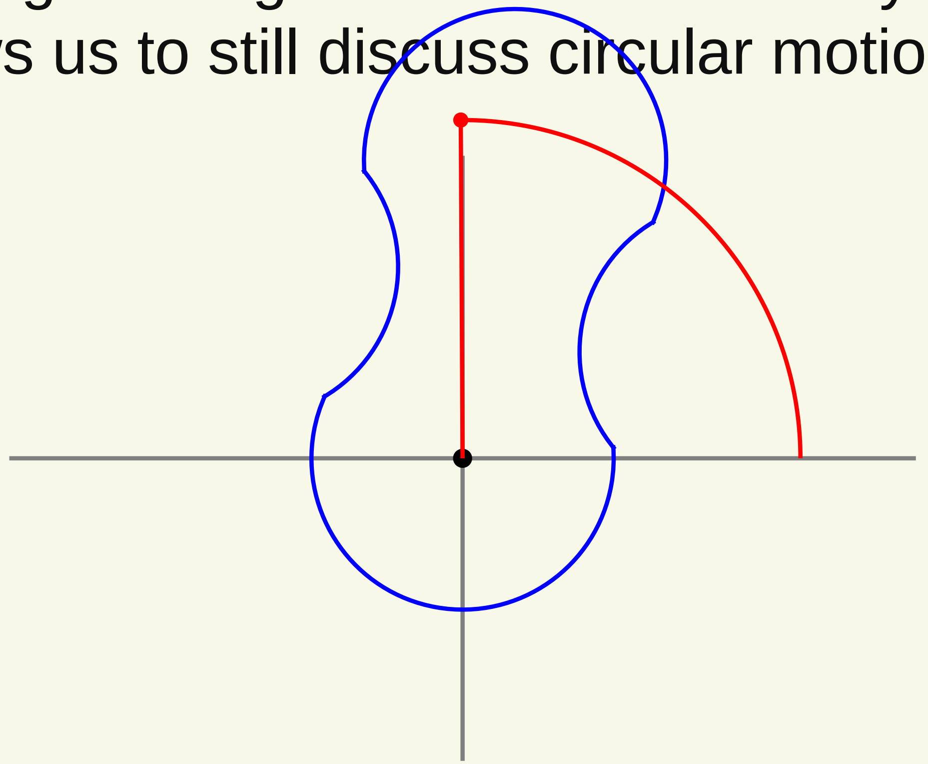

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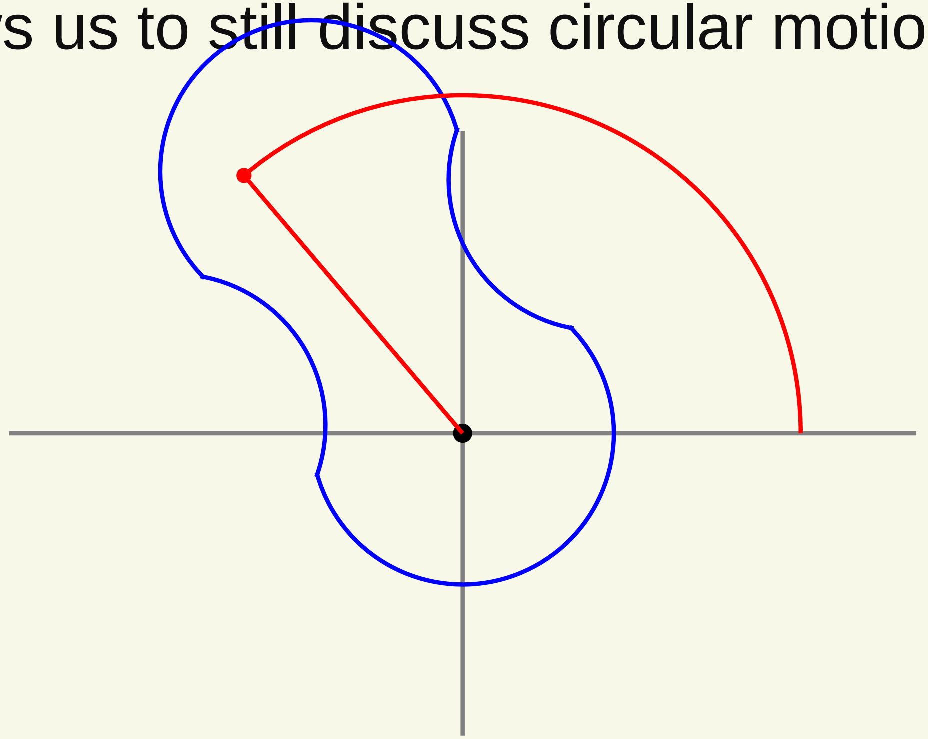

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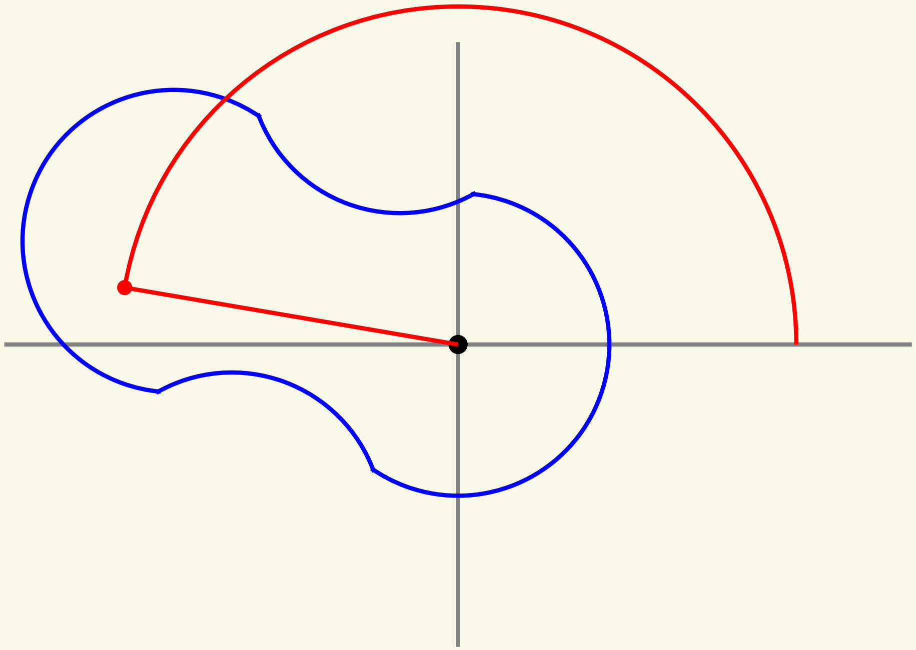

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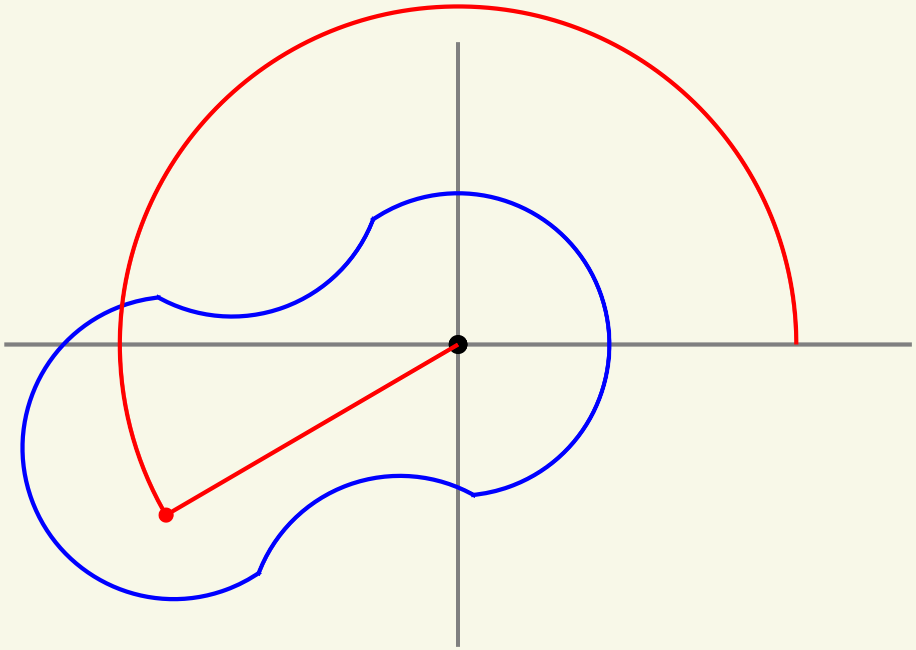

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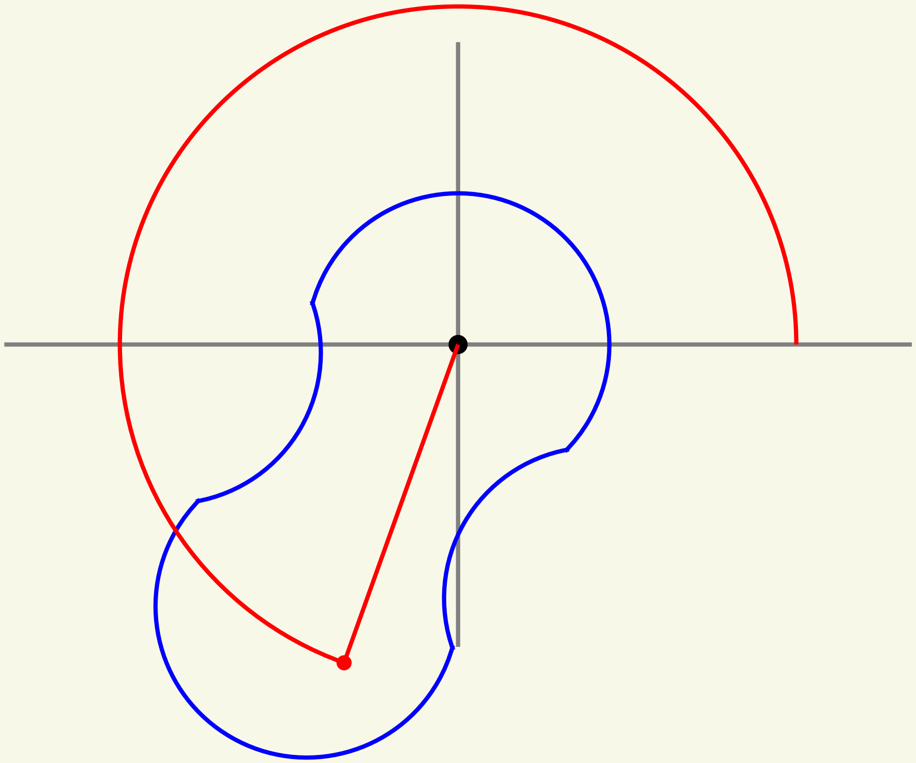

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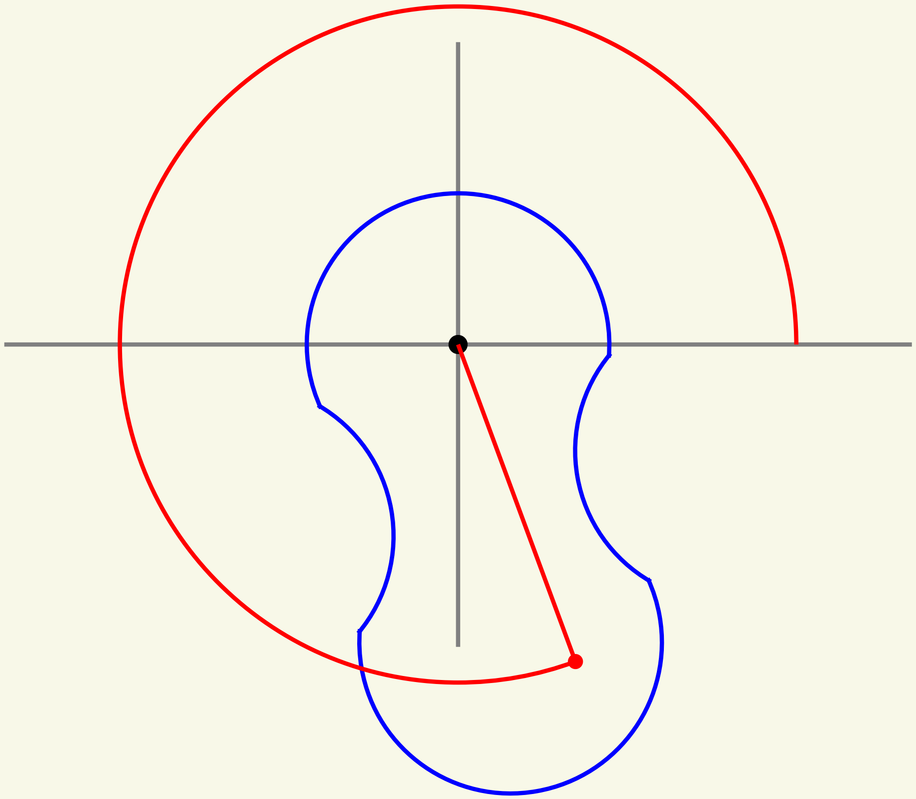

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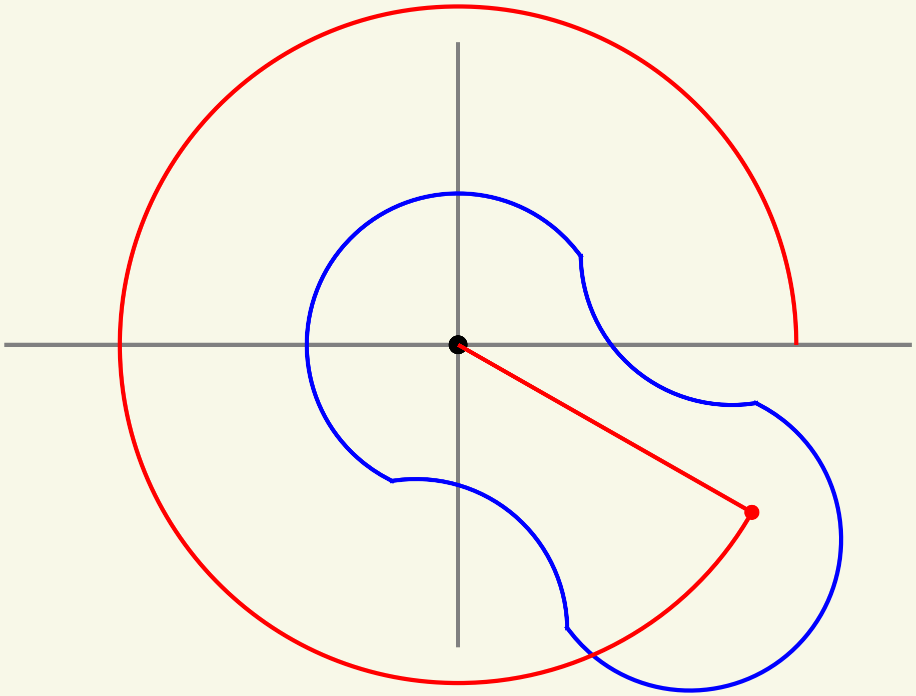

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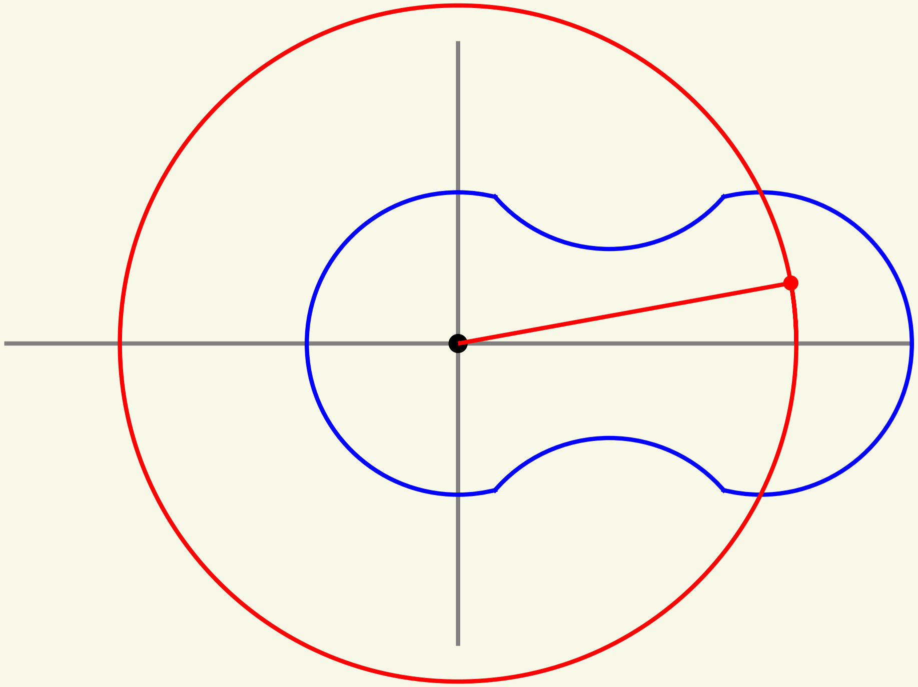

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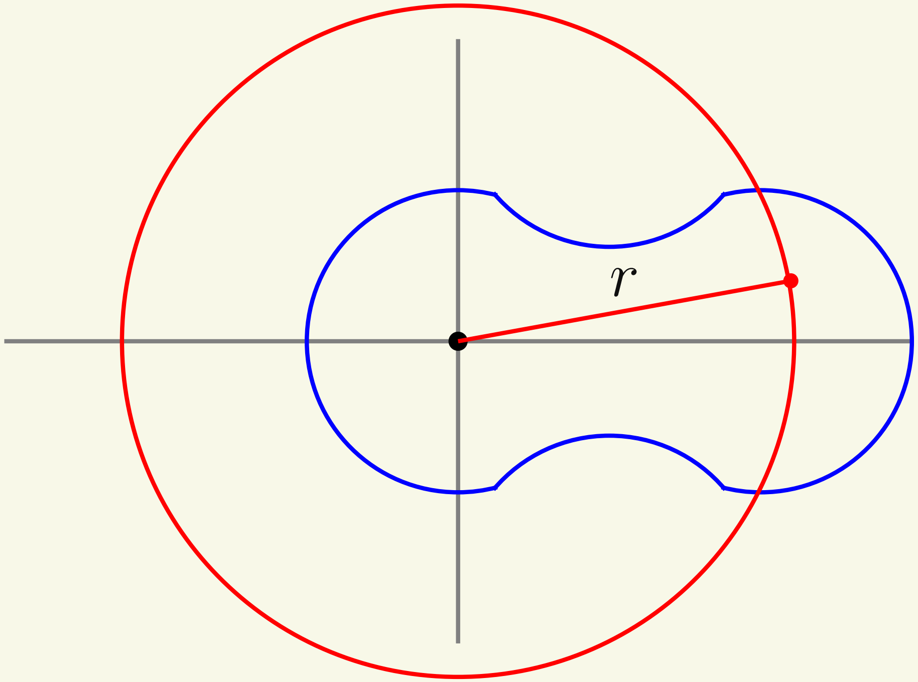

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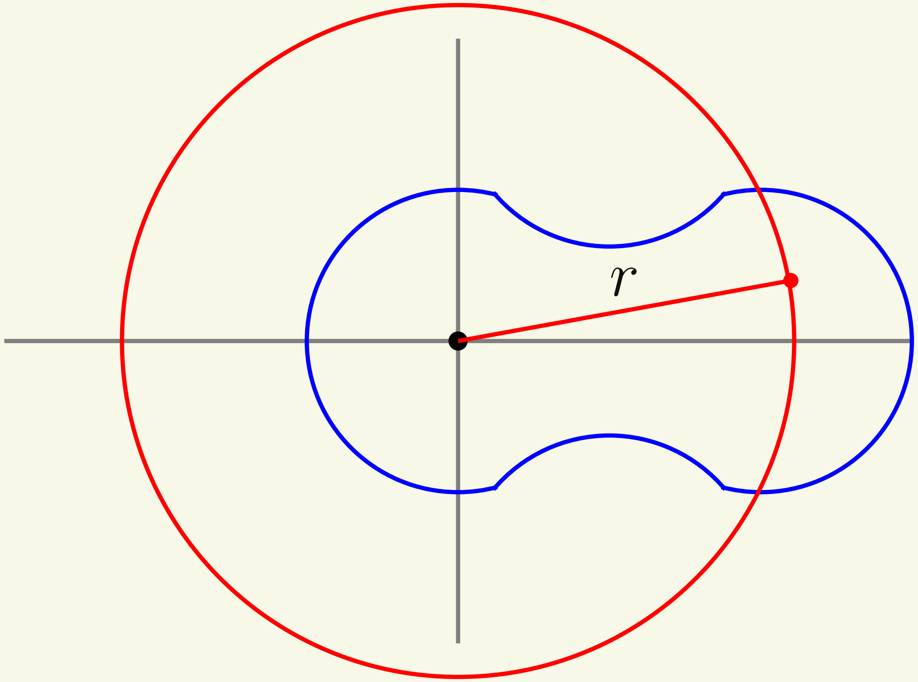

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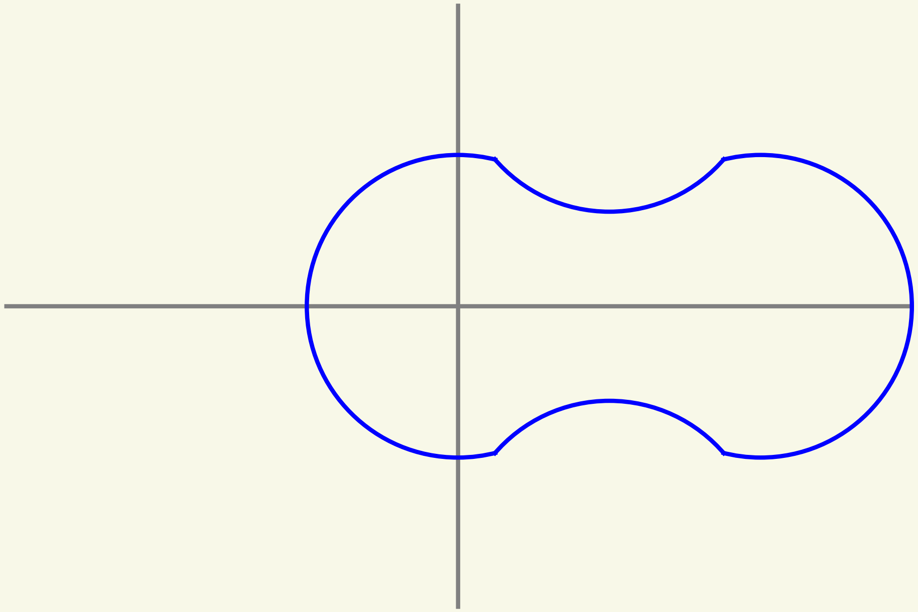
$r =$ distance from axis of rotation

Why Rotational Motion

The motion of a rigid body is very different than a particle



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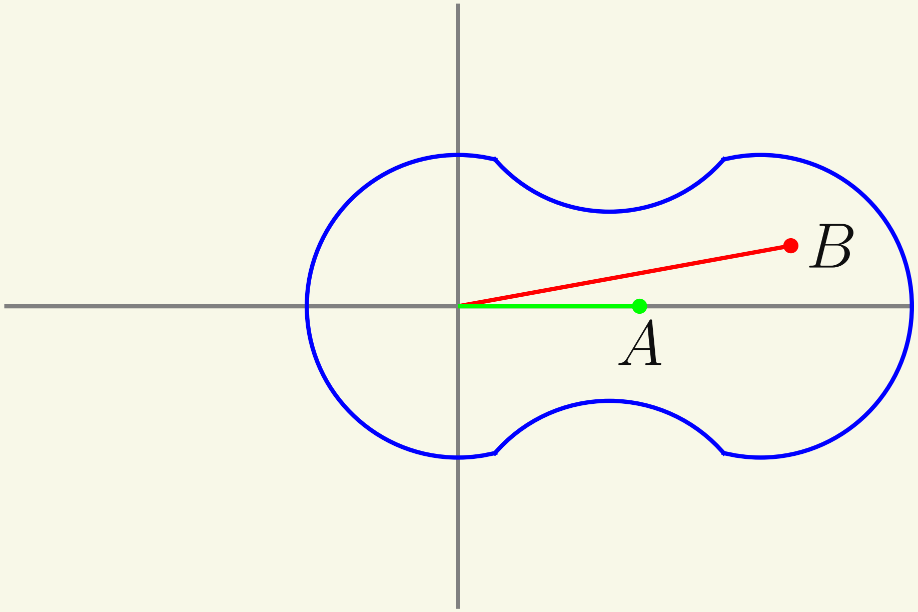

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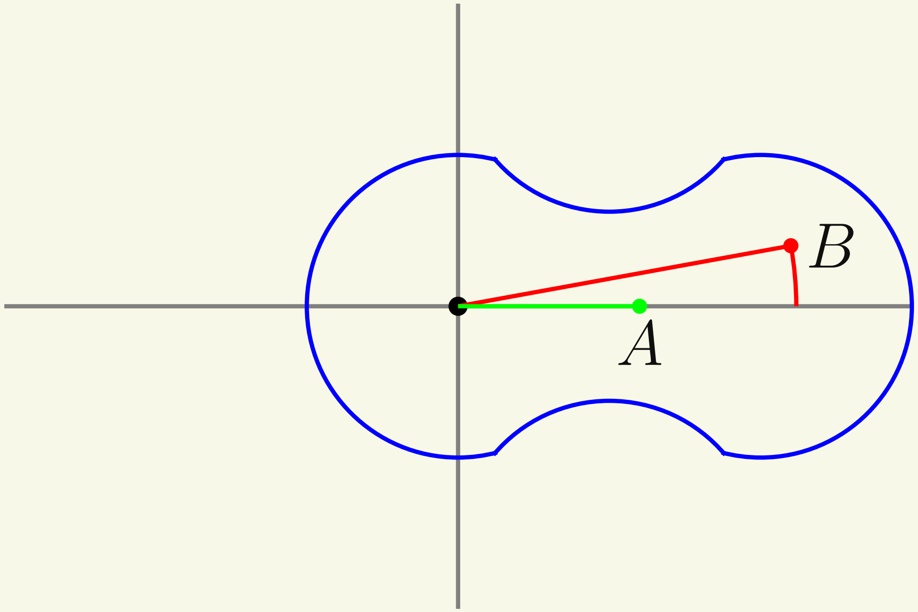

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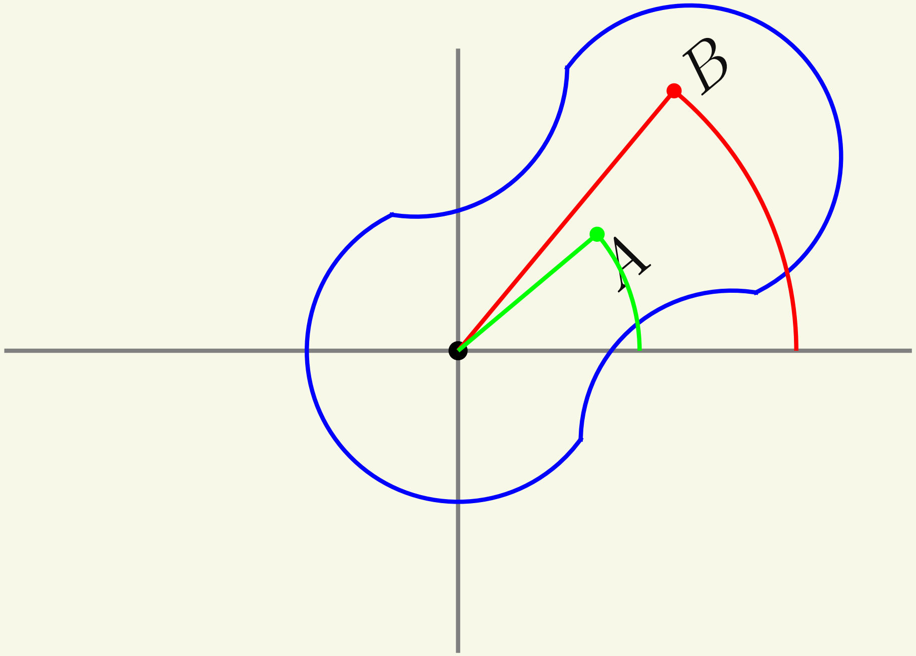

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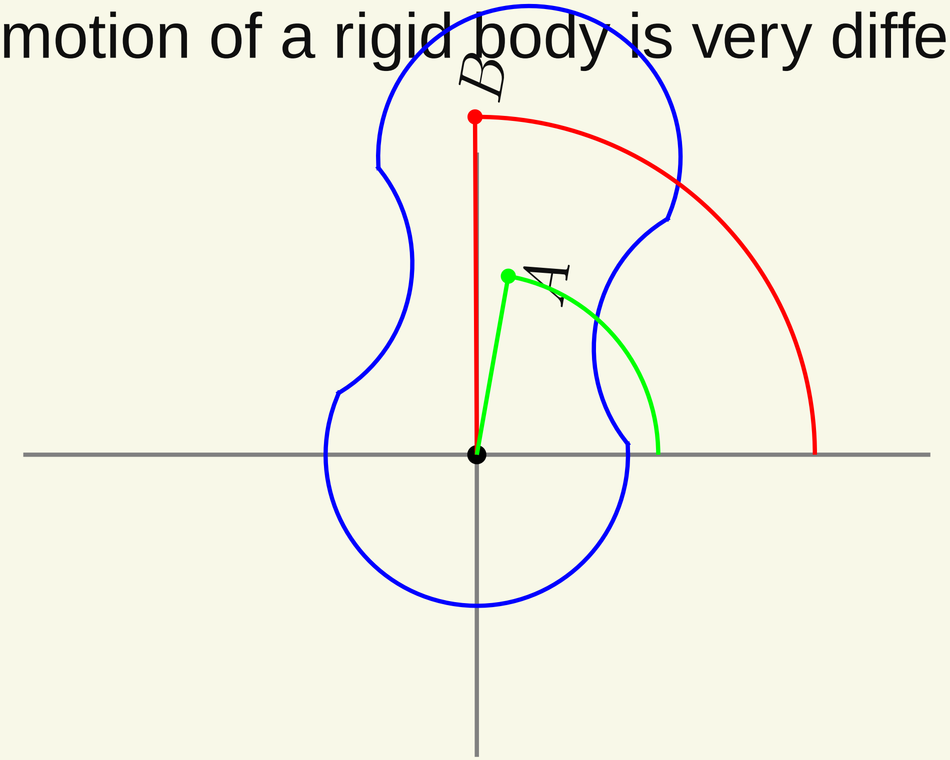

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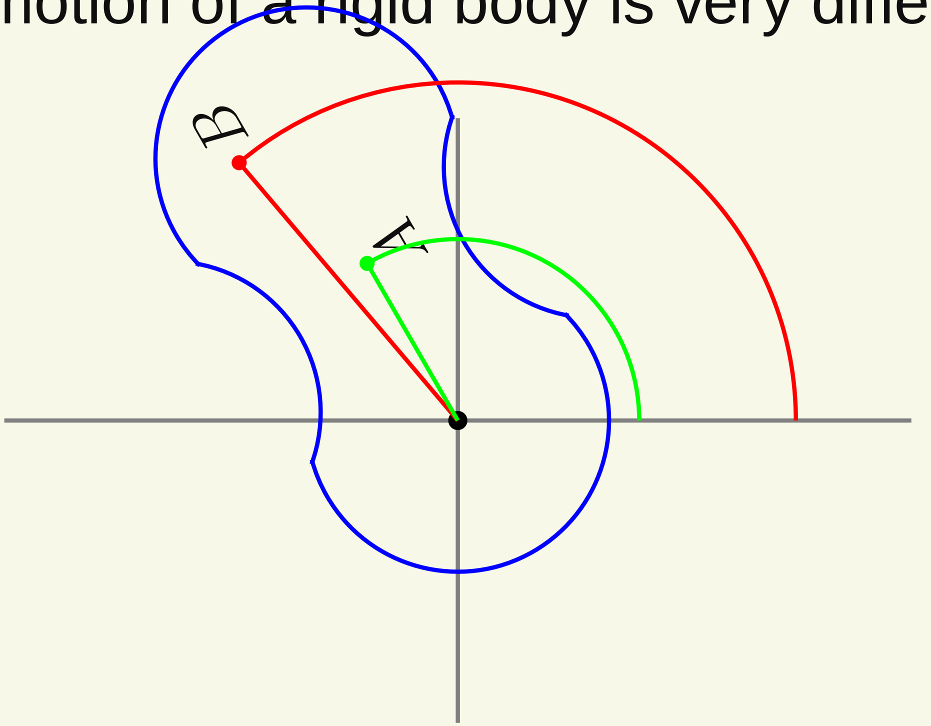

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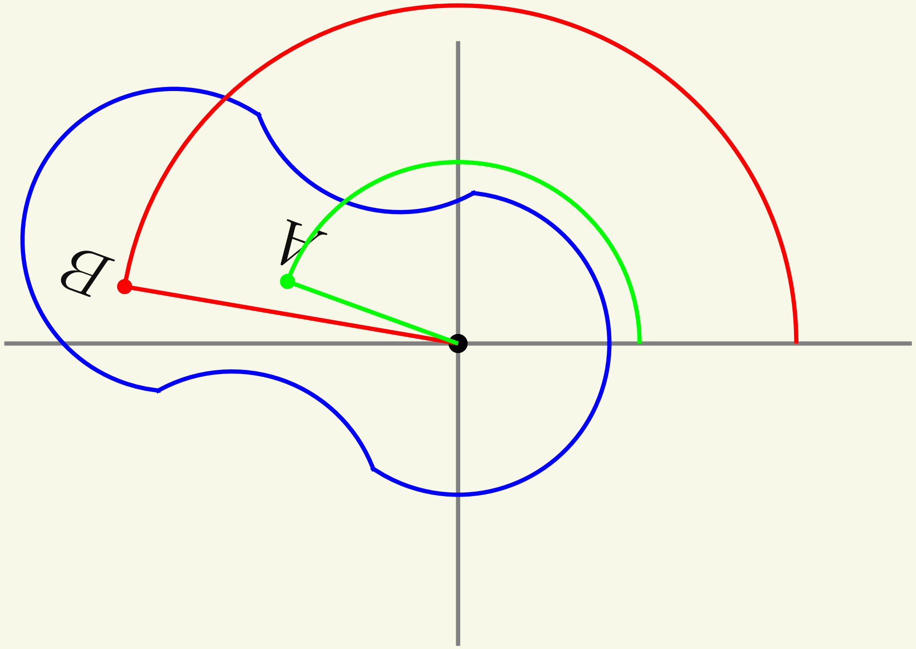

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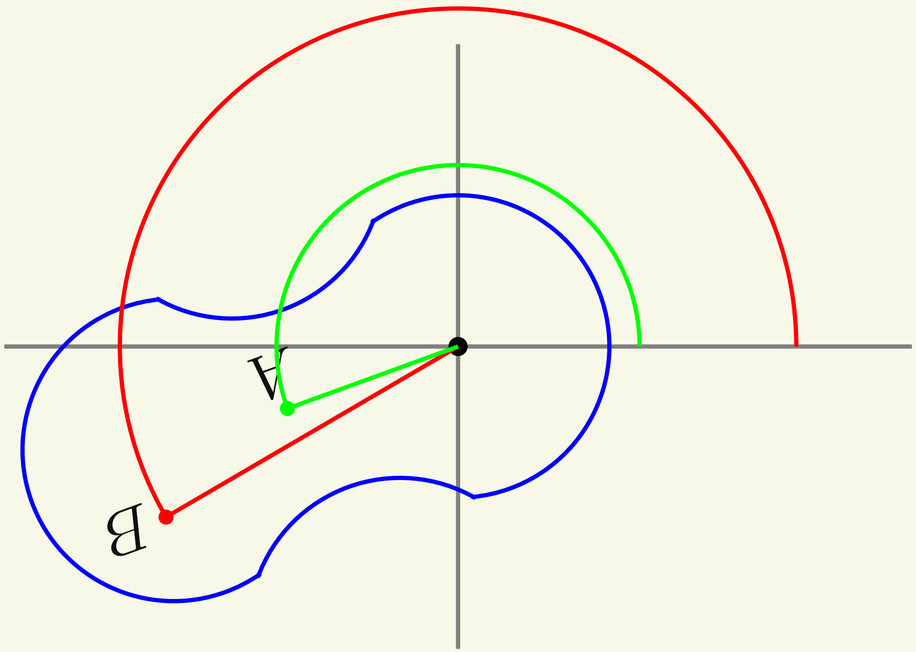

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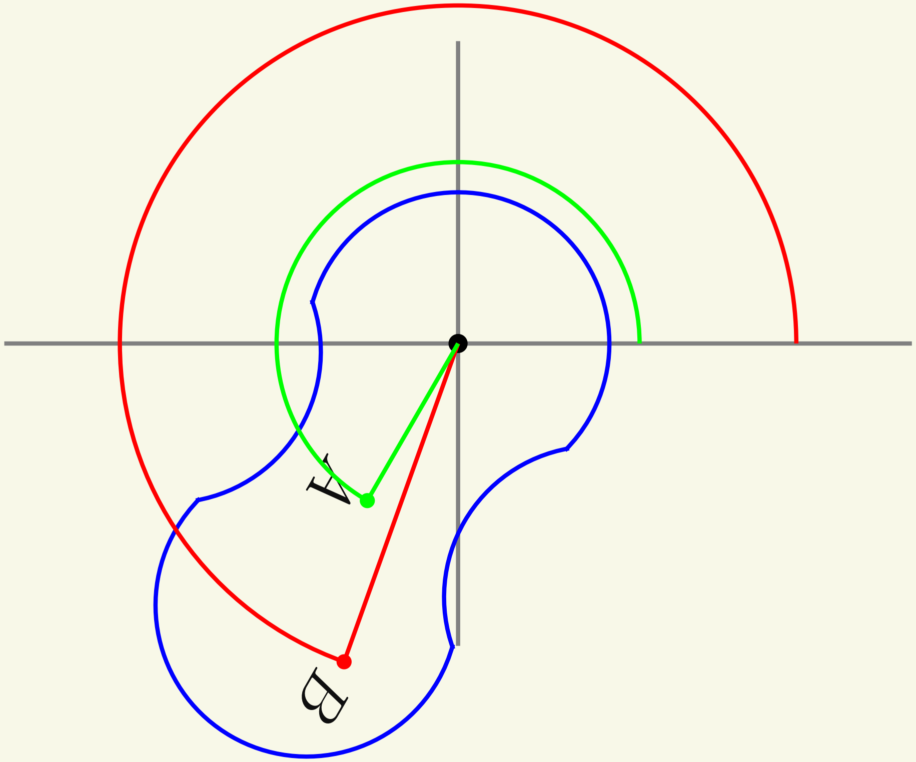

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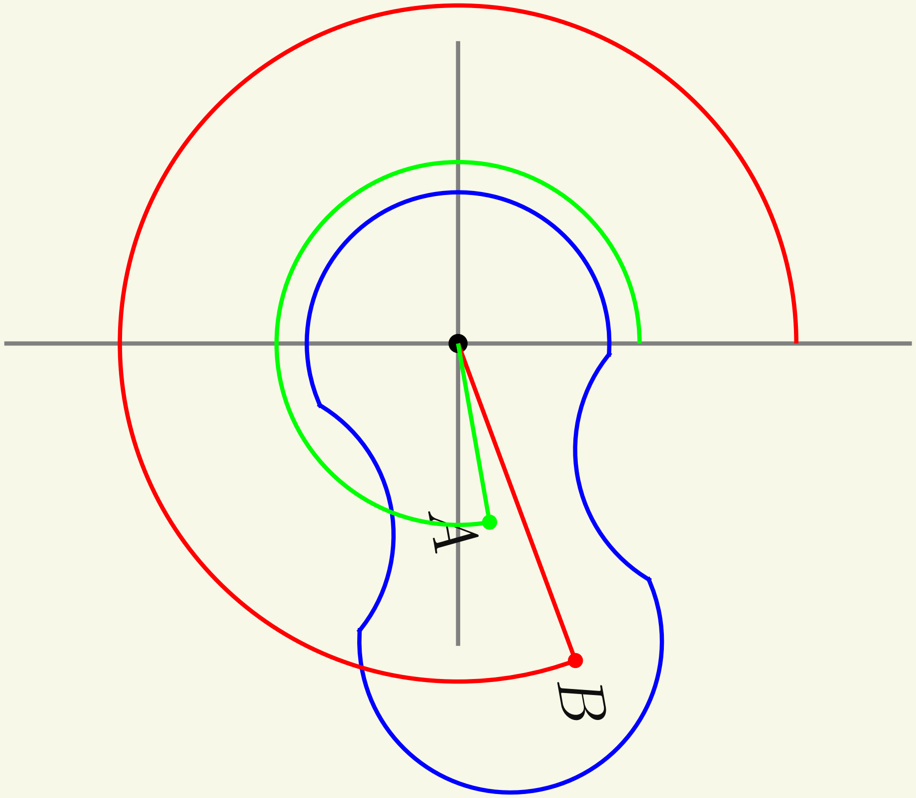

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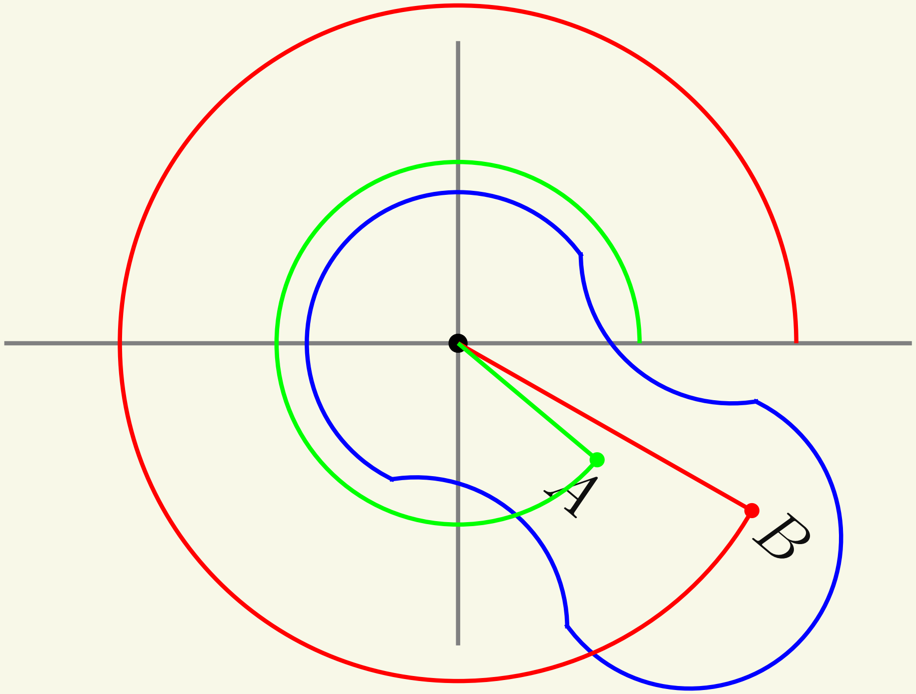

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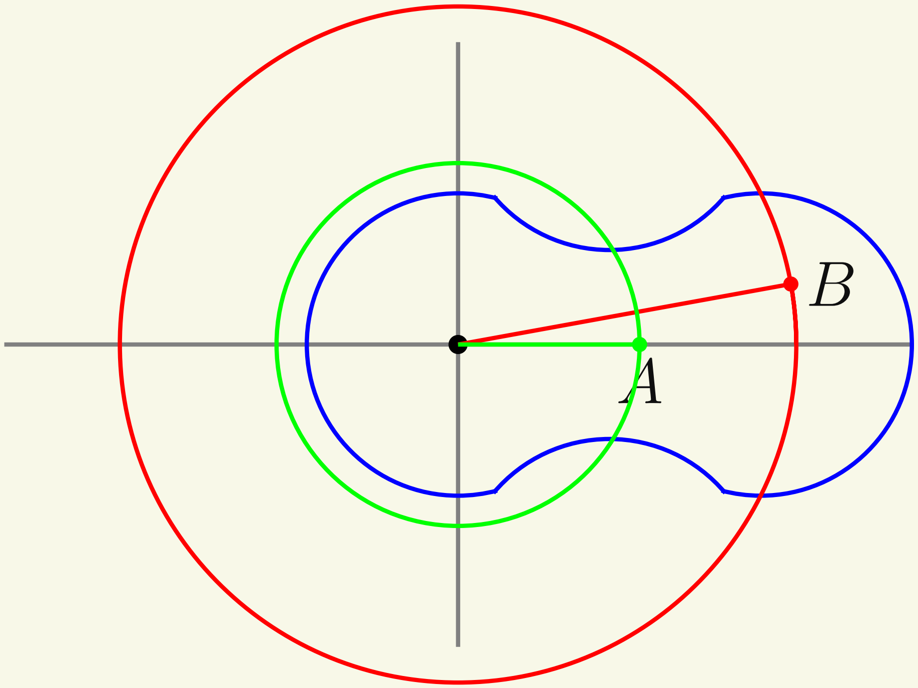

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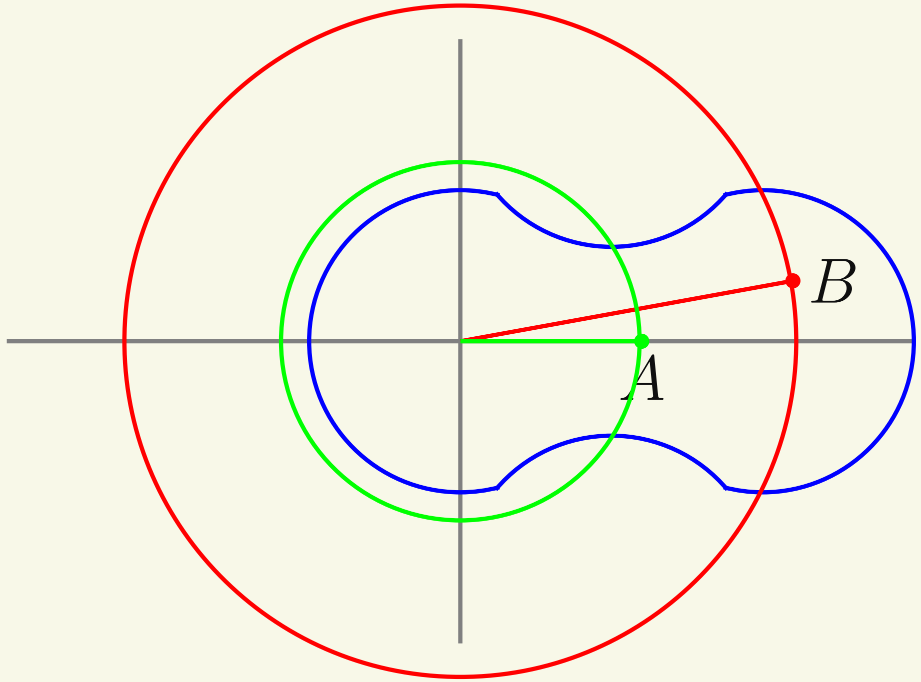

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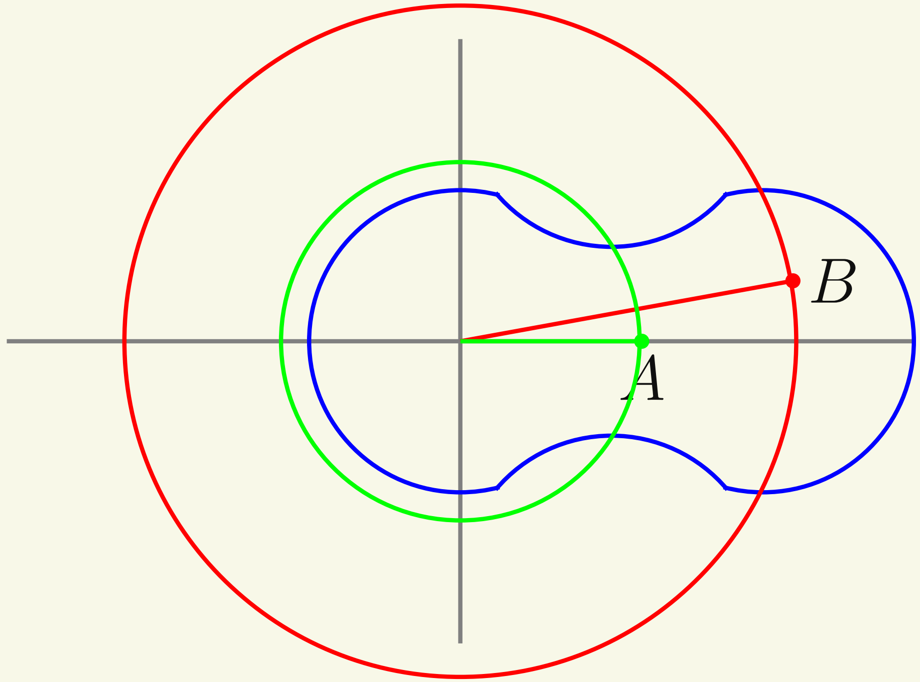

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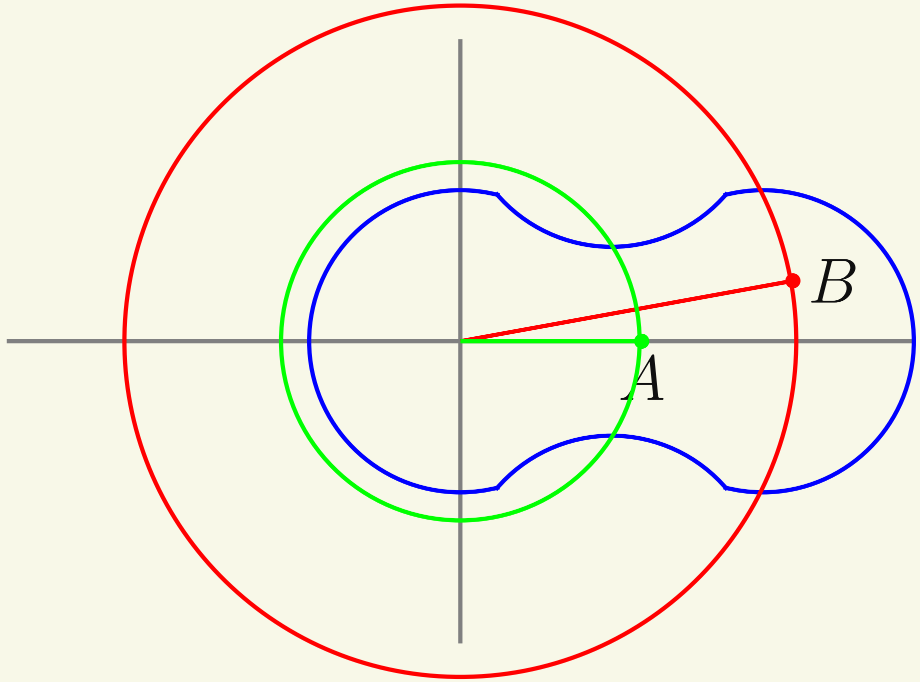

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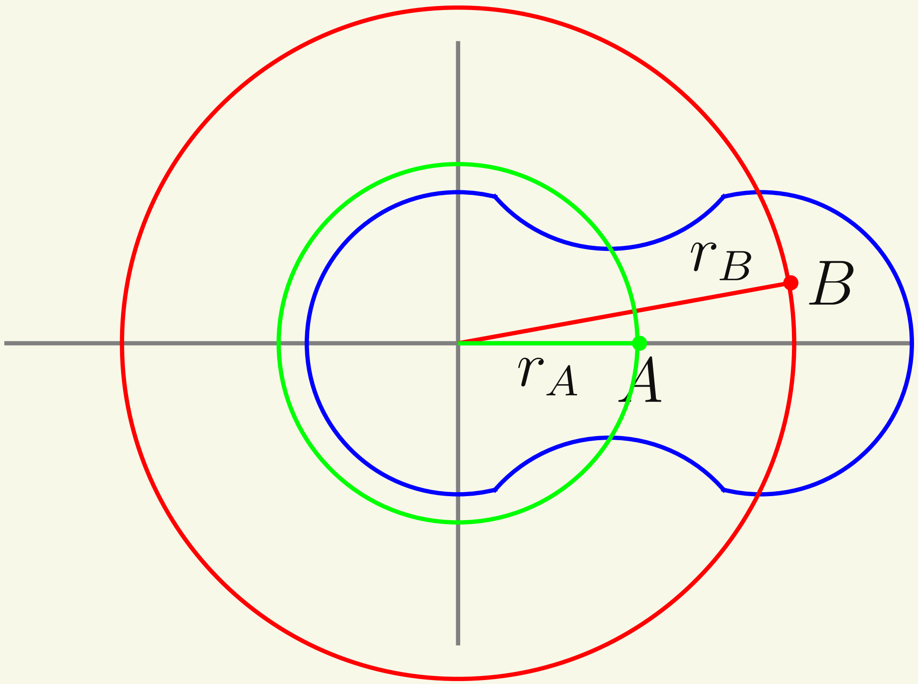

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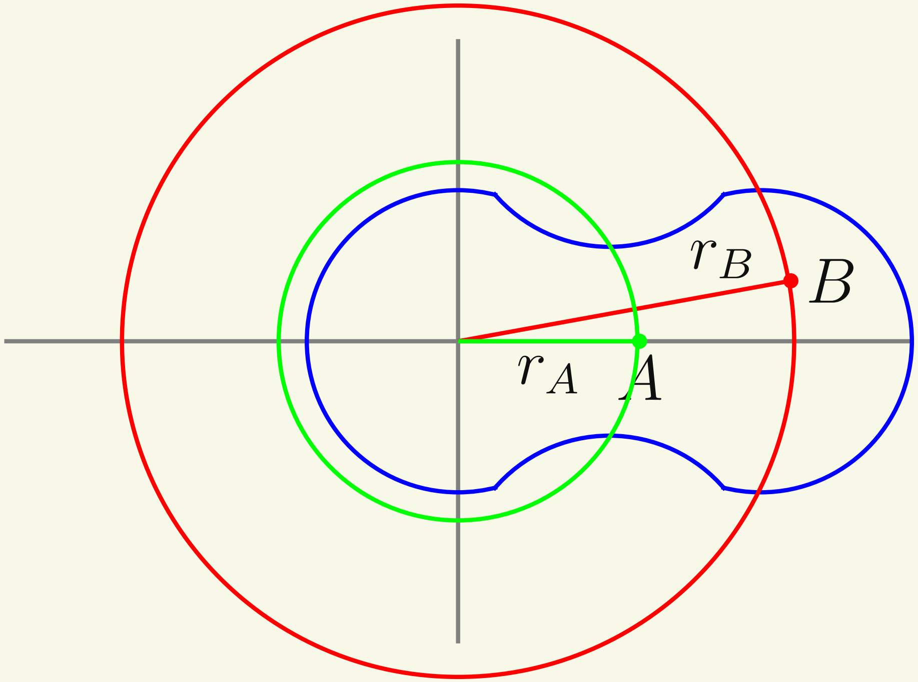

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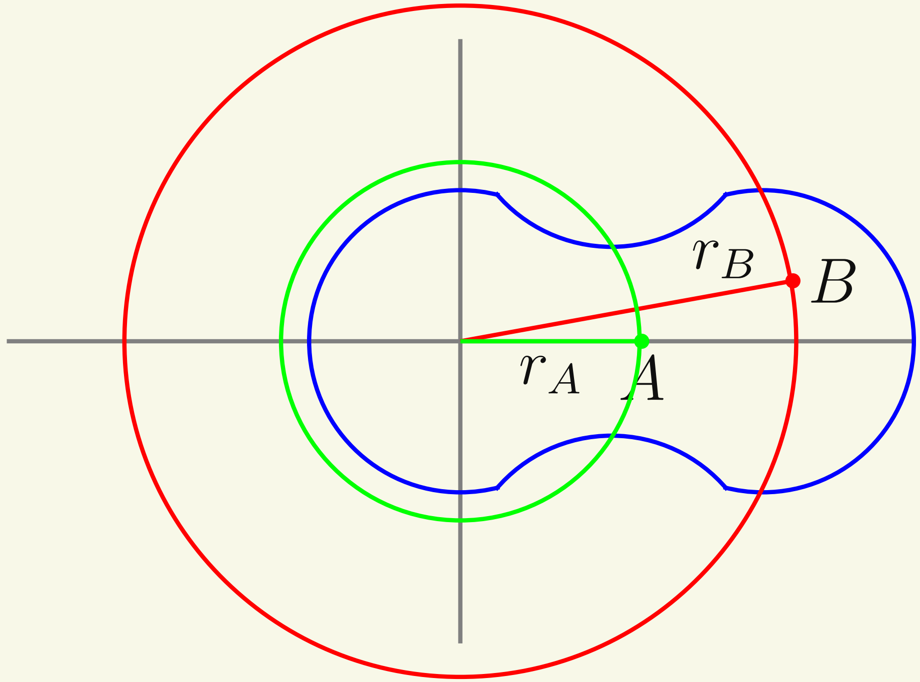

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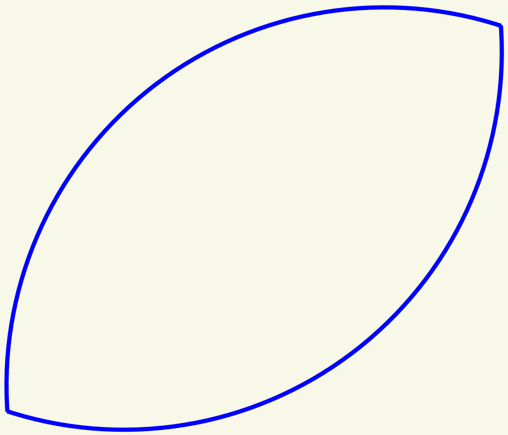

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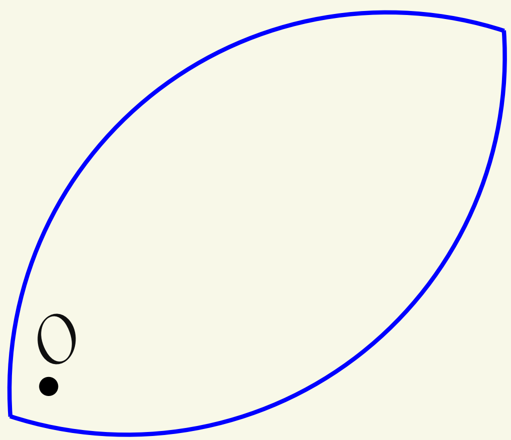

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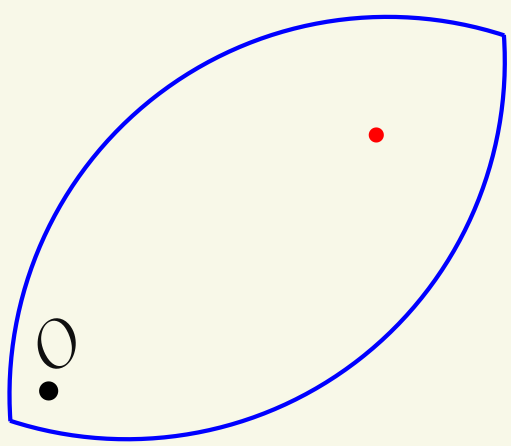

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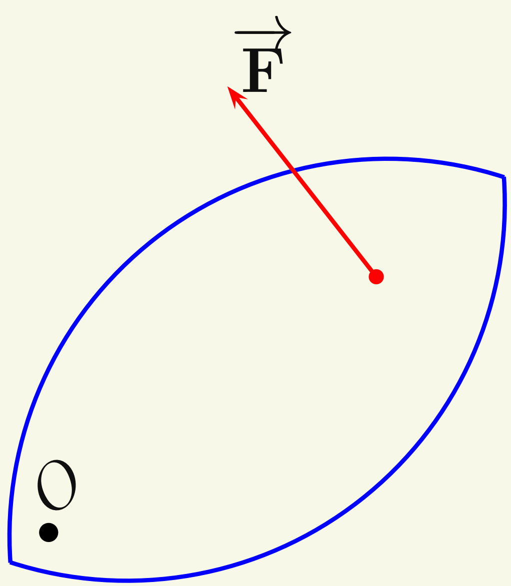

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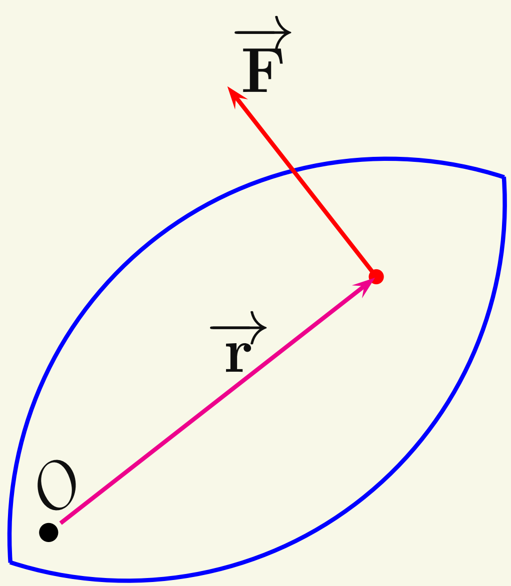

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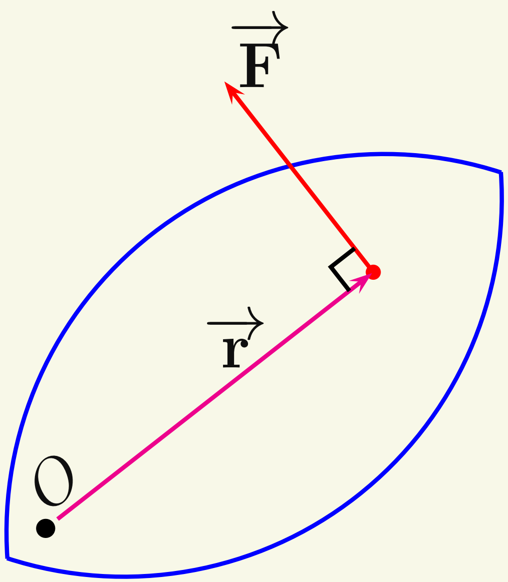

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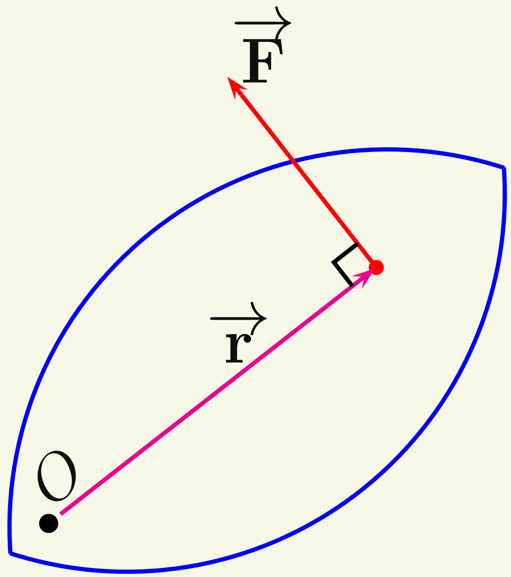

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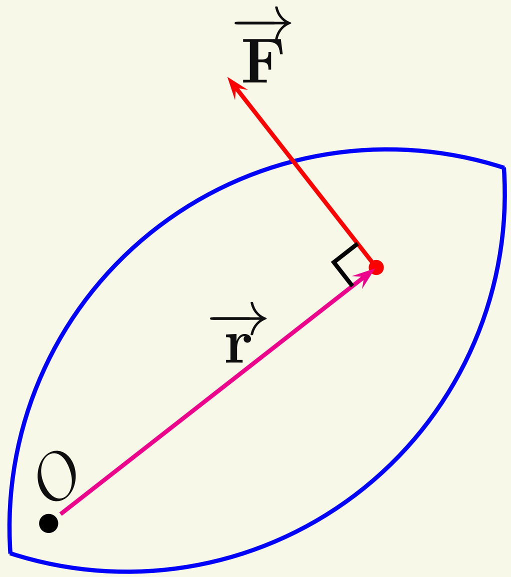

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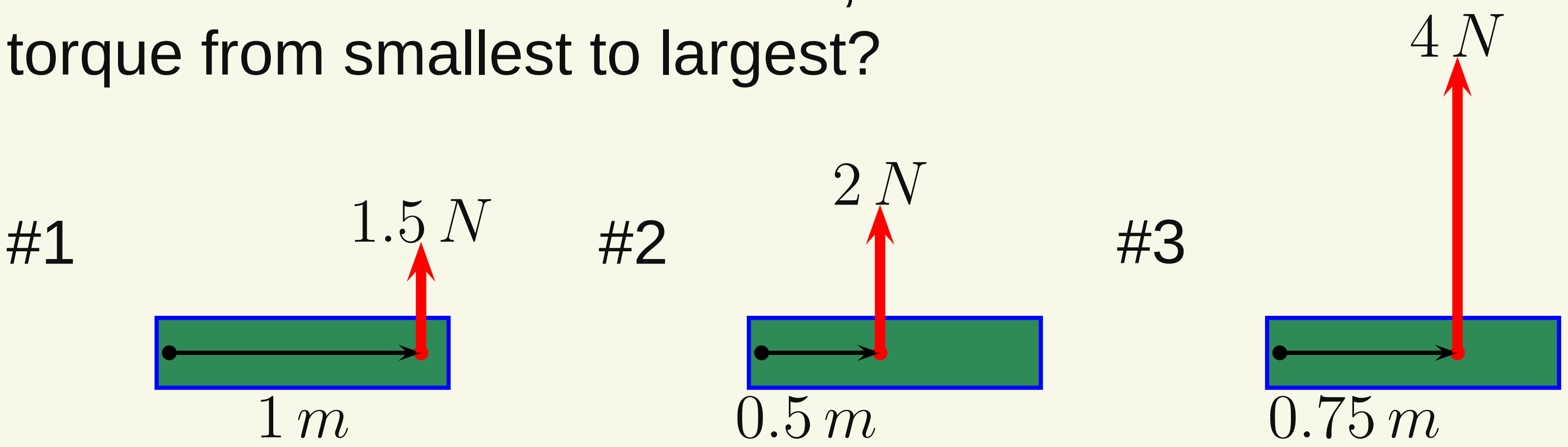
For the three situations shown, which is the correct ranking of torque from smallest to largest?



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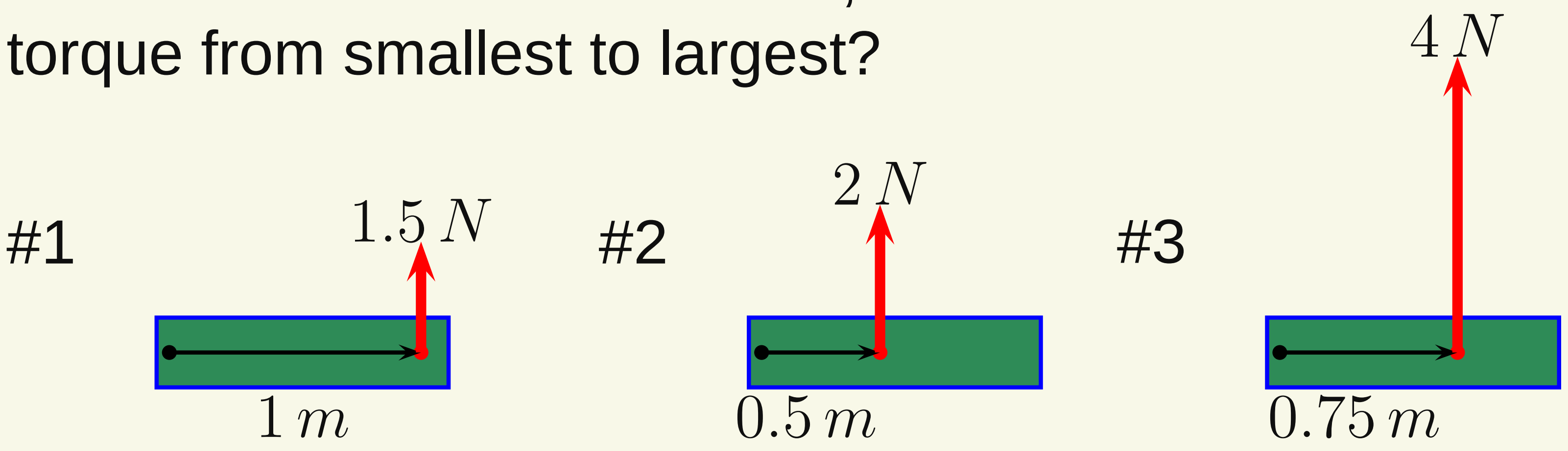

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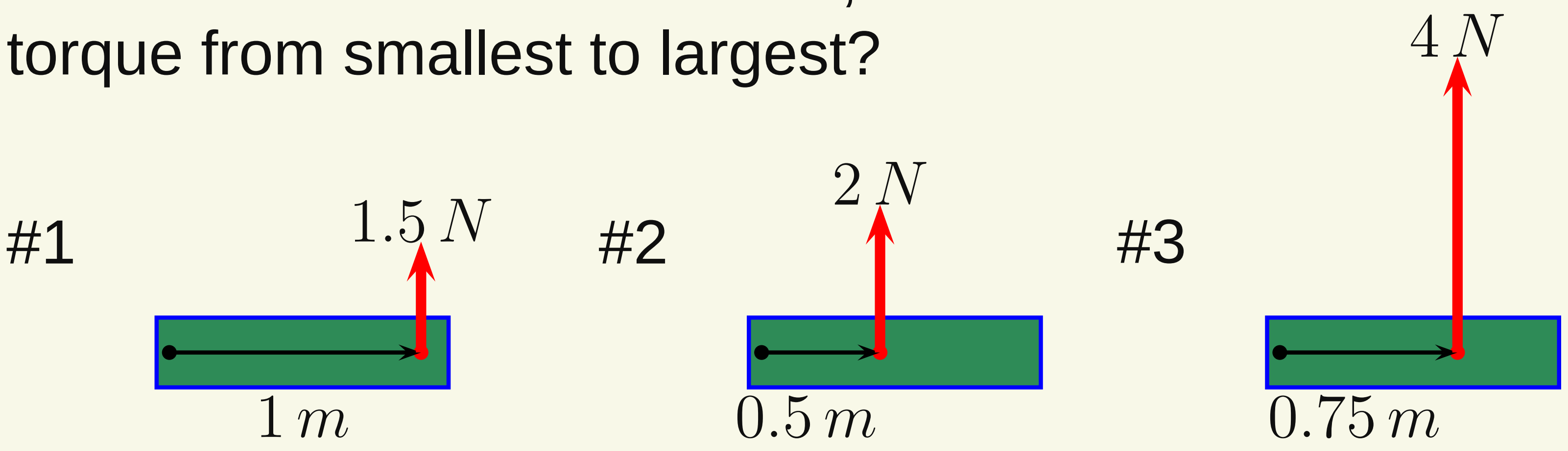

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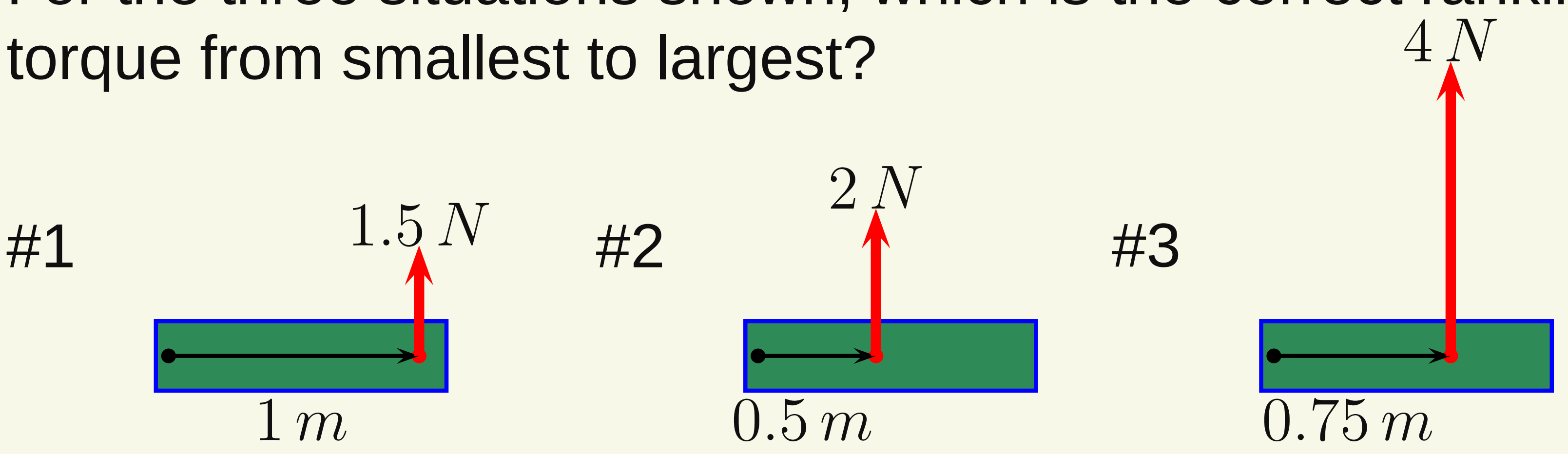

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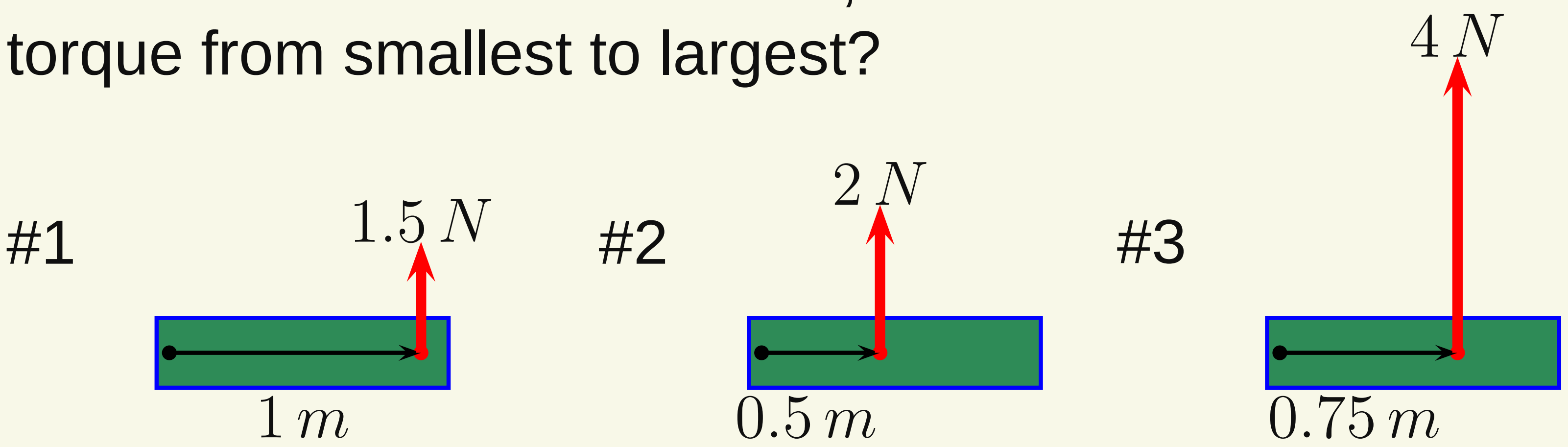

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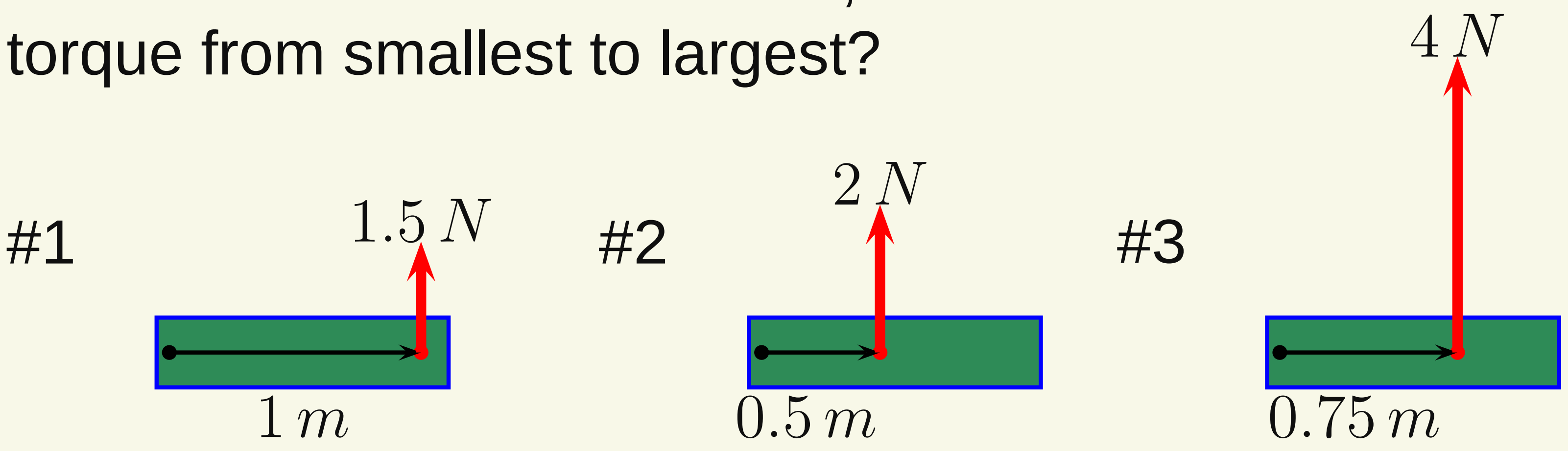

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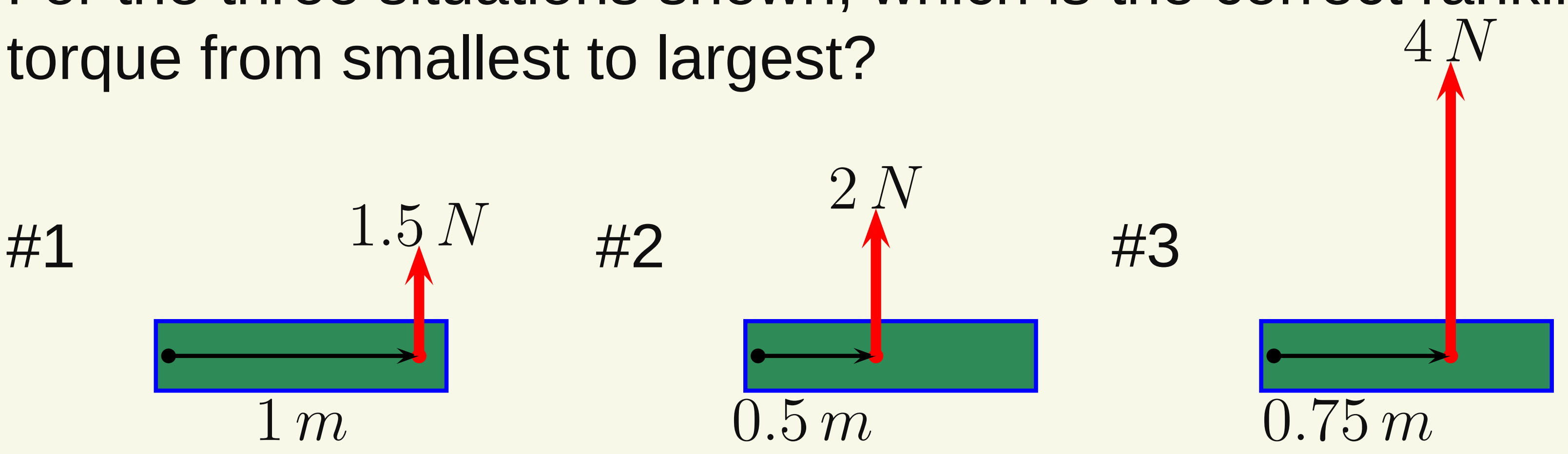

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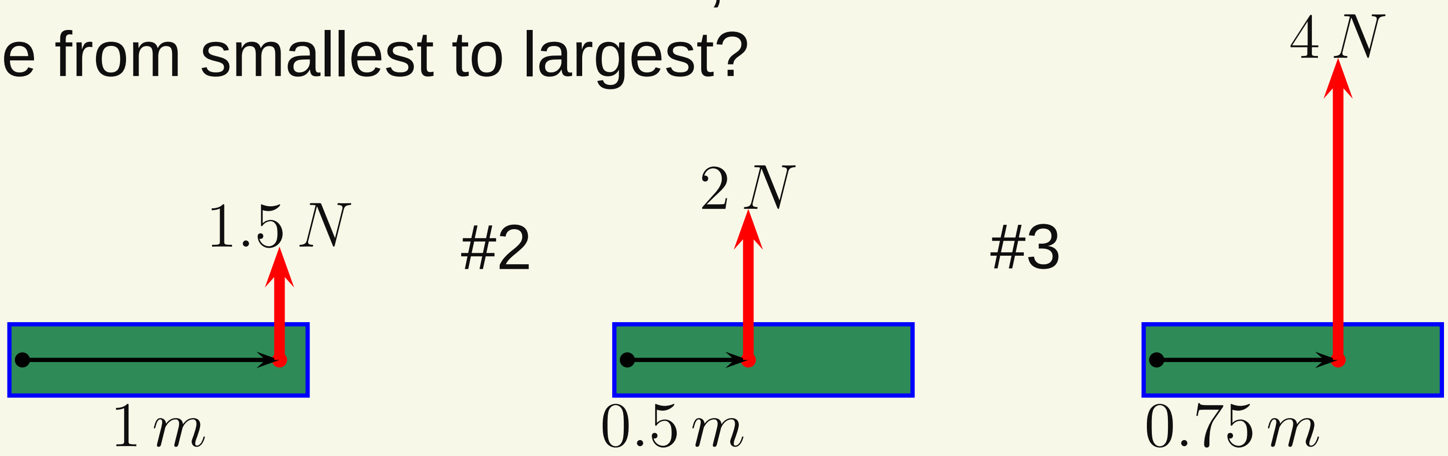
#1 #2 #3



$\tau_1 = 1.5\,N \cdot m$ $\tau_2 = 1\,N \cdot m$ $\tau_3 = 3\,N \cdot m$

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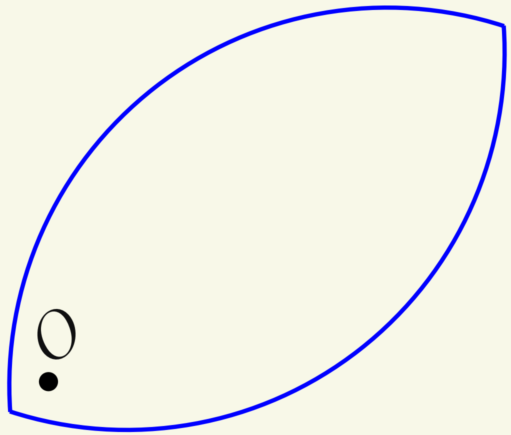
Torque Sign

Torque can be positive or negative.



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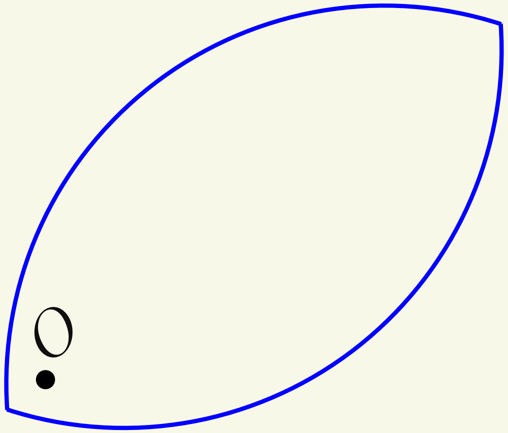

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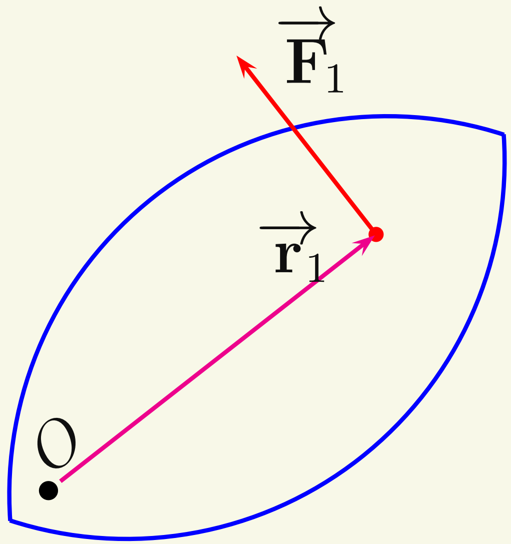

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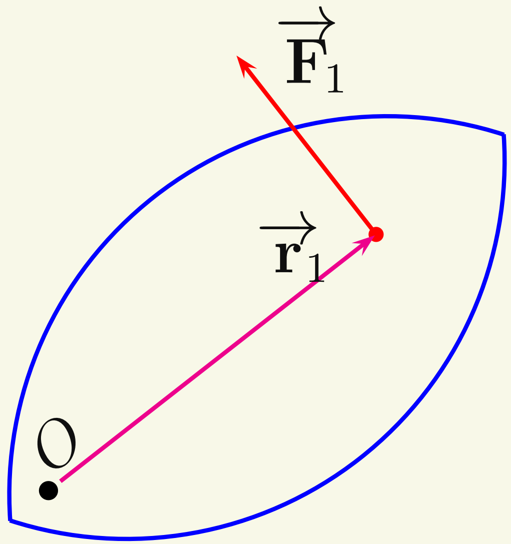

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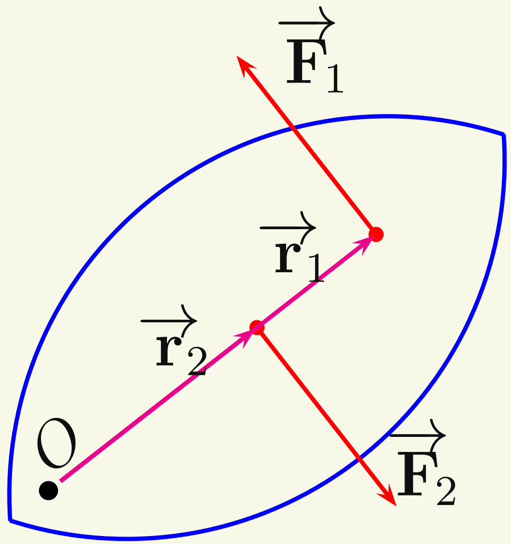

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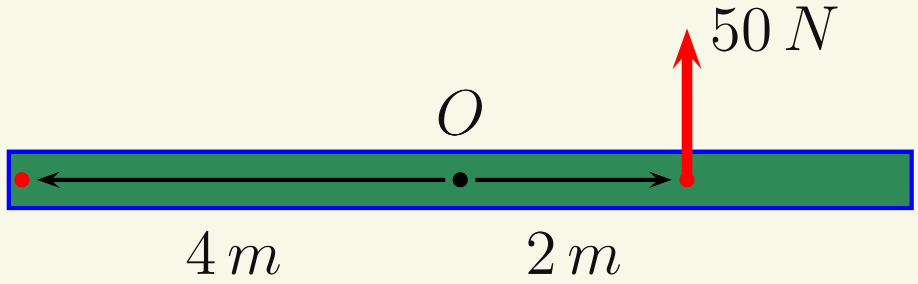
τ_2 is negative

Torque Sign Exercise

An 8-m long beam which can rotate about its center has an upwards 50-N force applied $2\,m$ to the right of its center. What force, both magnitude and direction, must be applied $4\,m$ to the left of the center to make the net torque zero?



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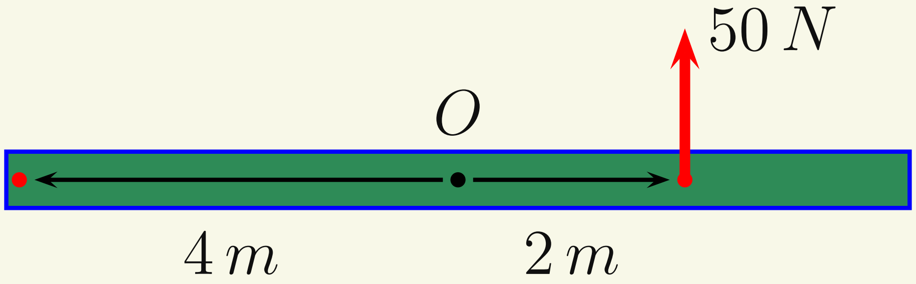

(a) $25\,N$, up

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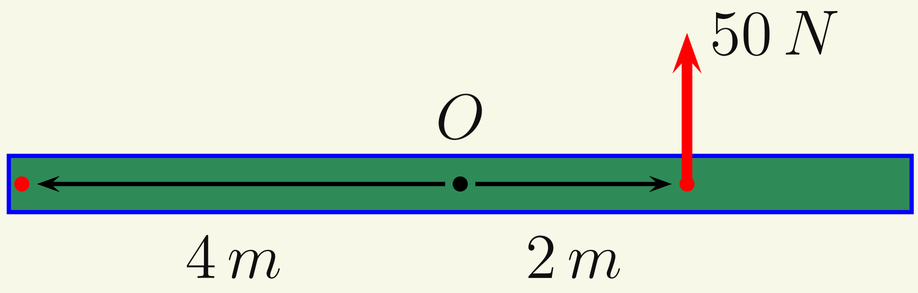

(a) $25\,N$, up

(b) $25\,N$, down

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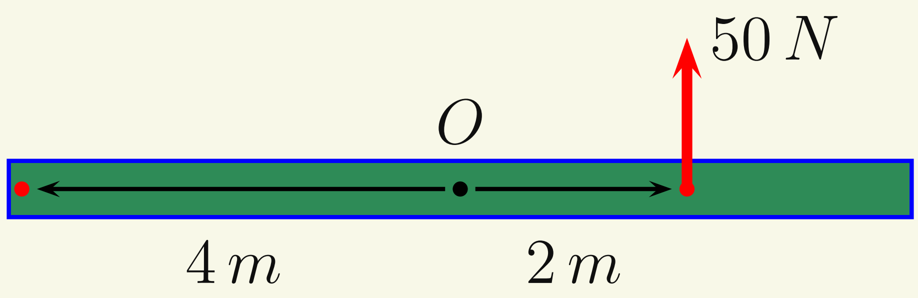

(a) $25\,N$, up

(b) $25\,N$, down

(c) $50\,N$, up

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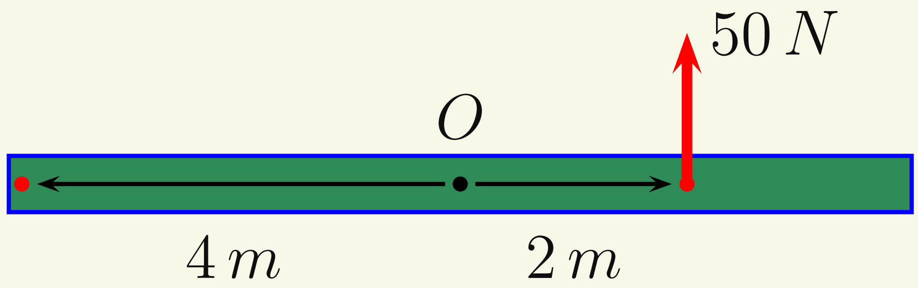

(a) $25\,N$, up

(b) $25\,N$, down

(c) $50\,N$, up

(d) $100\,N$, up

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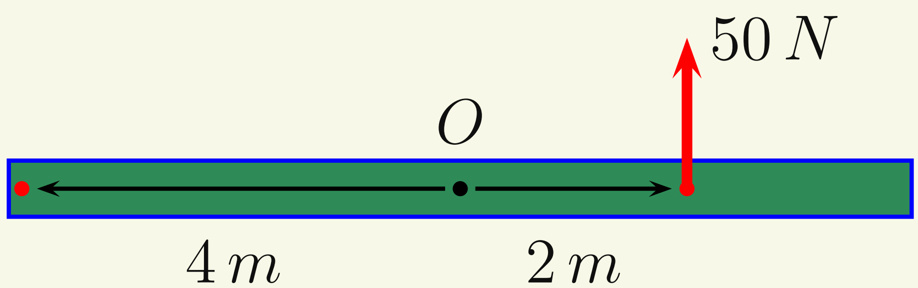

(a) $25\,N$, up (b) $25\,N$, down (c) $50\,N$, up

(d) $100\,N$, up (e) $100\,N$, down

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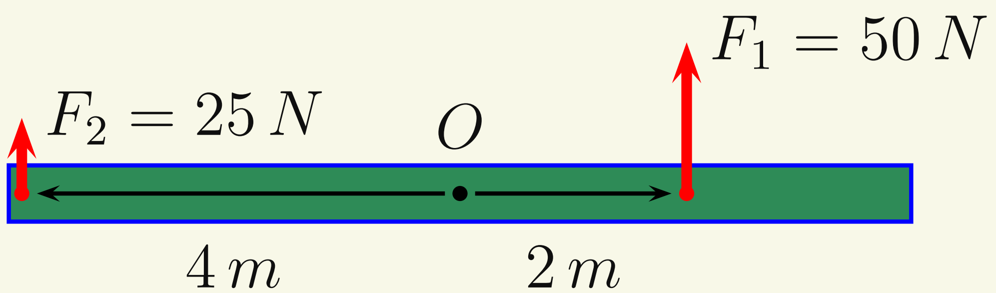

$\boxed{\text{(a) } 25\,N\text{, up}}$ (b) $25\,N$, down (c) $50\,N$, up

(d) $100\,N$, up (e) $100\,N$, down

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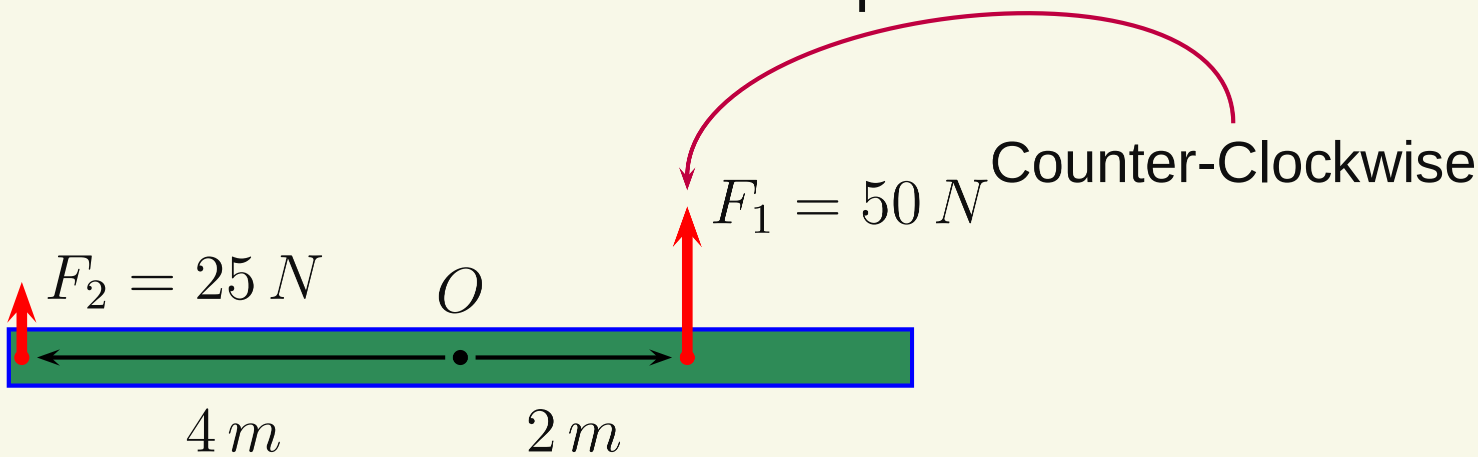

$\boxed{\text{(a) } 25\,N\text{, up}}$

(b) $25\,N$, down

(c) $50\,N$, up

(d) $100\,N$, up

(e) $100\,N$, down

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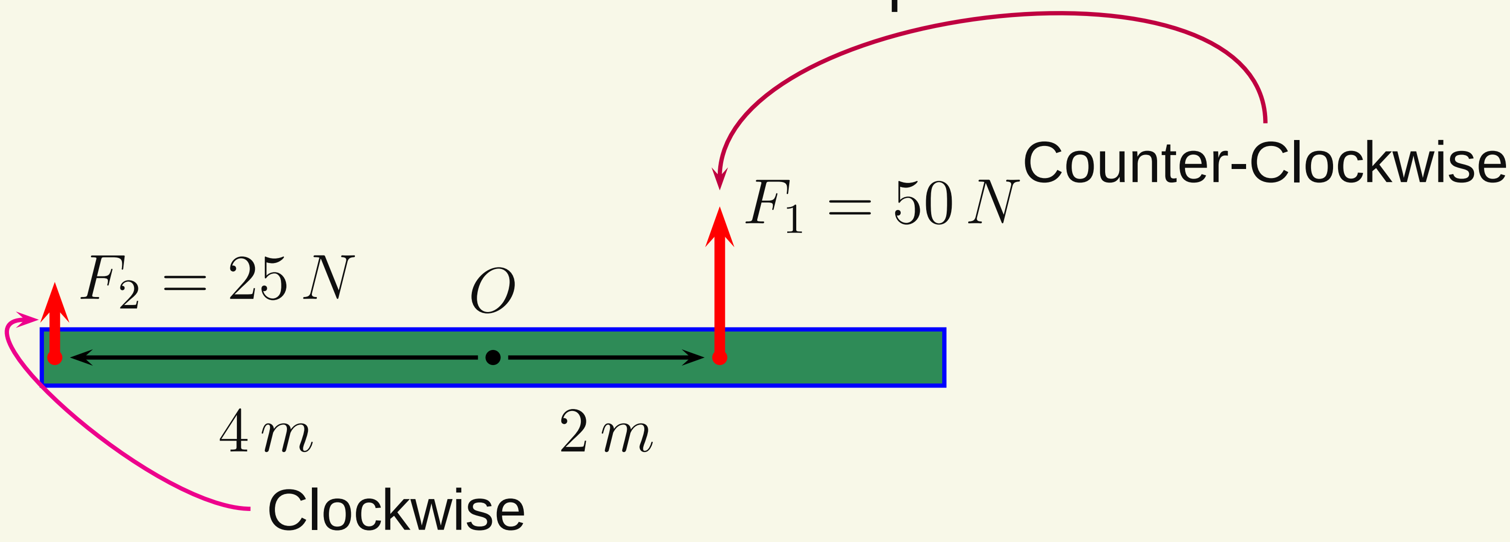

$\boxed{\text{(a) } 25\,N\text{, up}}$

(b) $25\,N$, down

(c) $50\,N$, up

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(e) $100\,N$, down

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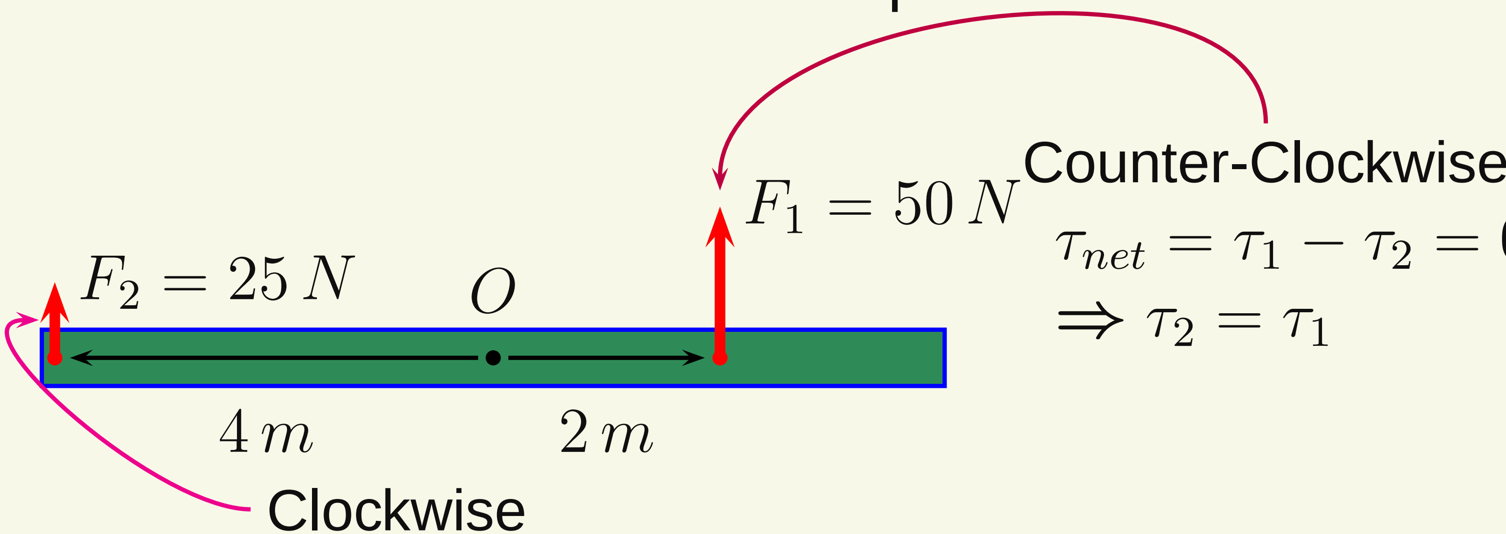

$$\tau_{net} = \tau_1 - \tau_2 = 0$$
$$\Rightarrow \tau_2 = \tau_1$$

$\boxed{\text{(a) } 25\,N\text{, up}}$

(b) $25\,N$, down

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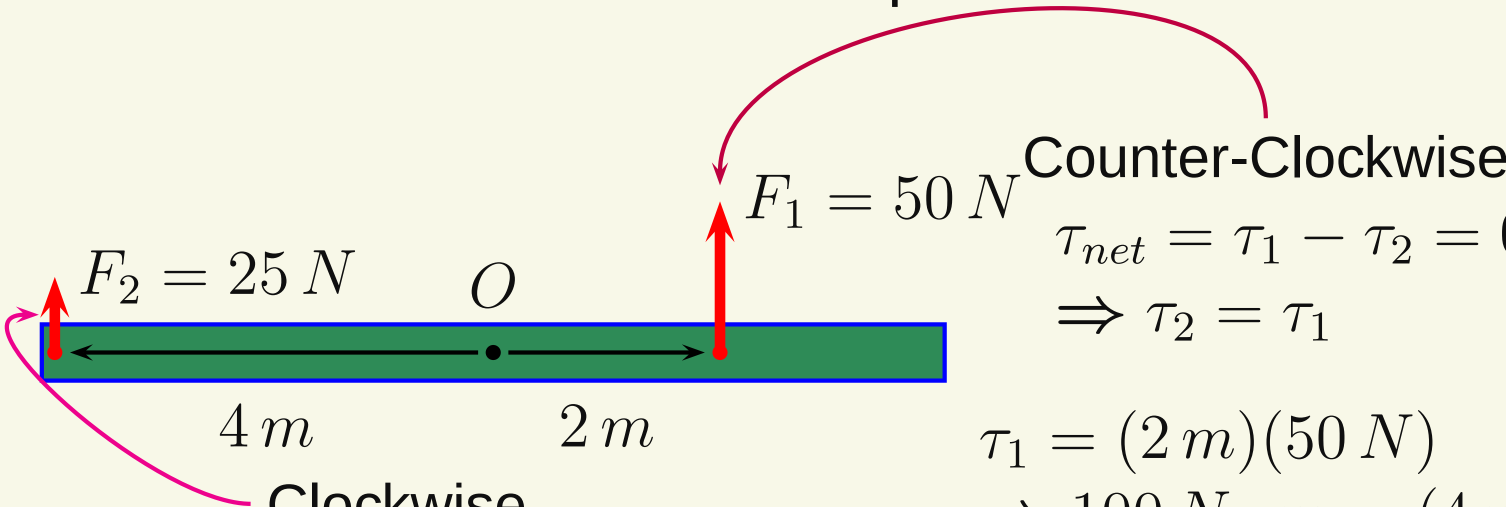

$$\tau_{net} = \tau_1 - \tau_2 = 0$$
$$\Rightarrow \tau_2 = \tau_1$$

$$\tau_1 = (2\,m)(50\,N)$$
$$\Rightarrow 100\,N \cdot m = (4\,m)(F_2)$$

$\boxed{\text{(a) } 25\,N\text{, up}}$ (b) $25\,N$, down (c) $50\,N$, up

(d) $100\,N$, up (e) $100\,N$, down