June 18, Week 3

Today: Chapter 4, Newton's First and Second Law

Homework #3 is now available.

Problem #1 had a typo in it. Both ships have velocities that are in miles per hour.

Superposition

Usually there is more than one force acting on an object.

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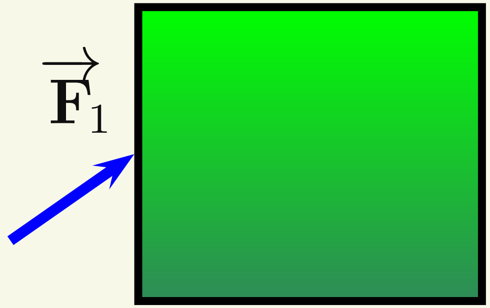

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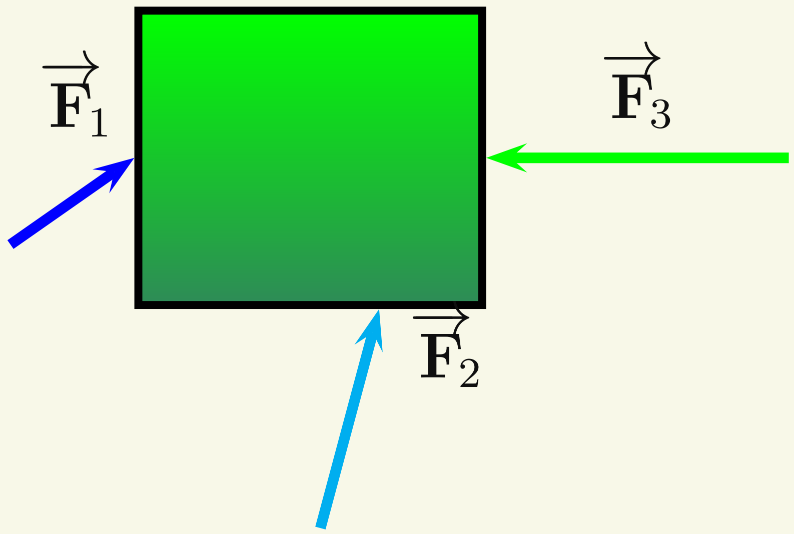

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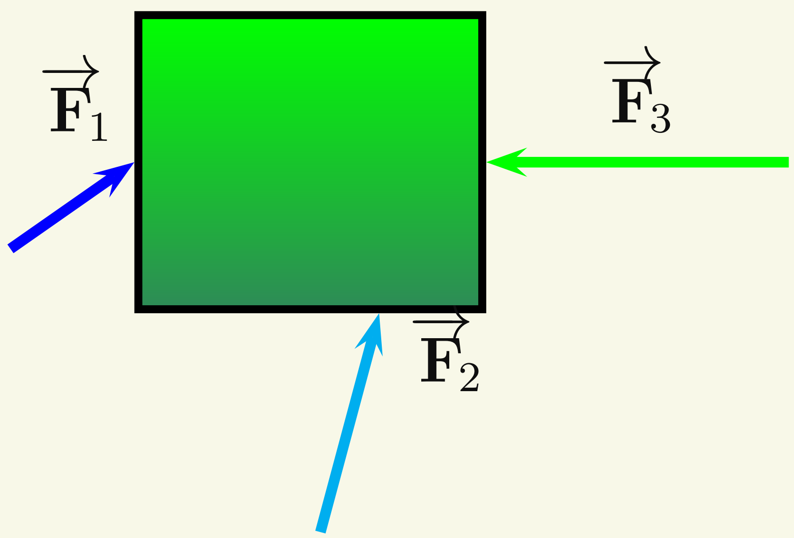

Superposition - The net result of two or more forces is given by the vector sum.

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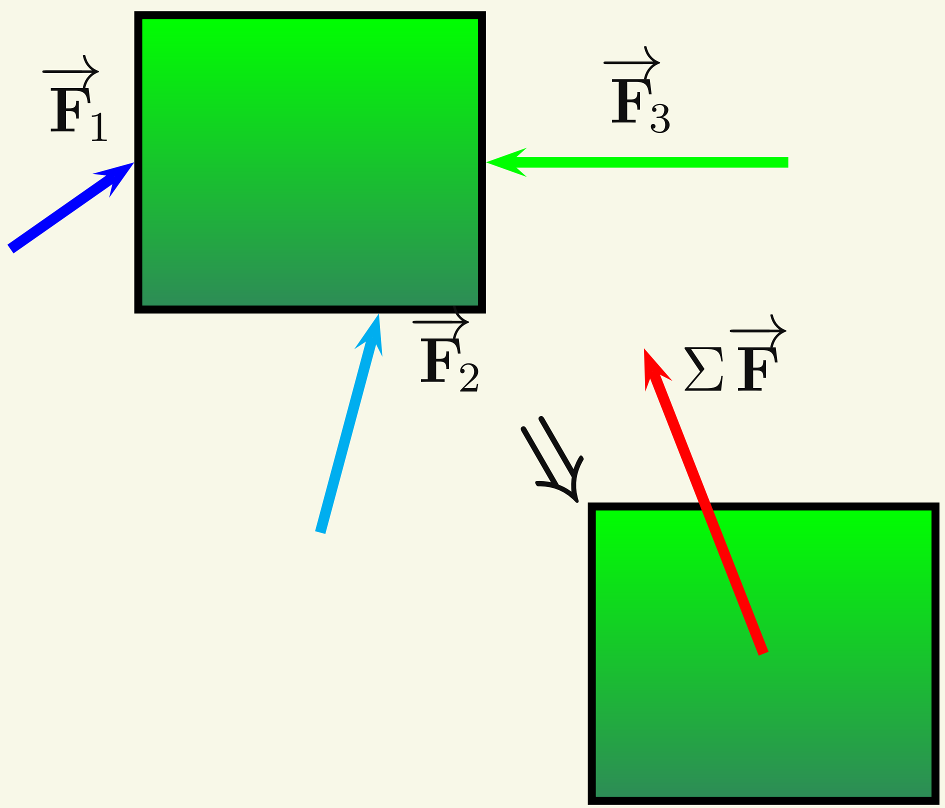

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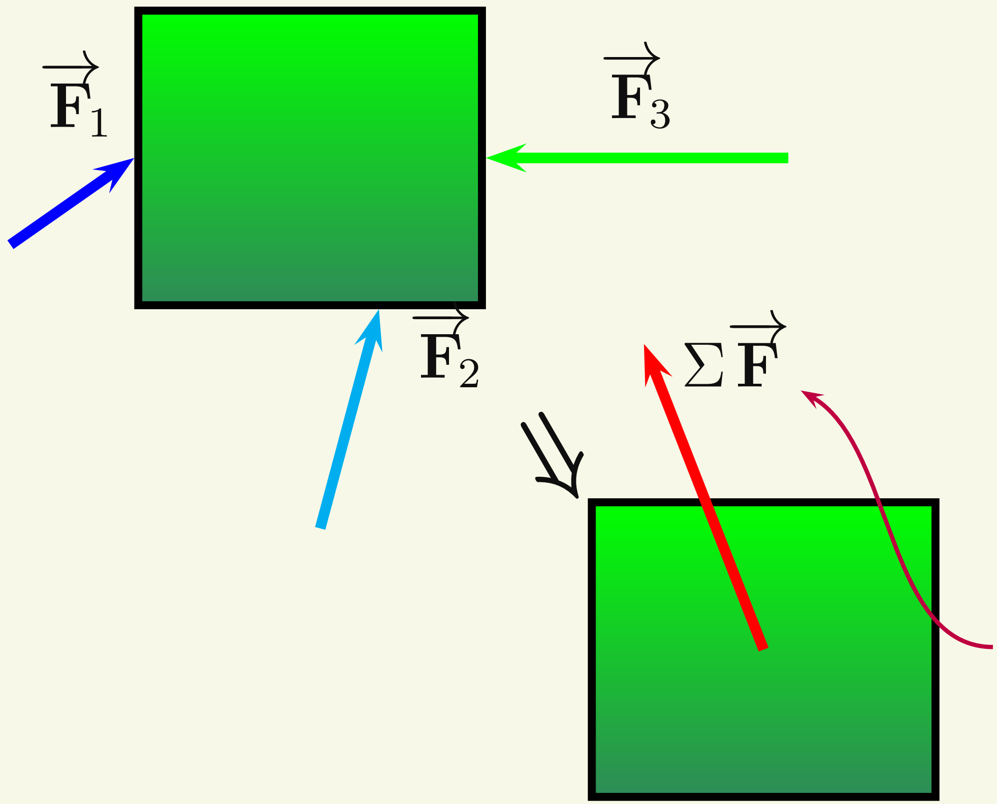

One single force.
Applied at the center
to avoid rotation.

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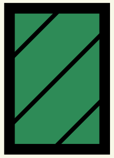
A box is subjected to the four forces shown. Which of the following correctly shows the net force $\sum \vec{\mathbf{F}}$ acting on the box?



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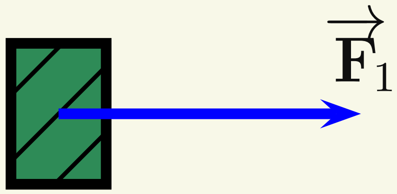

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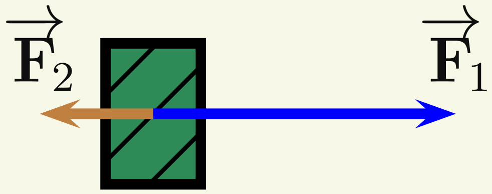

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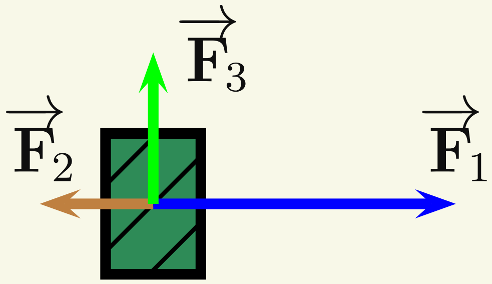

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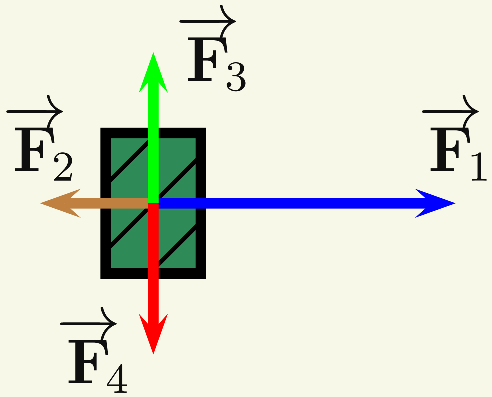

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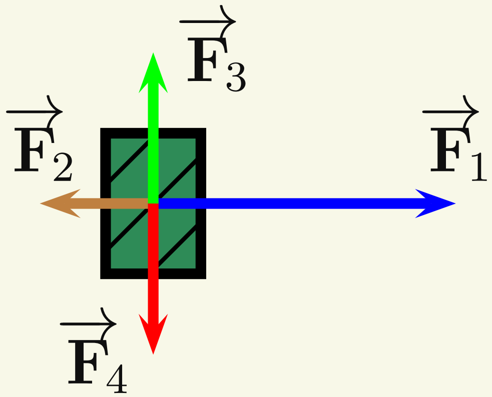

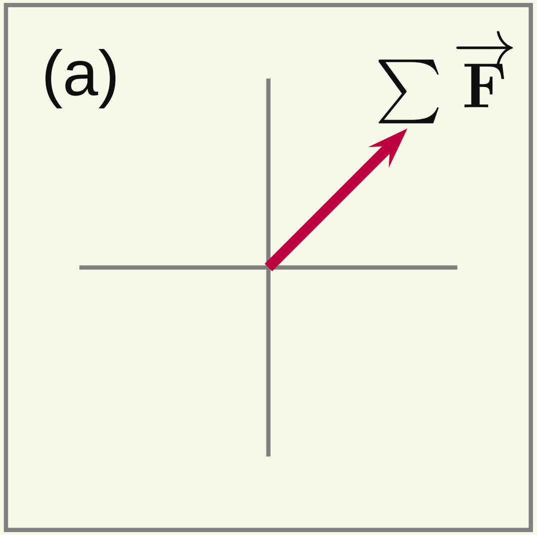

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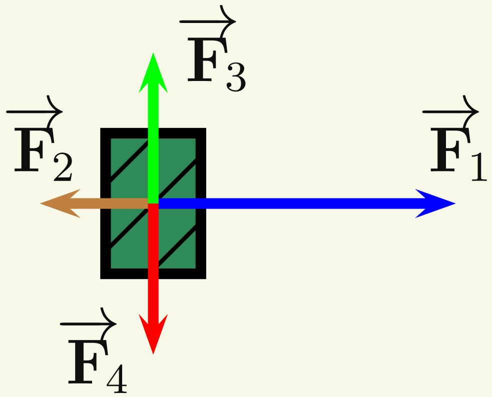

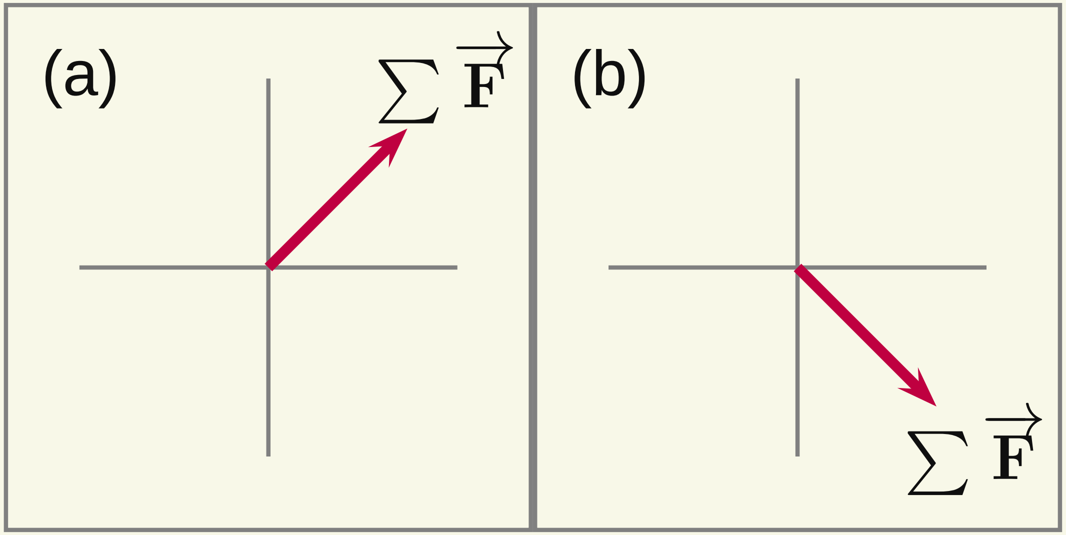

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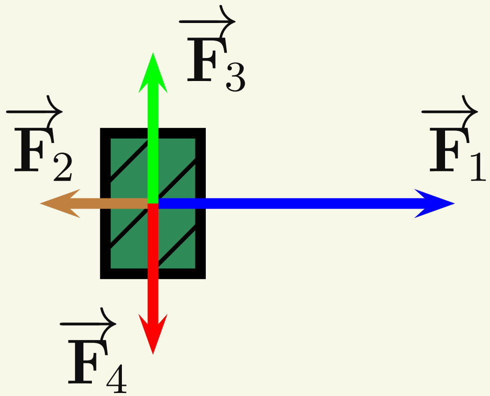

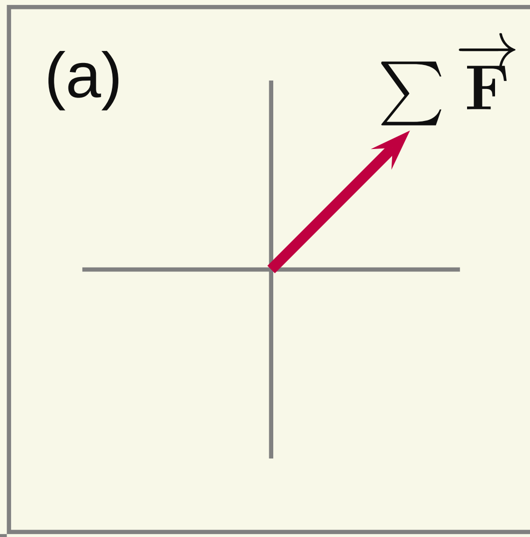

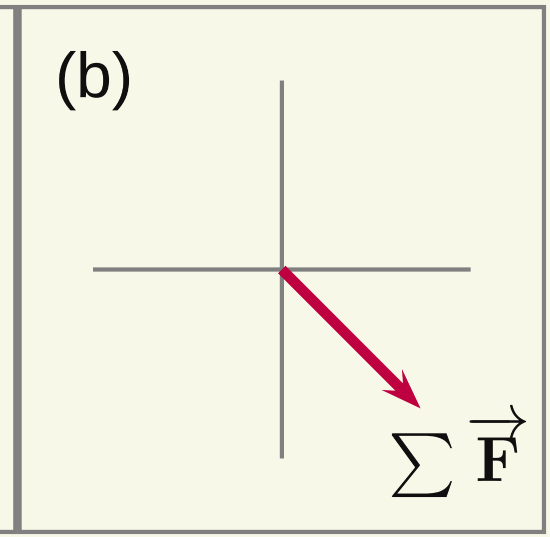

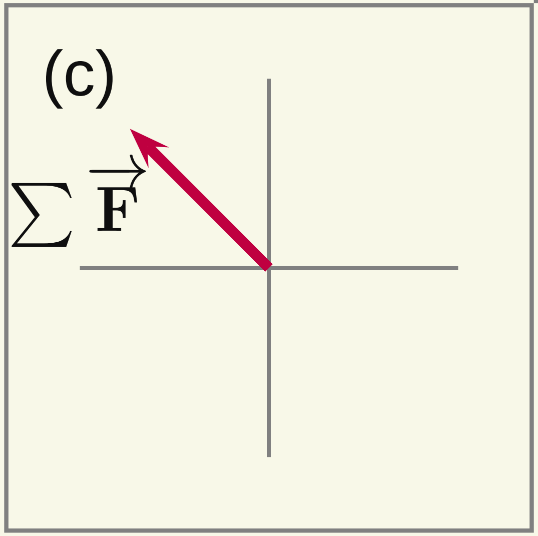

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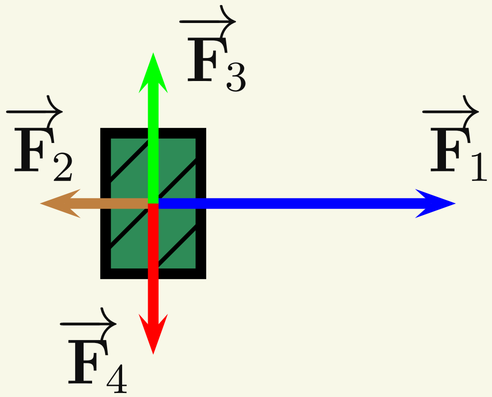

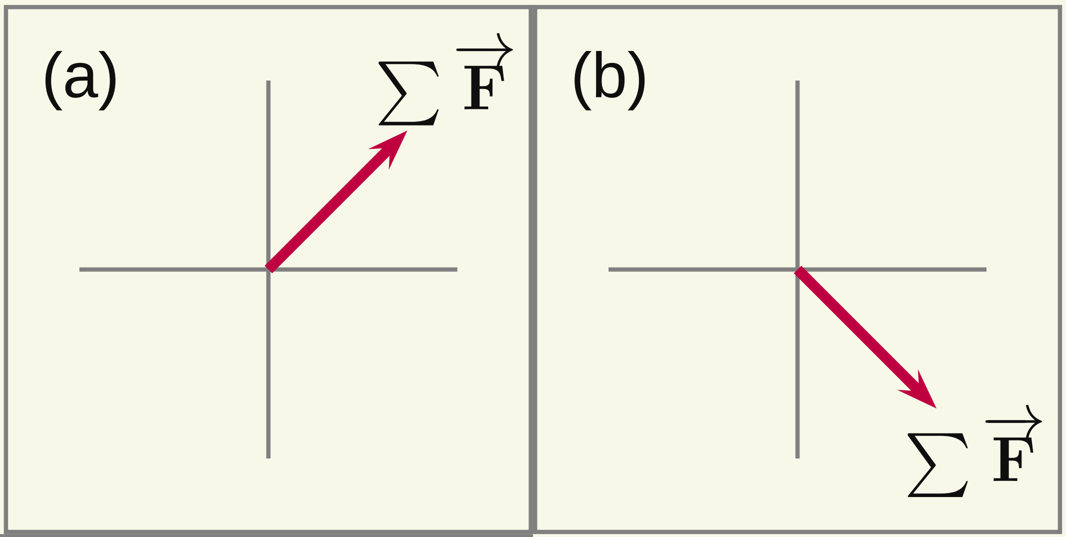

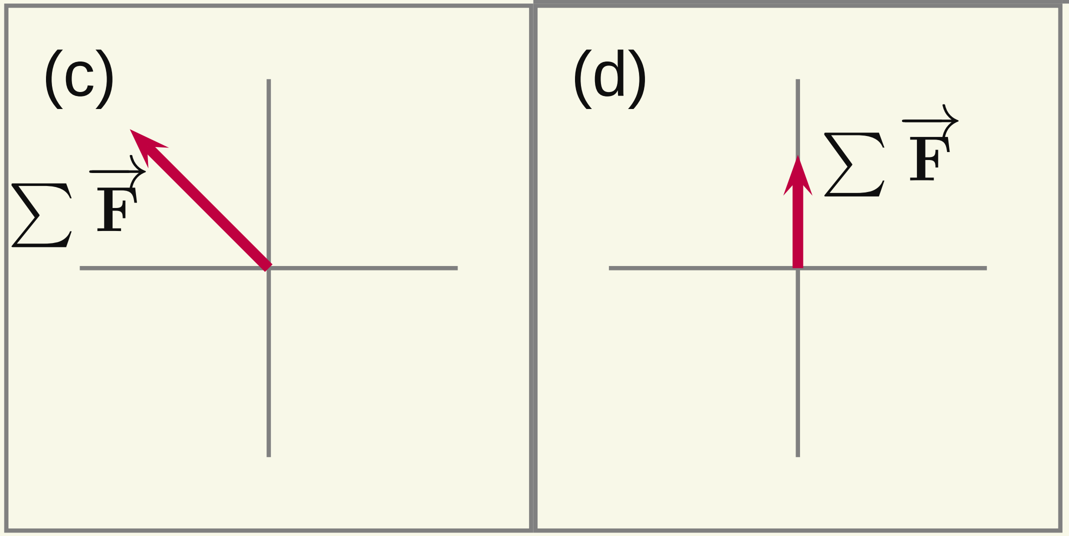

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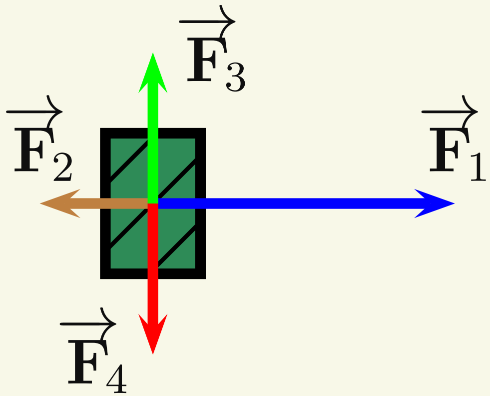

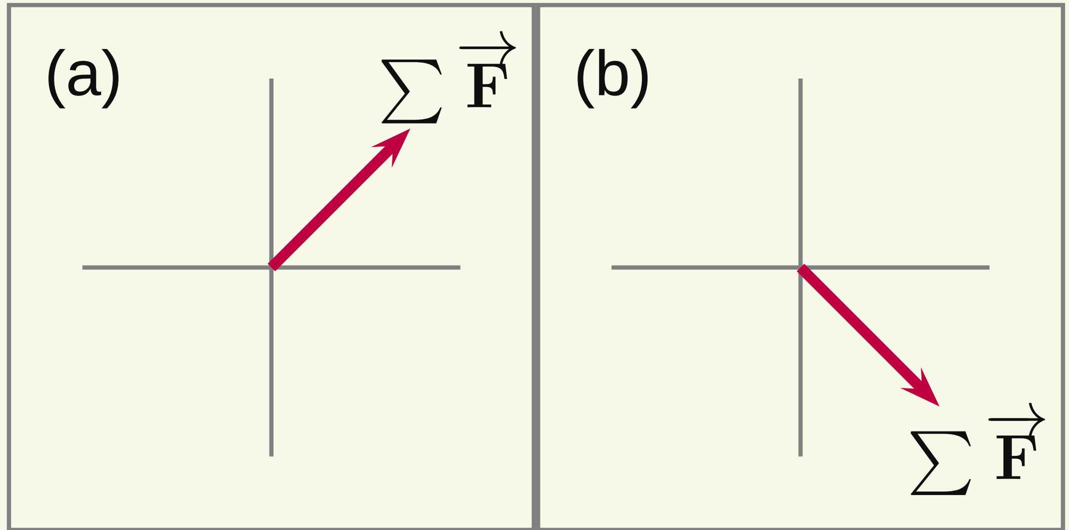

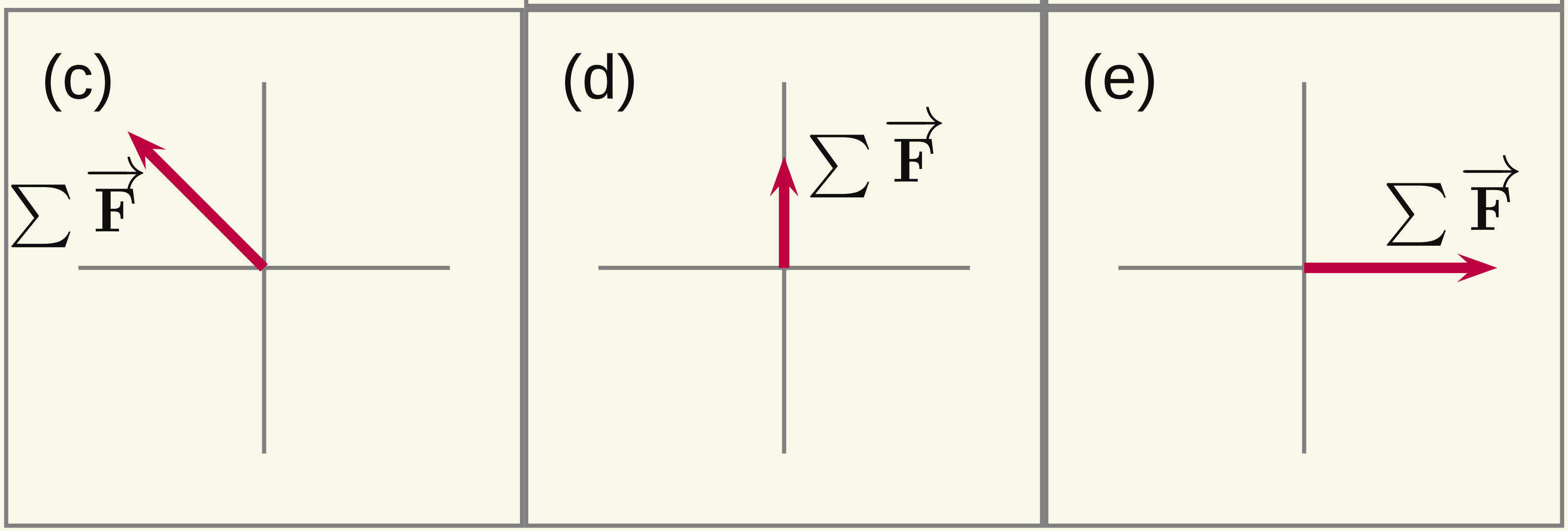

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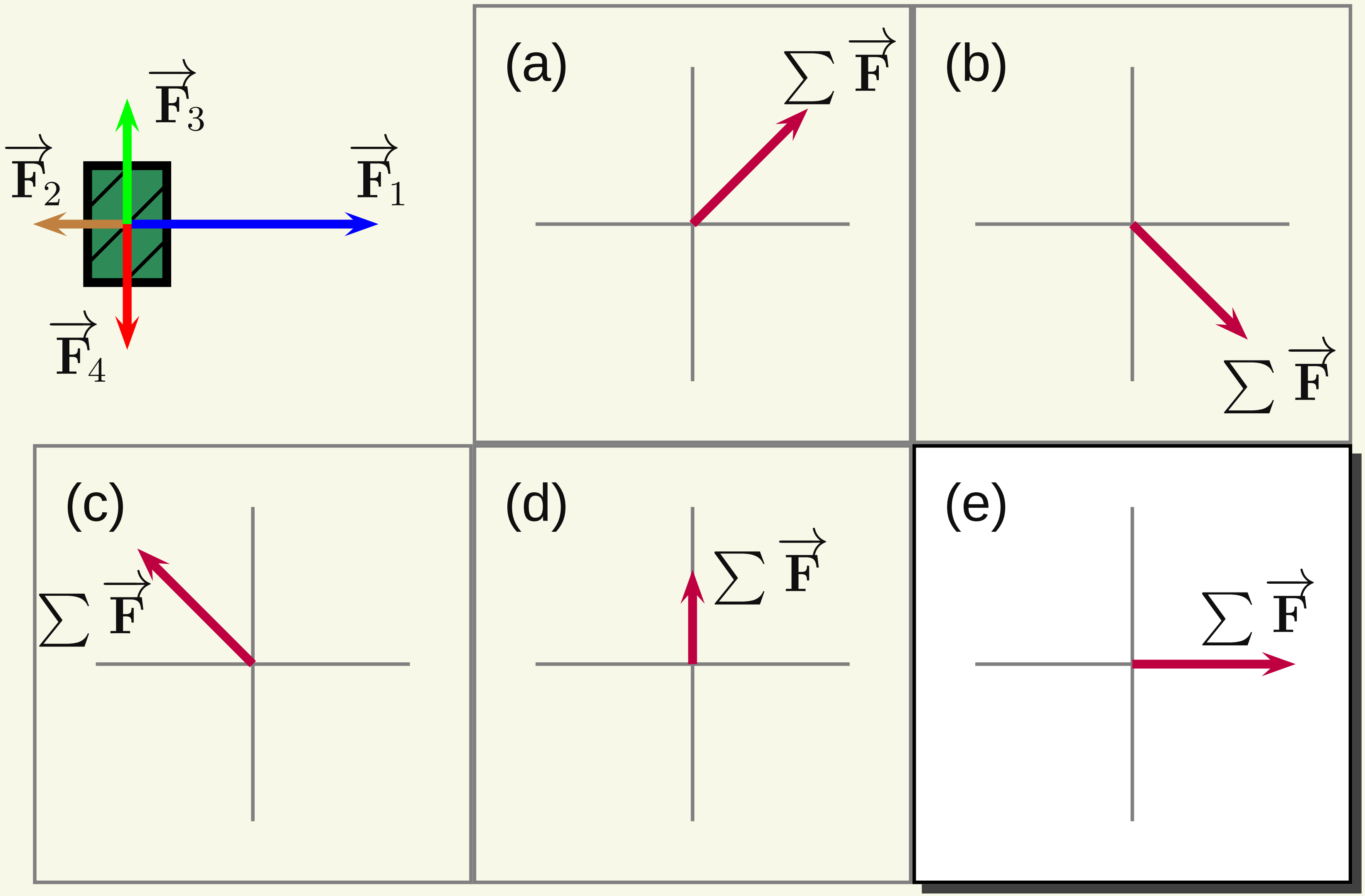

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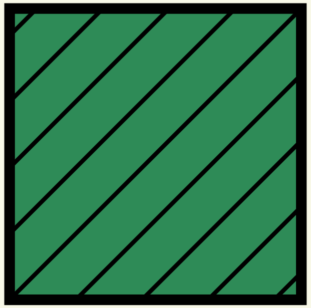

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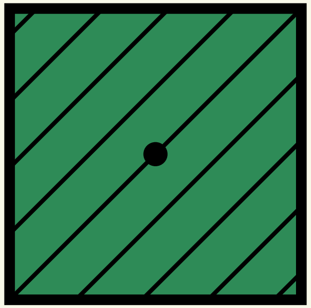

Still using the particle model, so think of a dot at the center of the object

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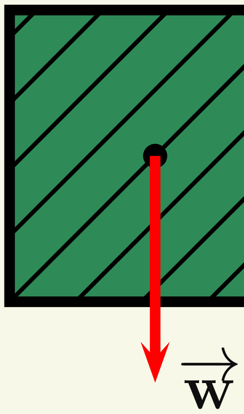

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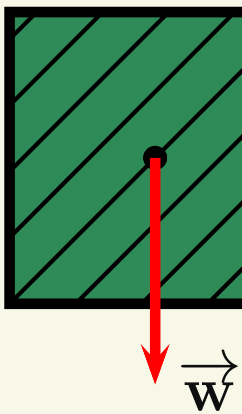

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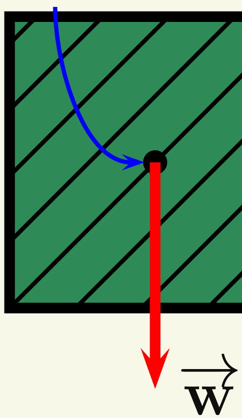
Center of Gravity



When we stop using the particle model and assuming all forces applied at the center, we'll locate the weight at a point called the center of gravity

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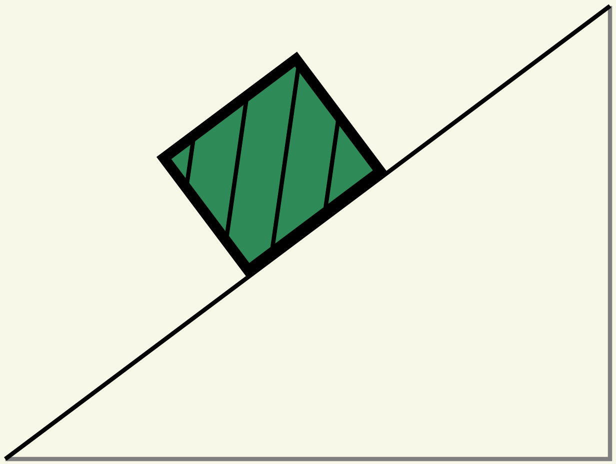

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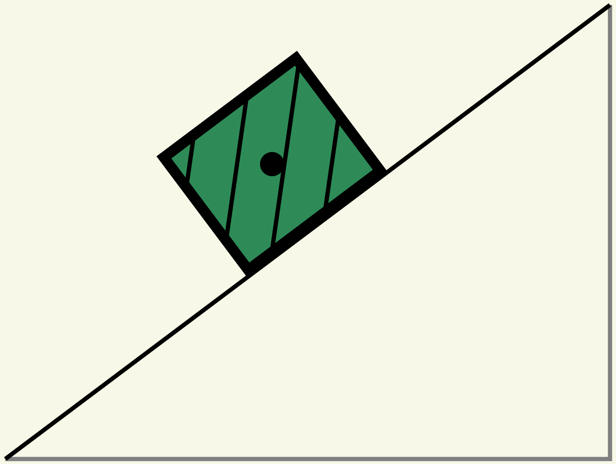

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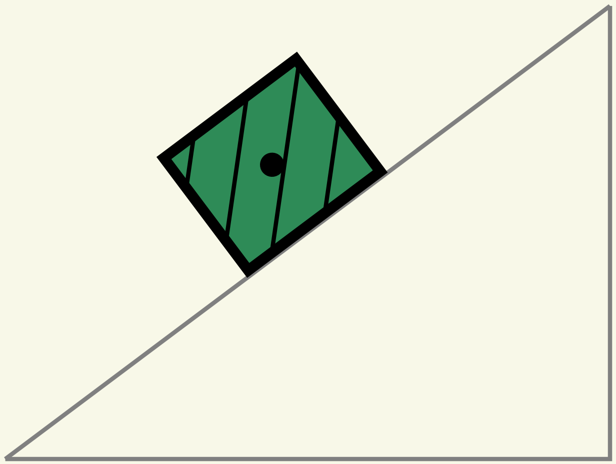

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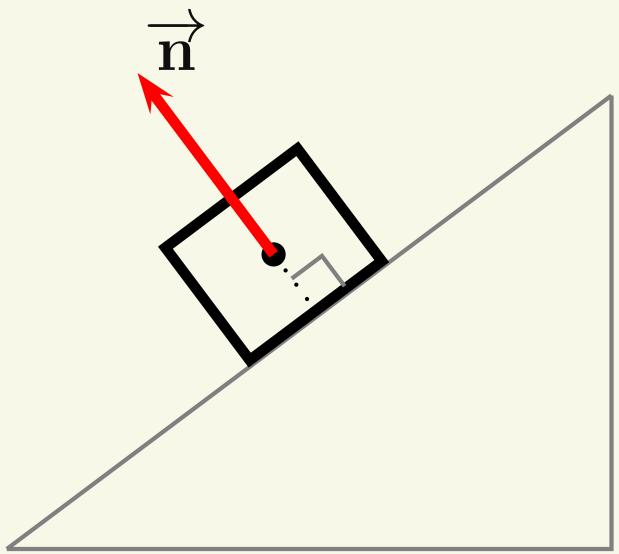

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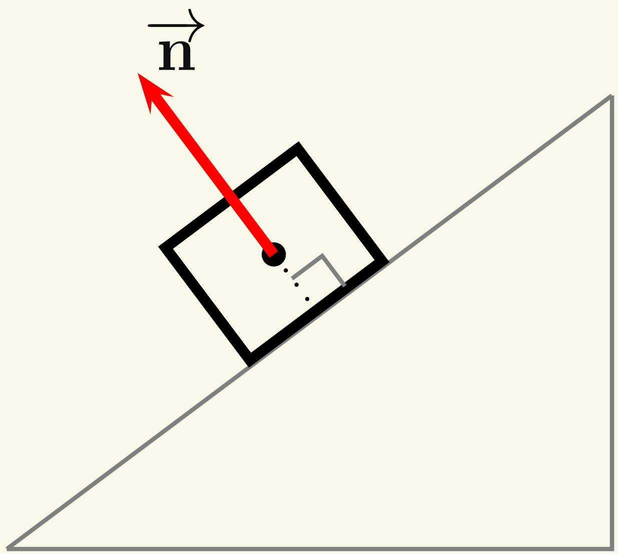

Whether object is being pushed or pulled we always draw the forces going away from the dot

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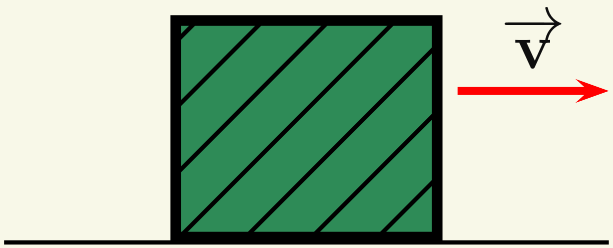

Kinetic friction acts on sliding objects. Opposed to motion $\Rightarrow$ opposite to the velocity

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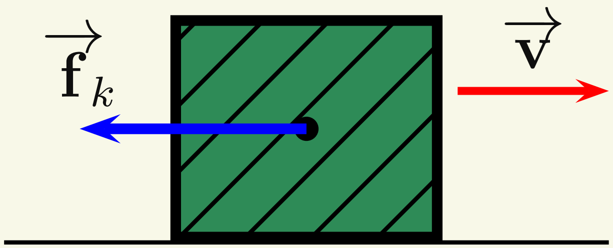

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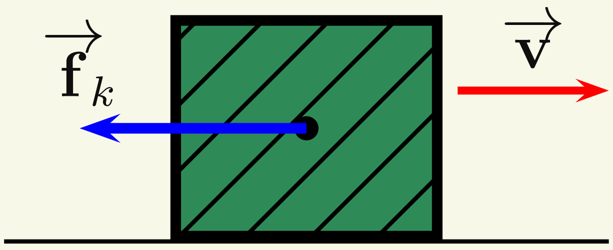

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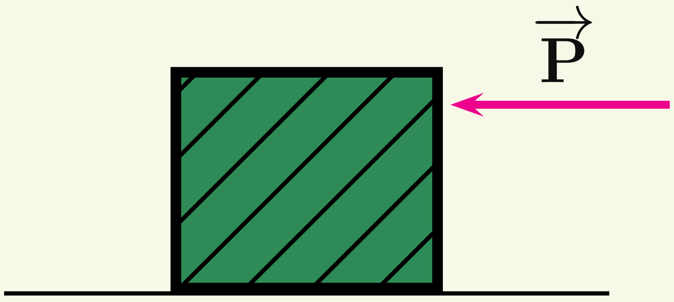

Static friction acts on stationary objects. It *prevents* motion when other forces are applied.

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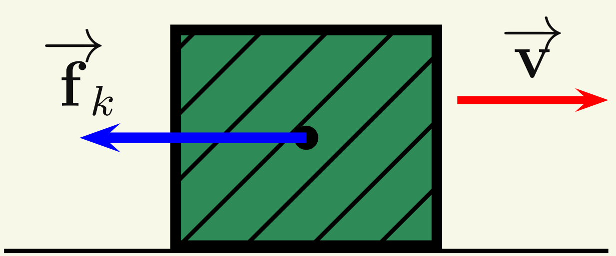

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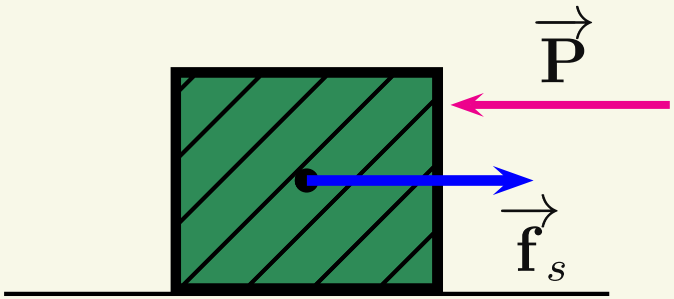

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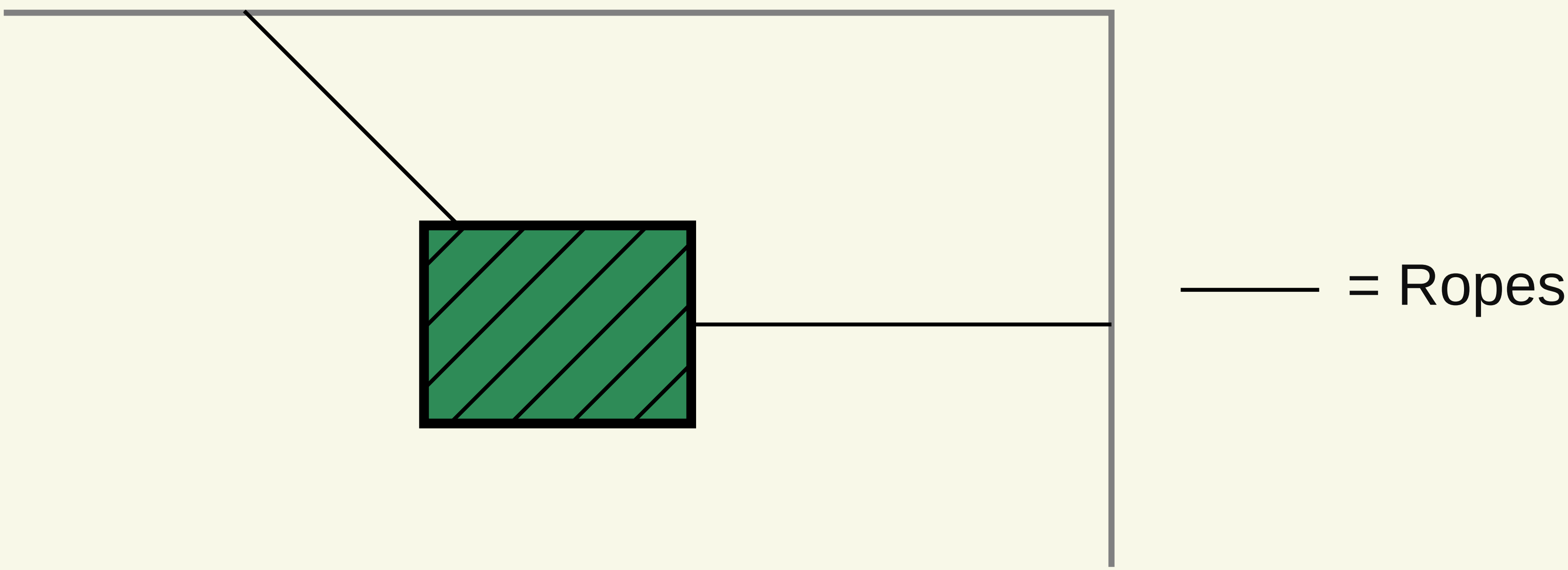

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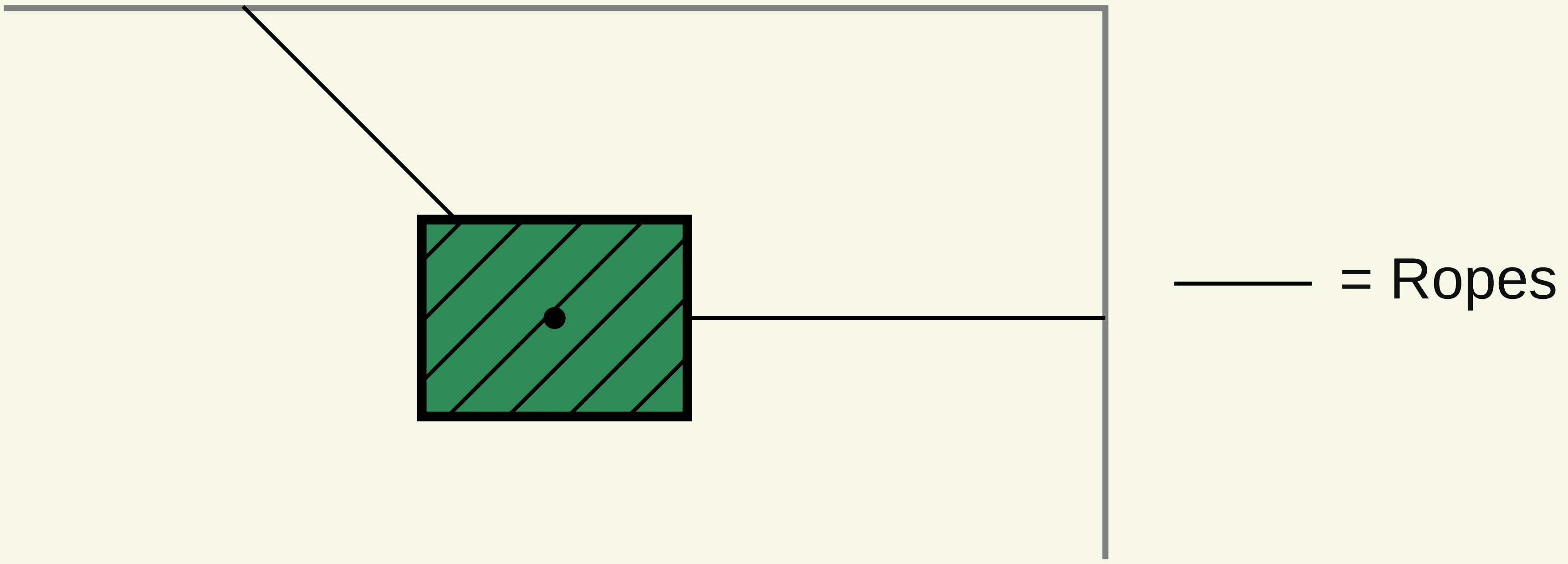

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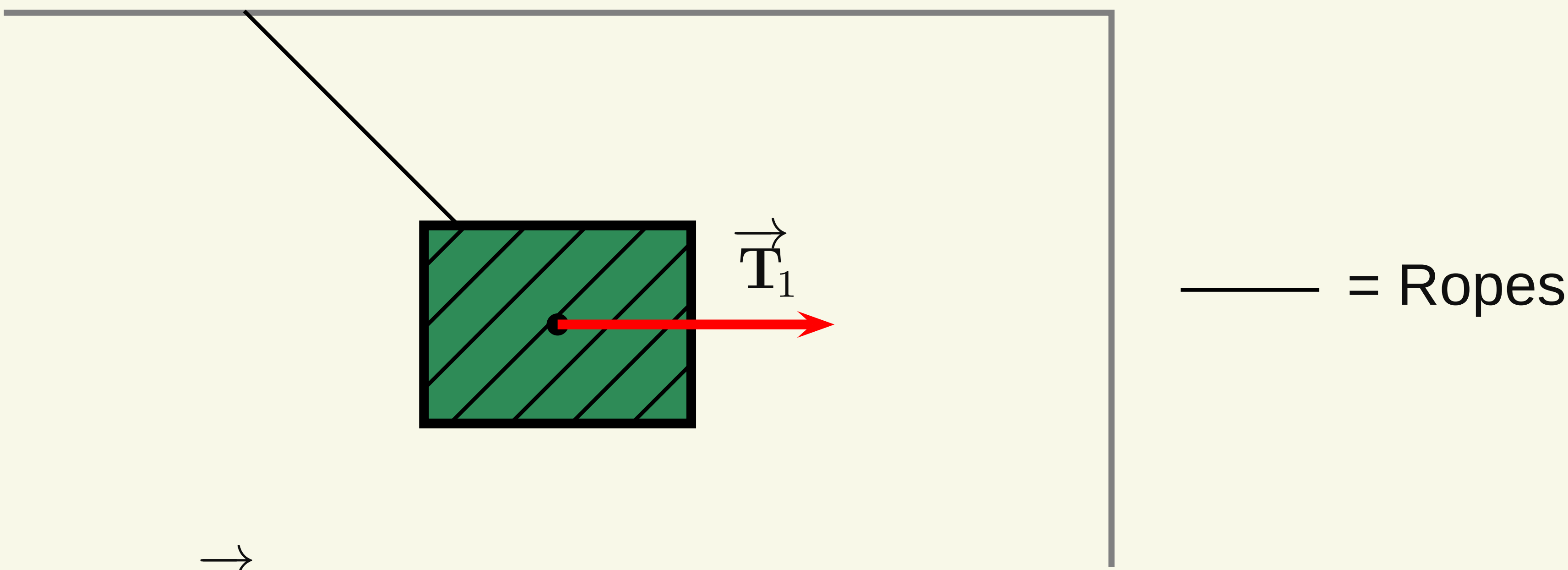

$\vec{\mathbf{T}}_1 =$ Tension exerted by 1st rope

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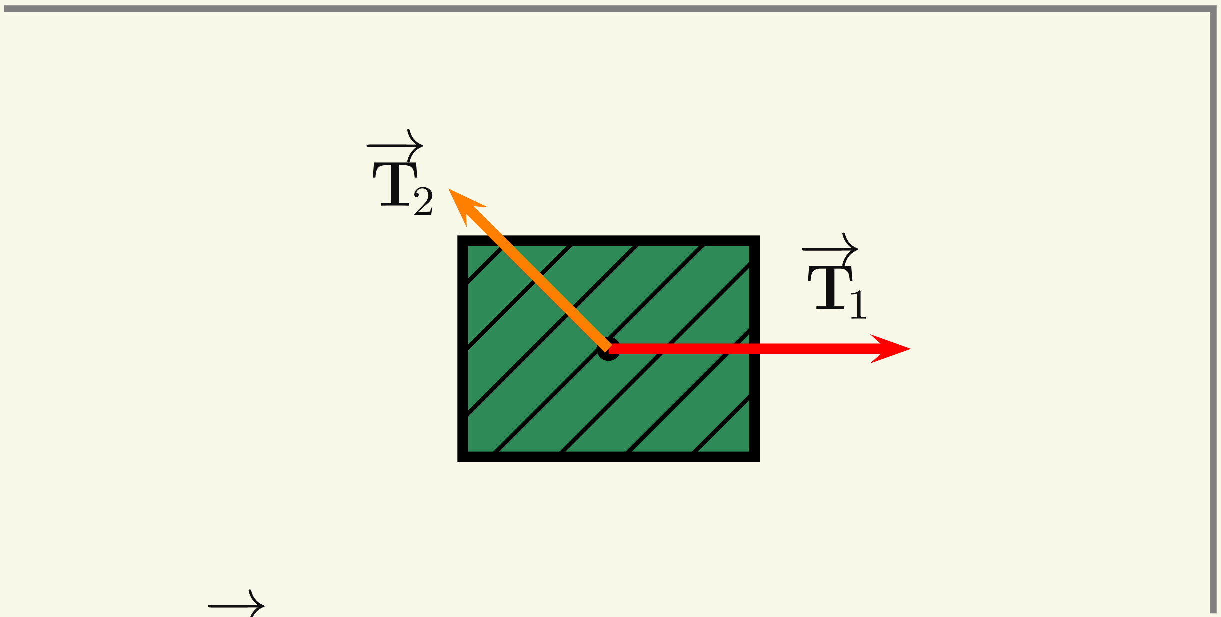

—— = Ropes

$\vec{\mathbf{T}}_1$ = Tension exerted by 1st rope
$\vec{\mathbf{T}}_2$ = Tension exerted by 2nd rope

Identifying Forces

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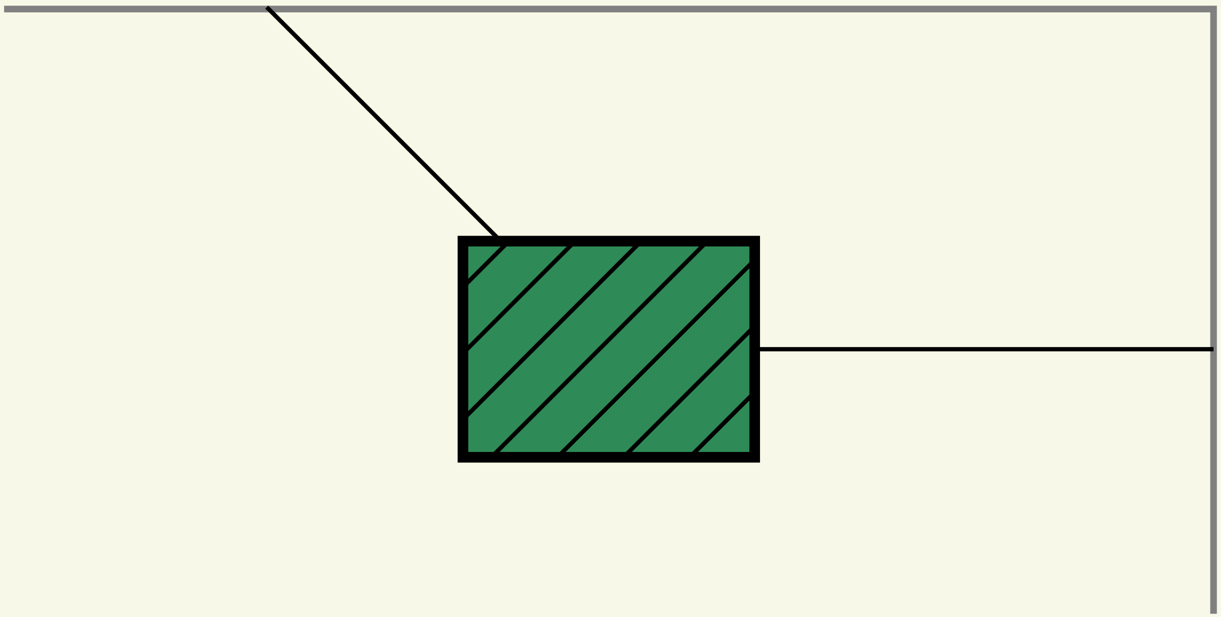

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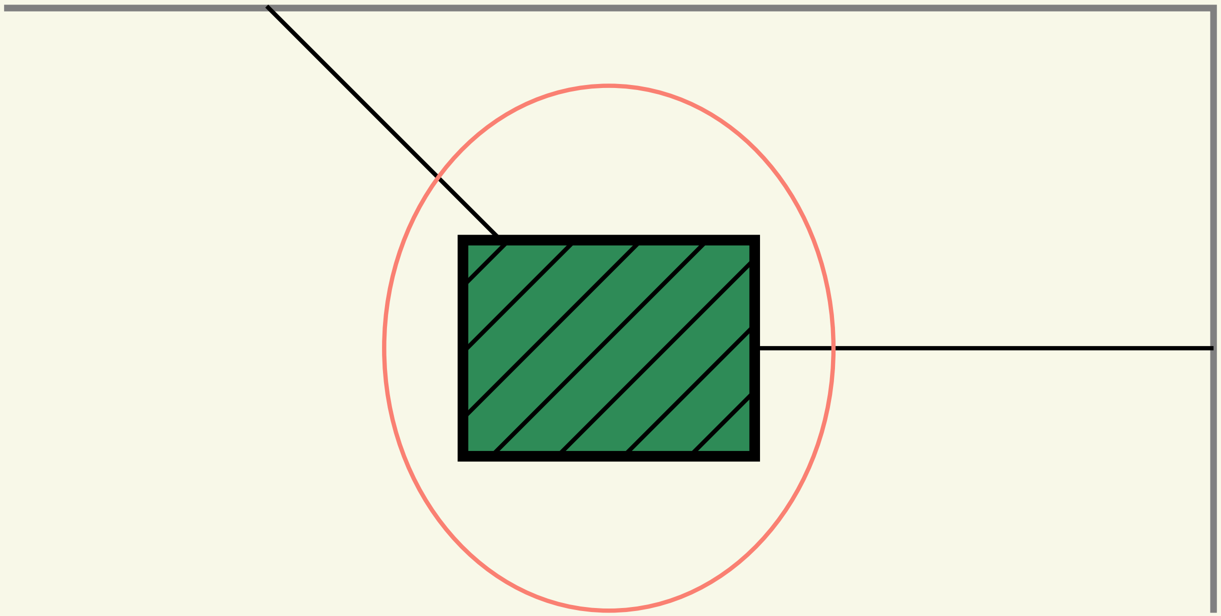

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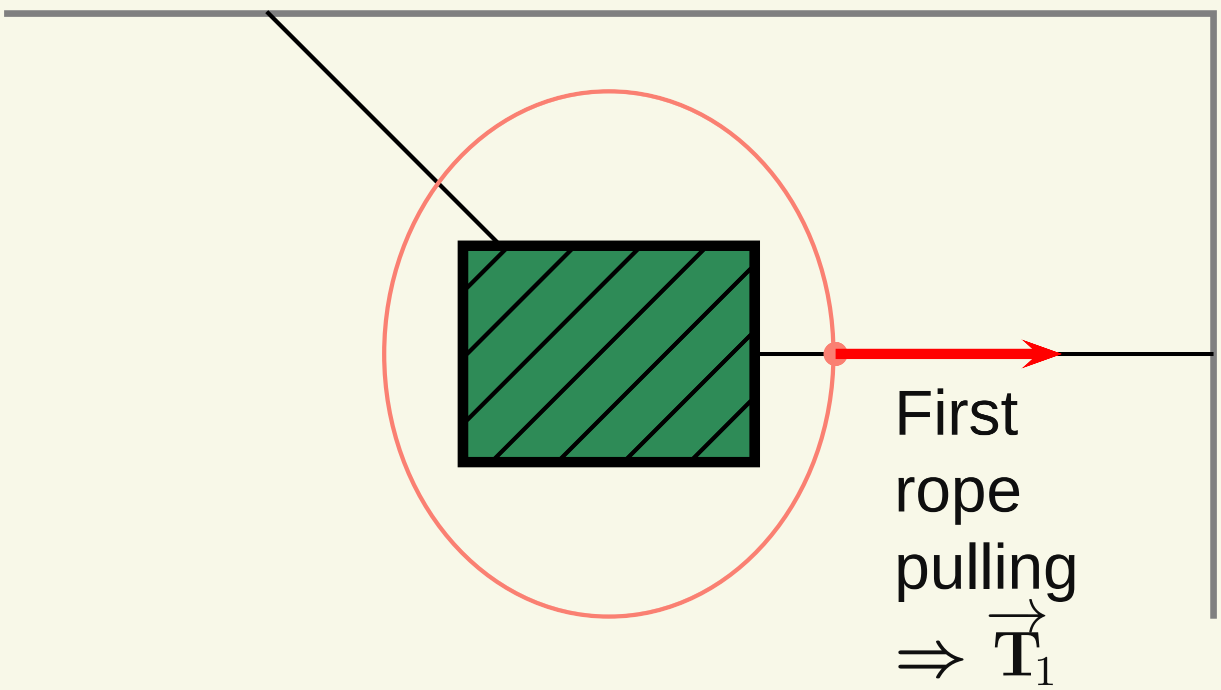

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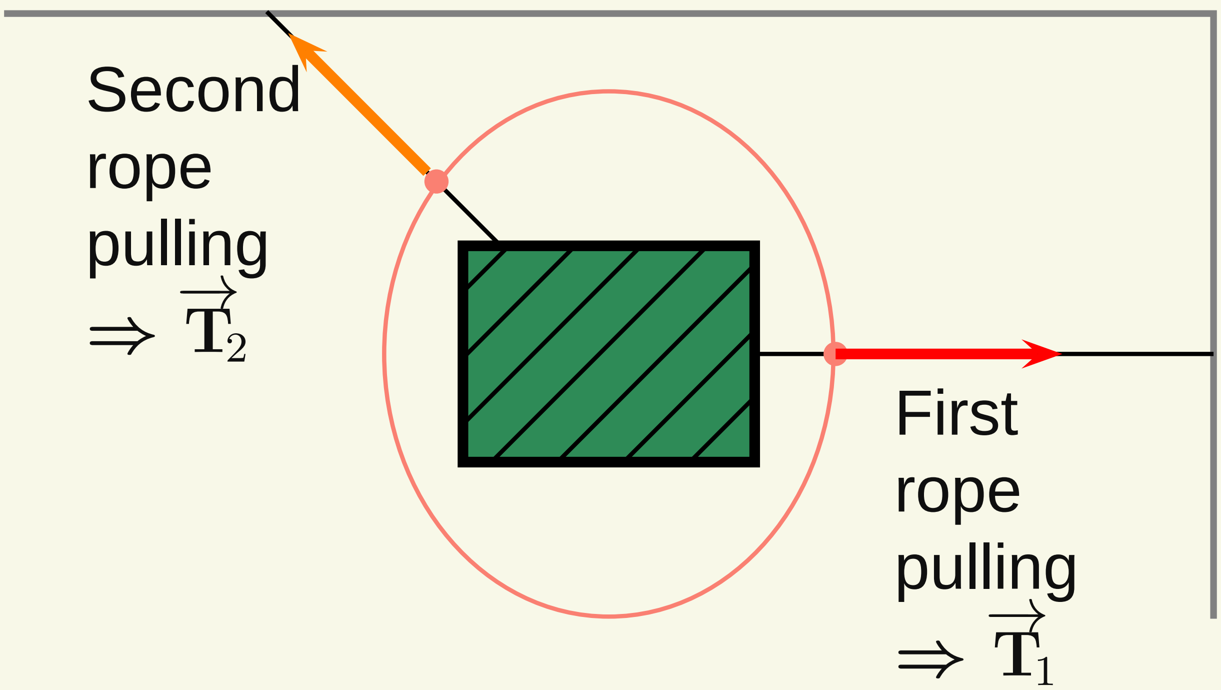

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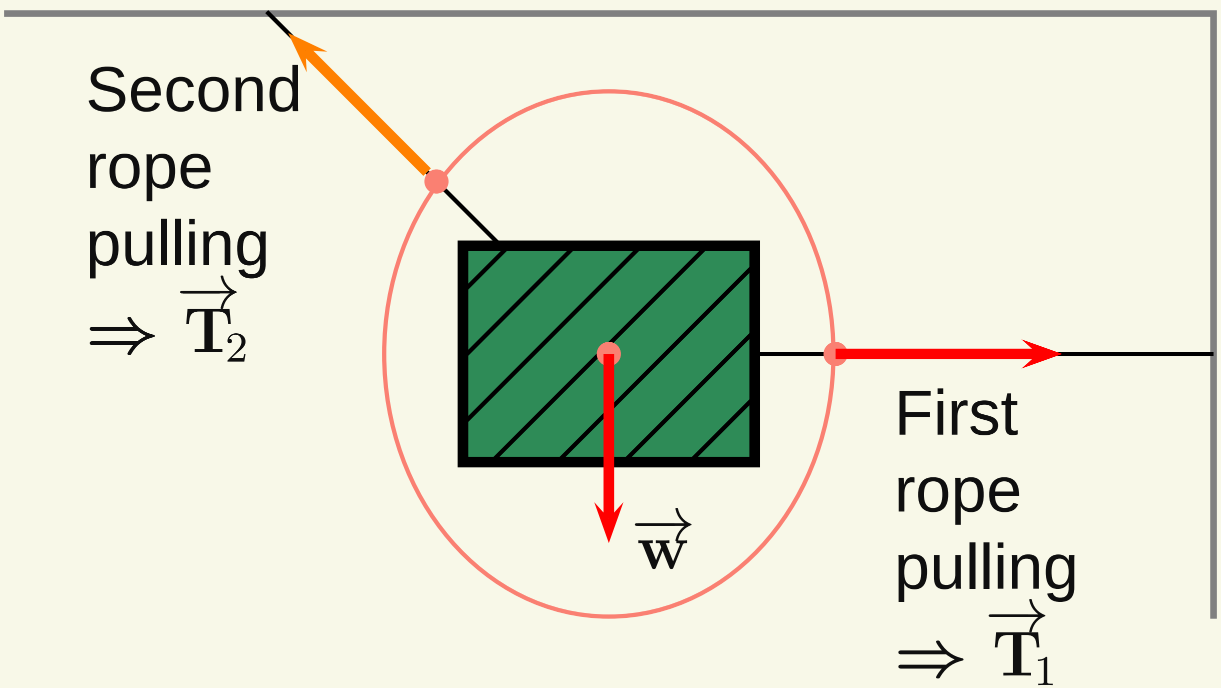
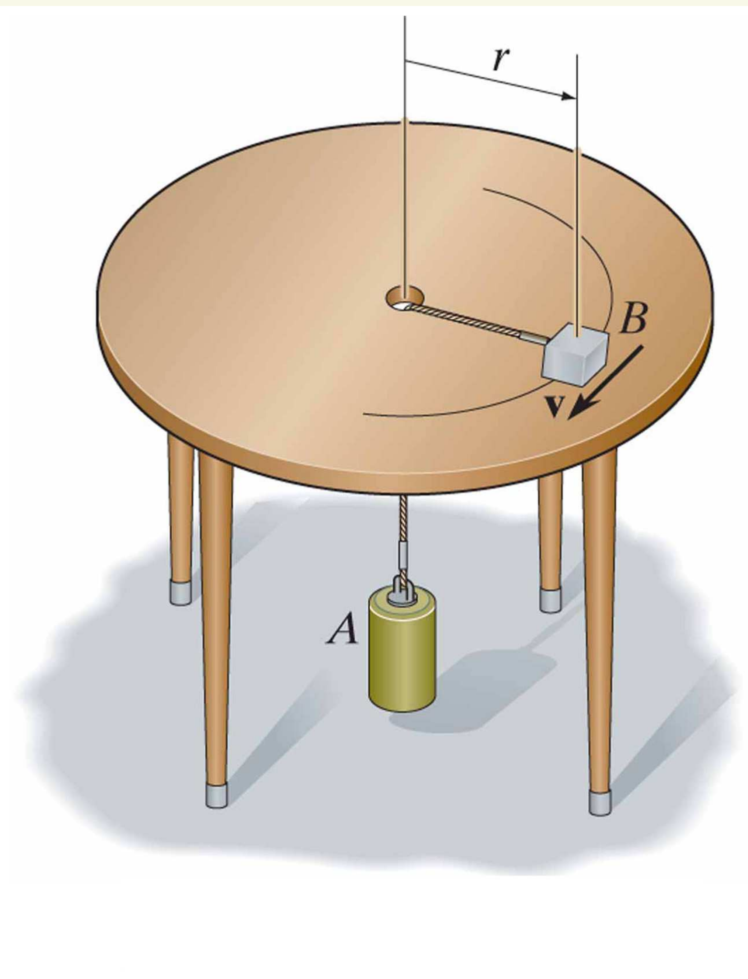


Finally, Identify our only long-range force: Gravity $\Rightarrow \overrightarrow{\mathbf{w}}$

Force Identification Exercise

Block B is circling around a rough table while connected to a rope that passes through a hole in the center of the table down to cylinder A. Which of the following forces do we *NOT* identify as acting on the block B?



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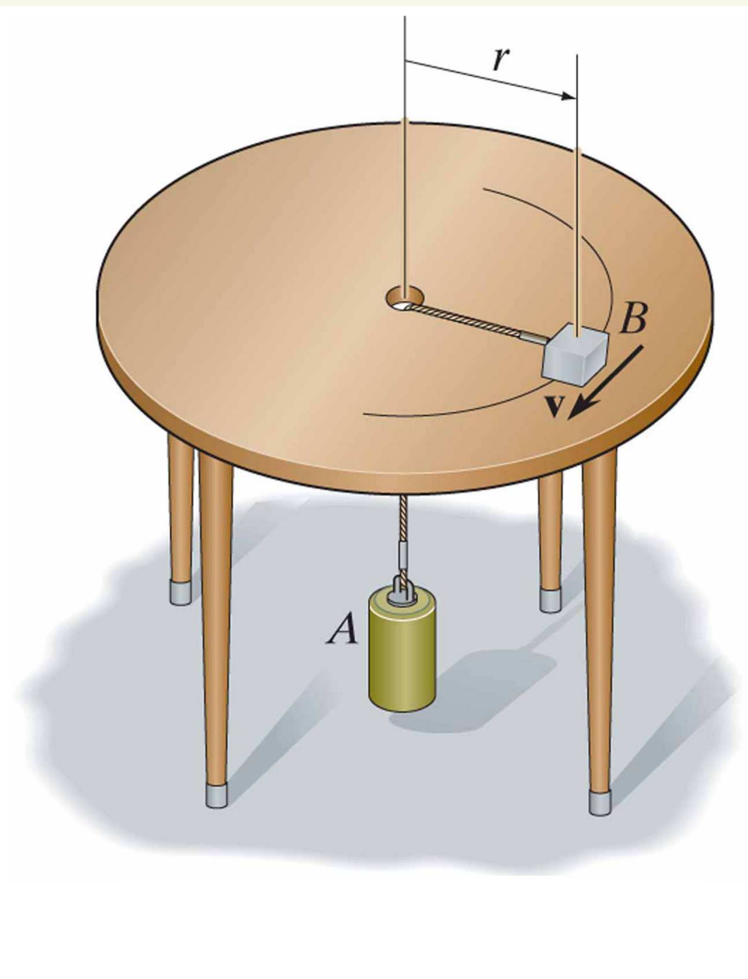

(a) The weight of block B

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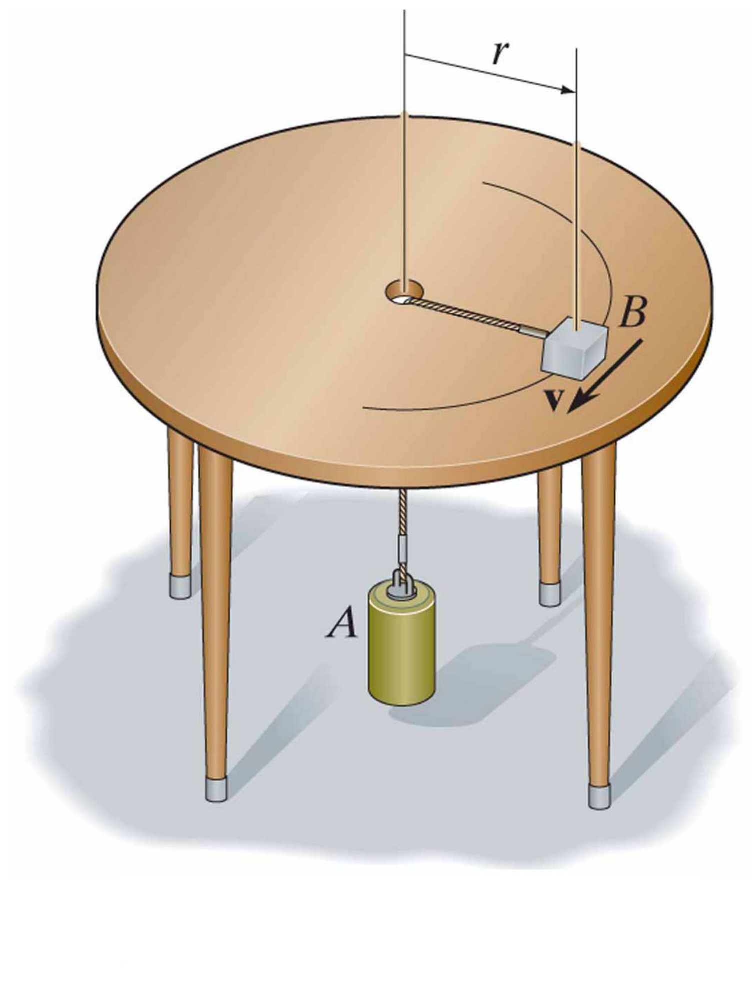

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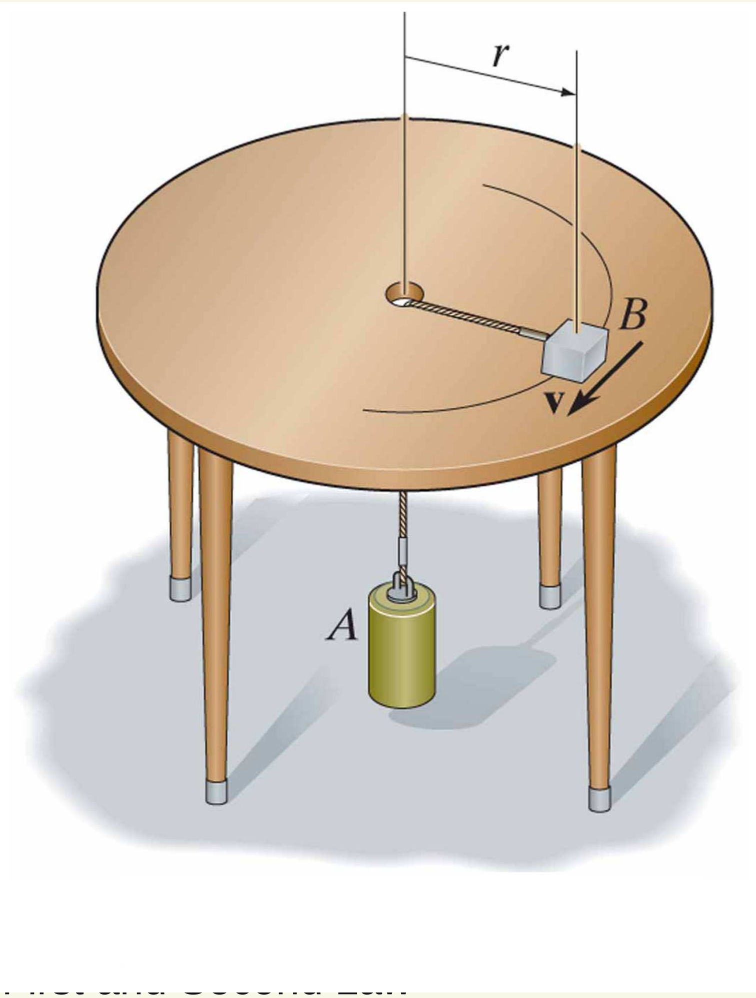

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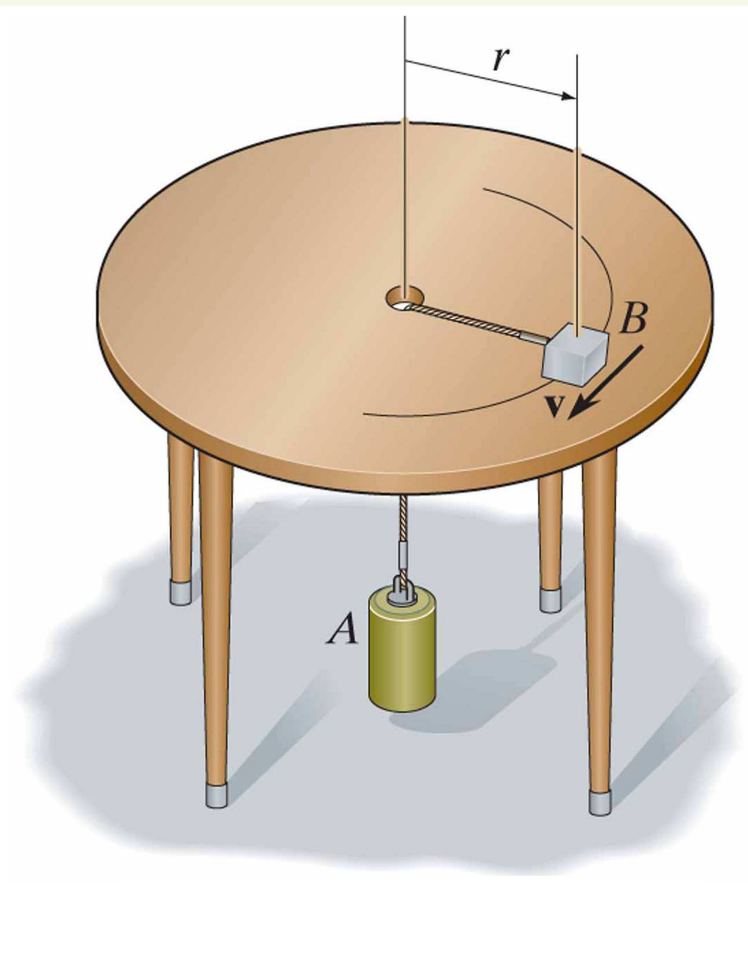

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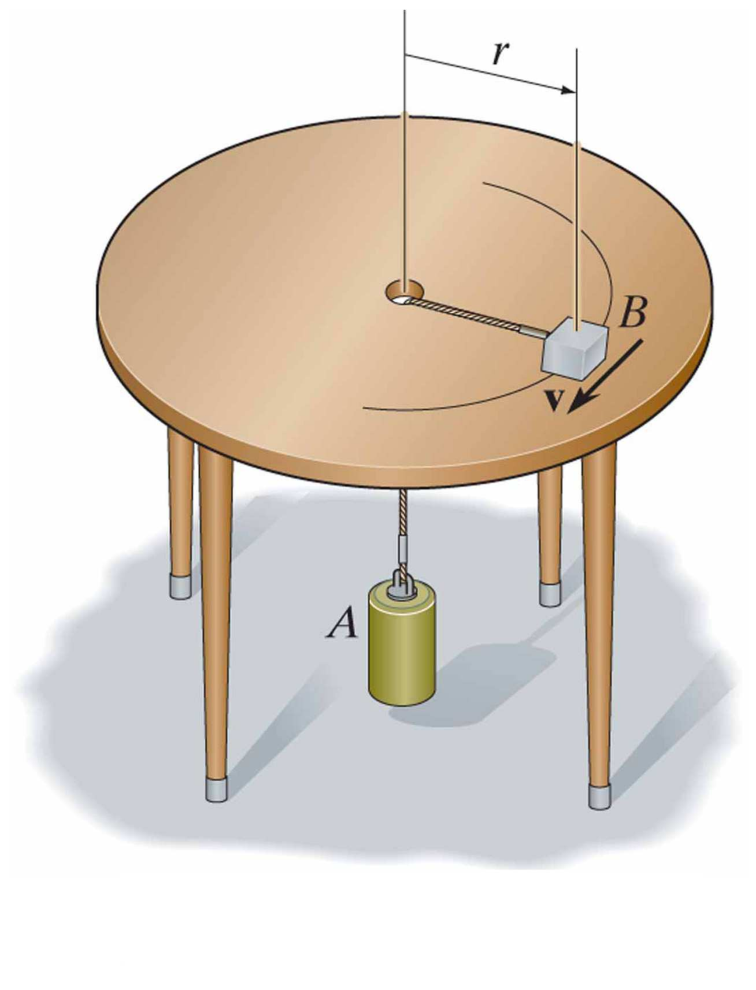

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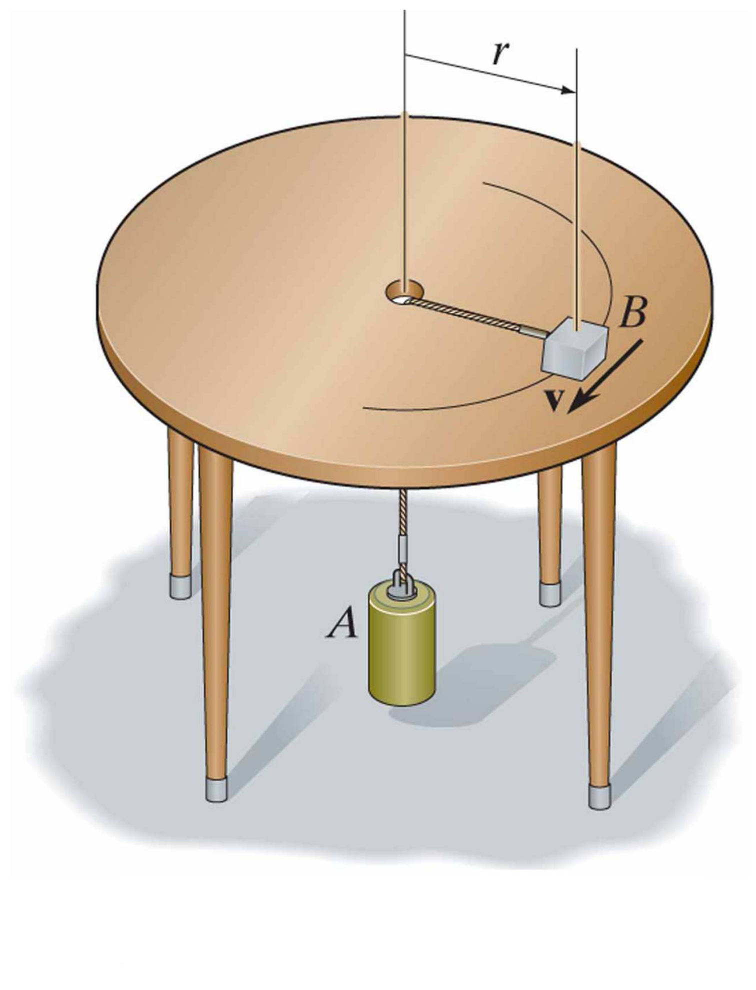

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Newton's First Law

<u>First Law</u> - The Law of Inertia

An object at rest stays at rest, an object in uniform motion stays if uniform motion if (and only if) the net force acting on the object is zero.

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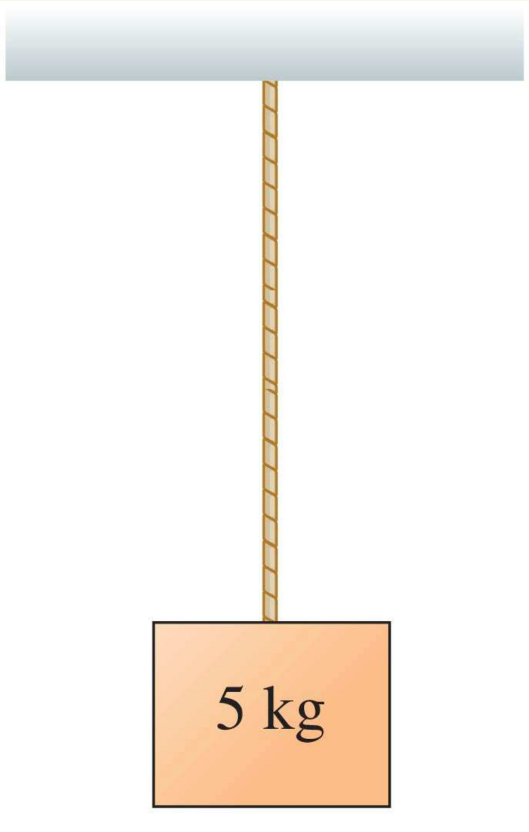
Uniform motion - Straight line and constant speed, *i.e*, constant velocity.

Inertia - The property of all matter to stay in motion if already in motion; to stay at rest if already at rest.

First-Law Exercise I

A $5\,kg$ mass is hung from the ceiling using a ”massless” rope. What is the magnitude of the tension force exerted by the rope on the mass? **Hint:** A $5\,kg$ mass has a weight of $49\,N$ on earth where this problem is taking place.



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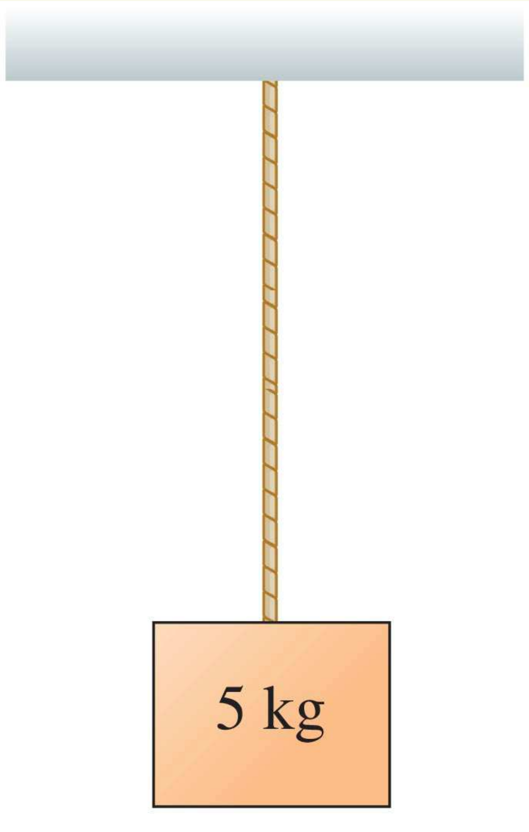

(a) $0\,N$

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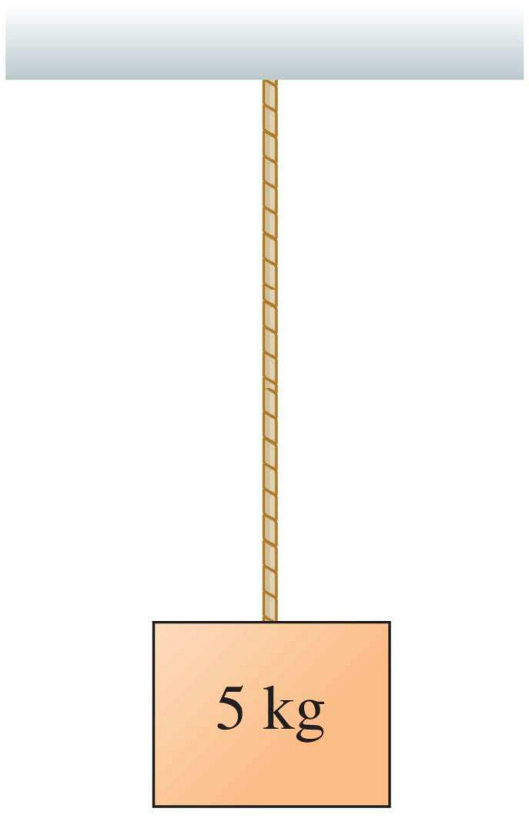

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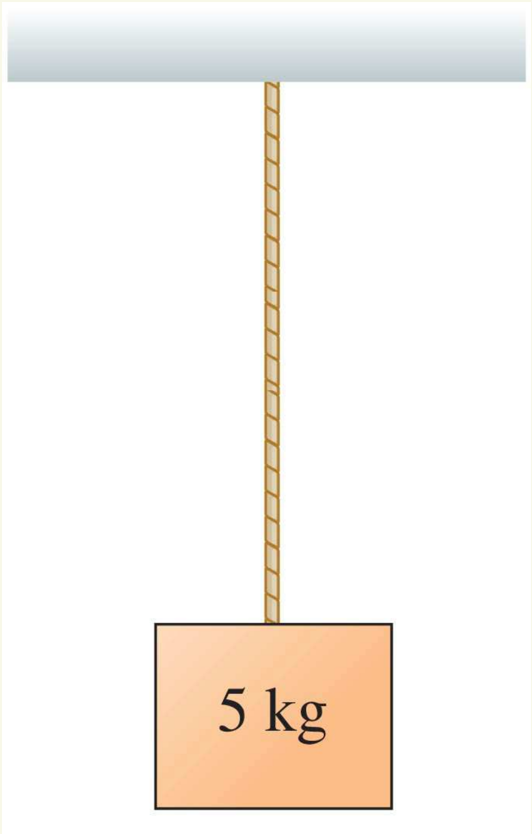

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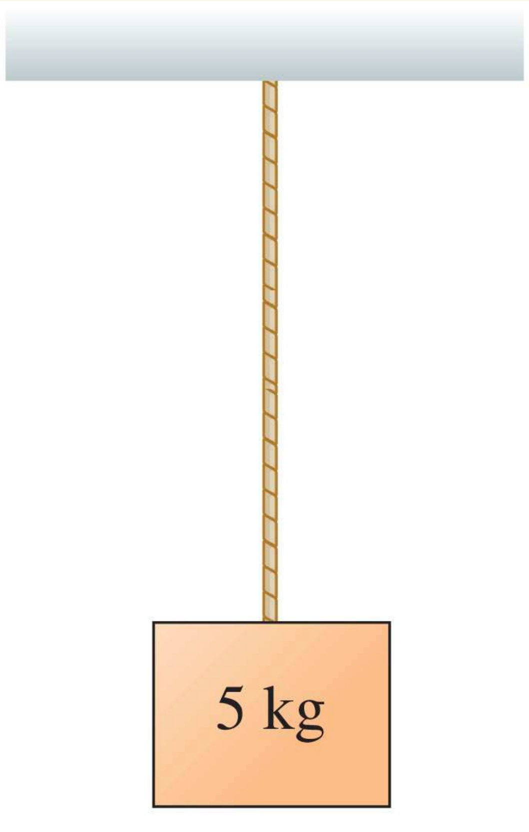

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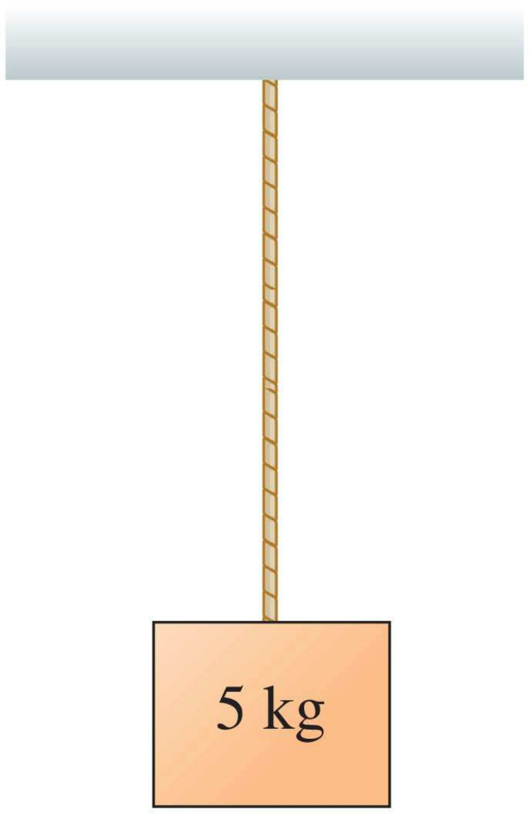

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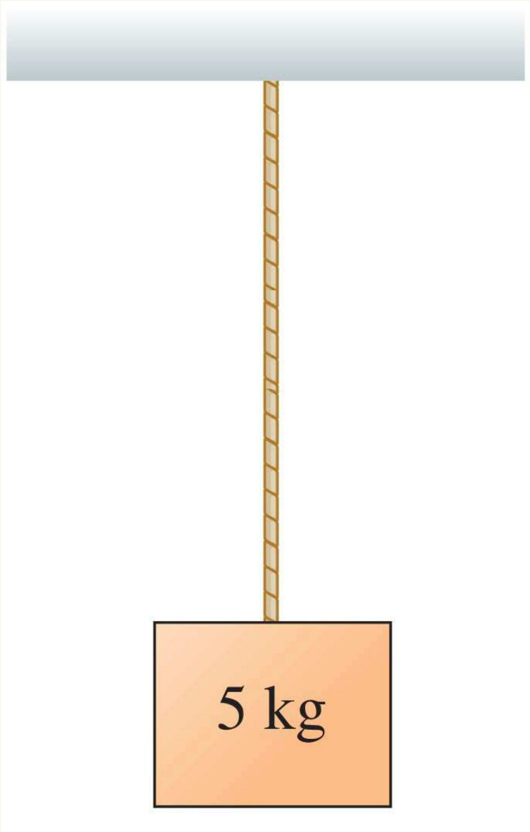

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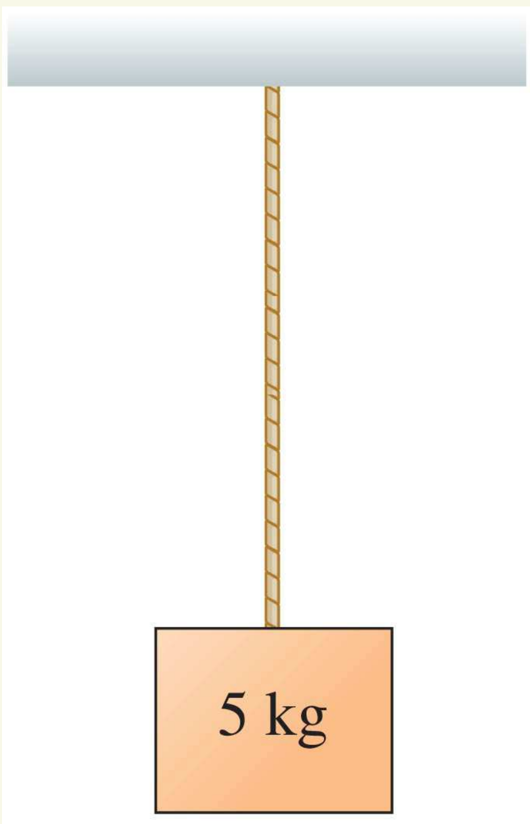

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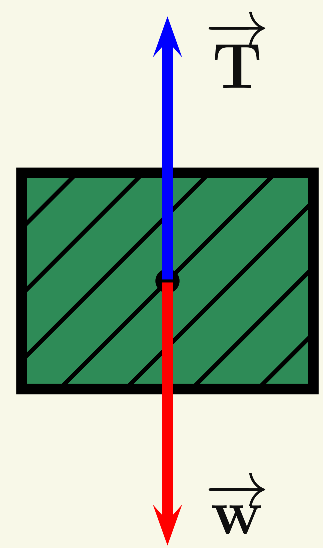

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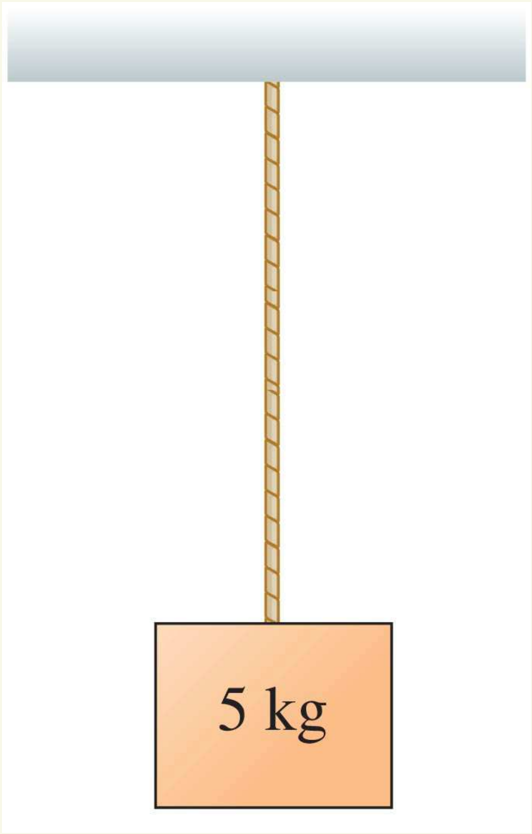
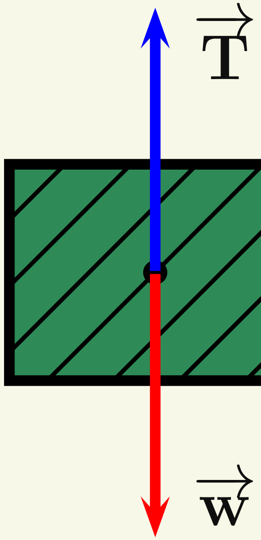


Free-Body Diagram - f.b.d. - sketch of all the *forces* acting on an object using a convenient coordinate system.

(c) $49\,N$



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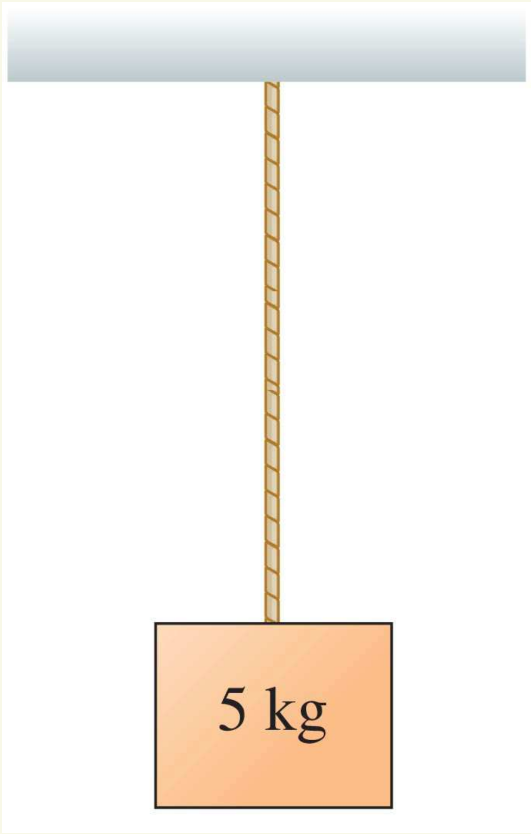

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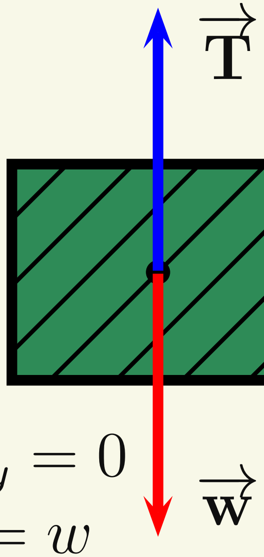

$$\sum F_y = 0 \Rightarrow T_y + w_y = 0$$
$$\Rightarrow T - w = 0 \Rightarrow T = w$$

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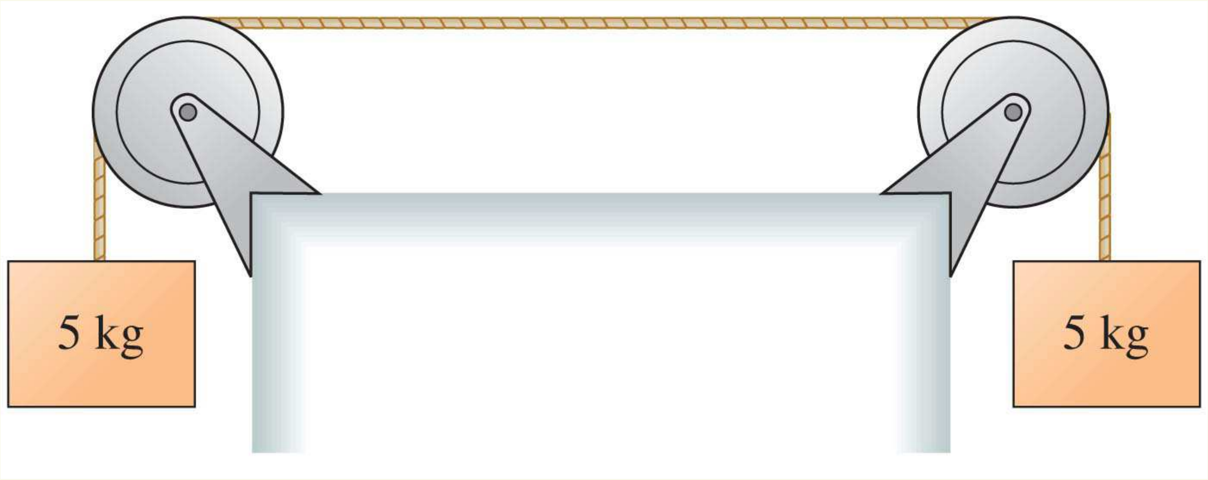
Two $5\,kg$ masses are connected to each over pulleys using a rope. What is the tension force that the rope exerts on the right-hand mass if they are both at rest?



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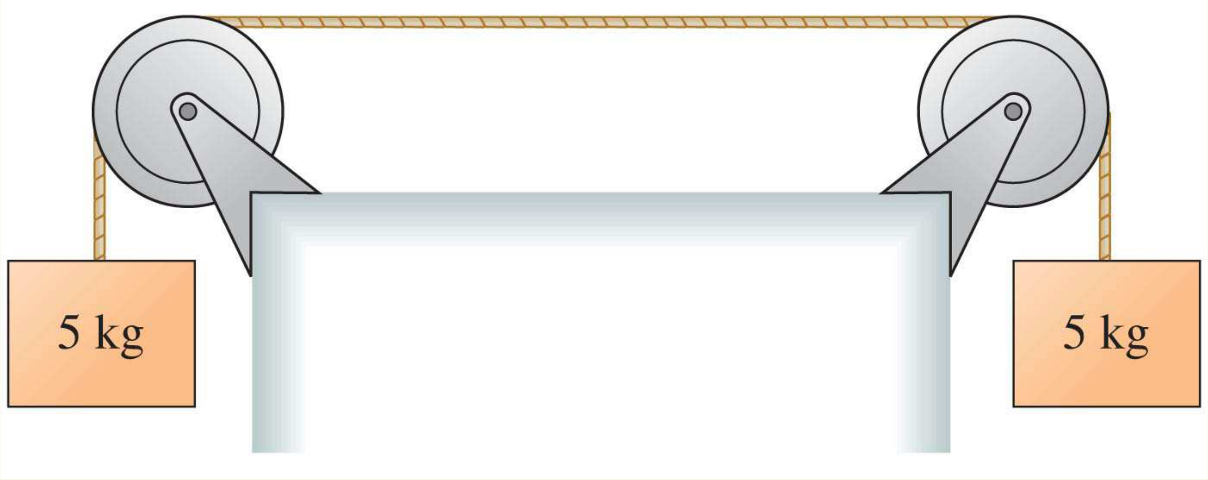

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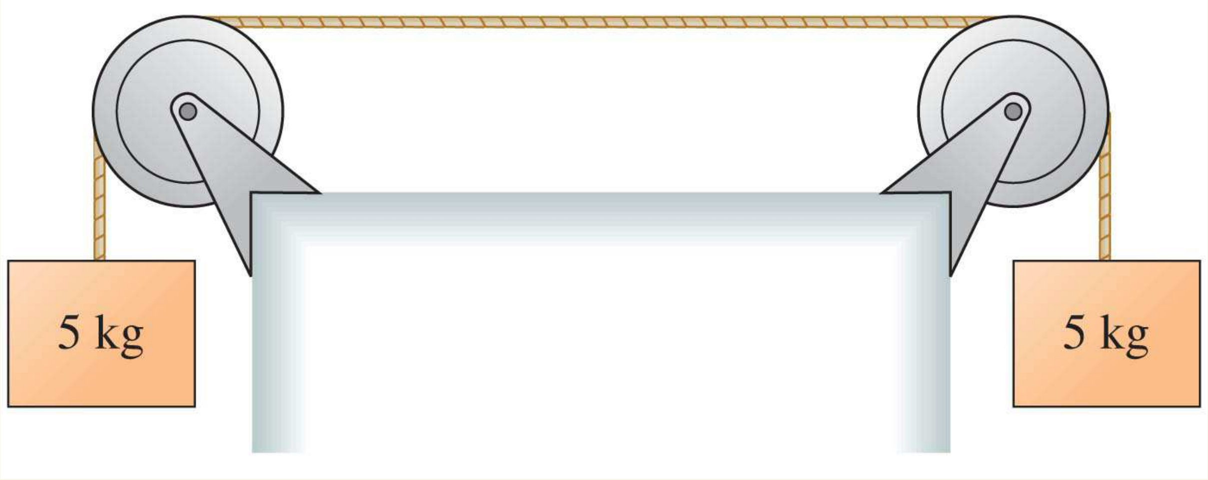

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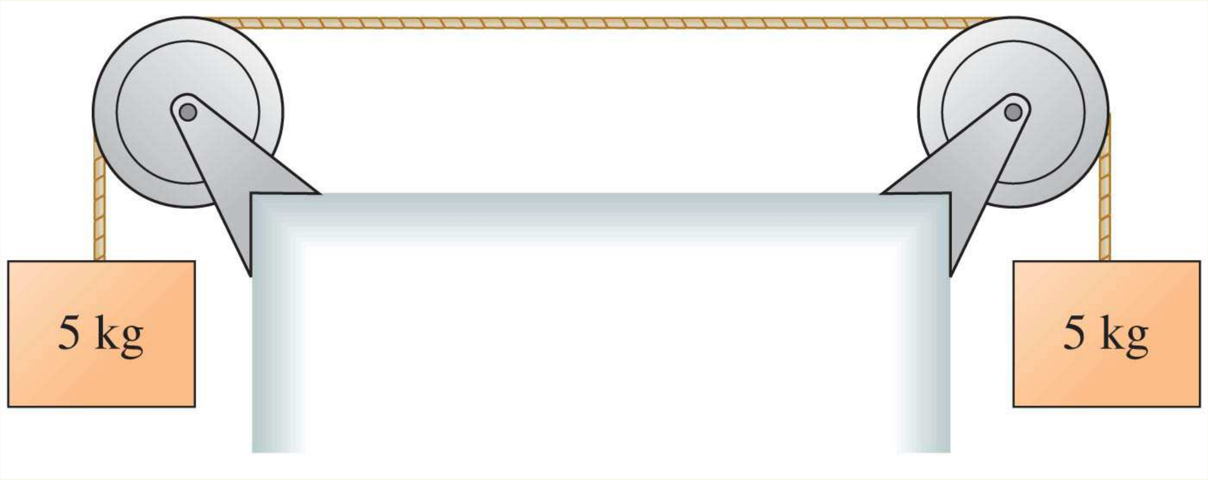

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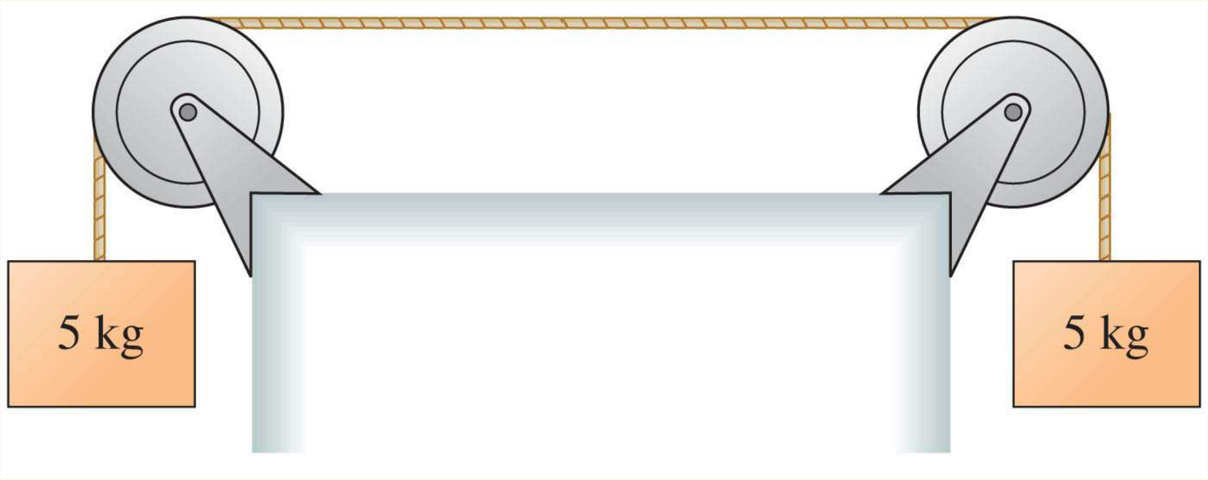

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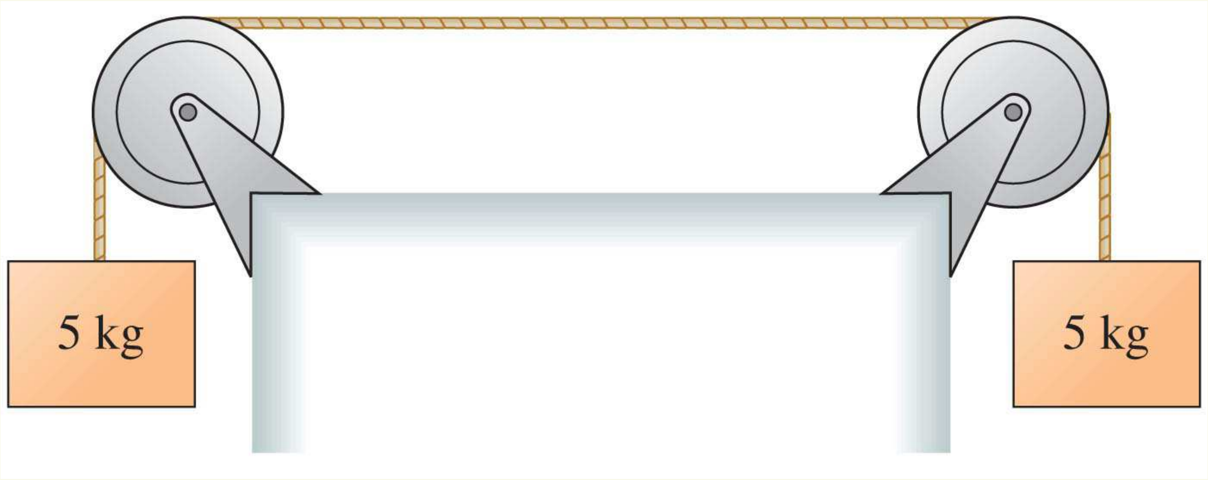

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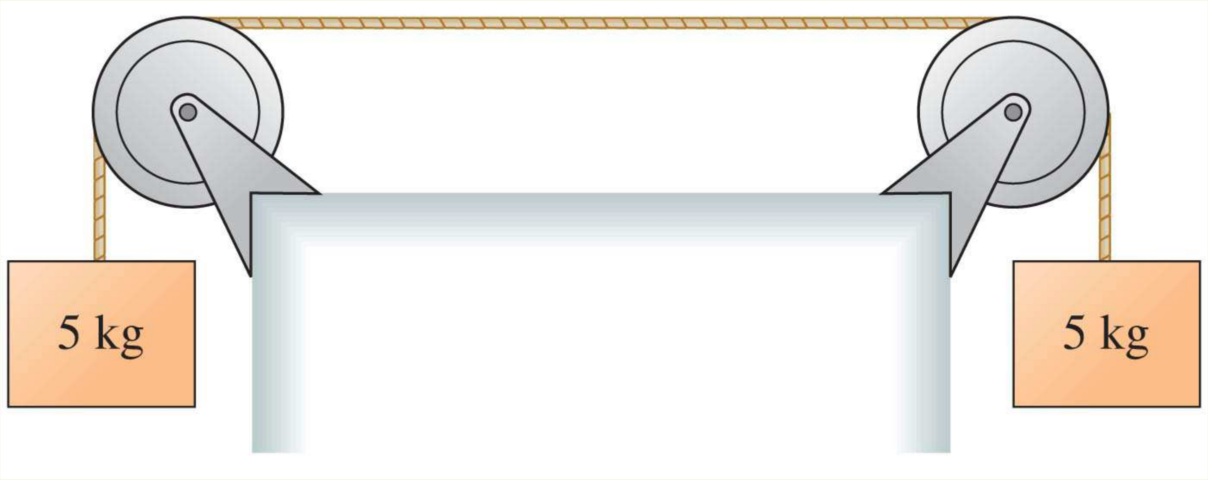

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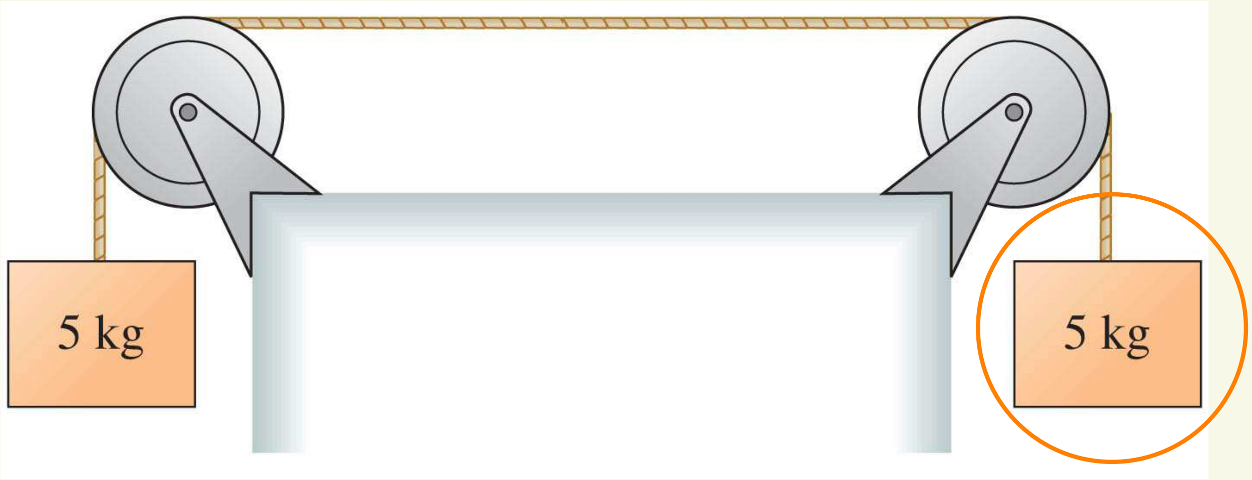

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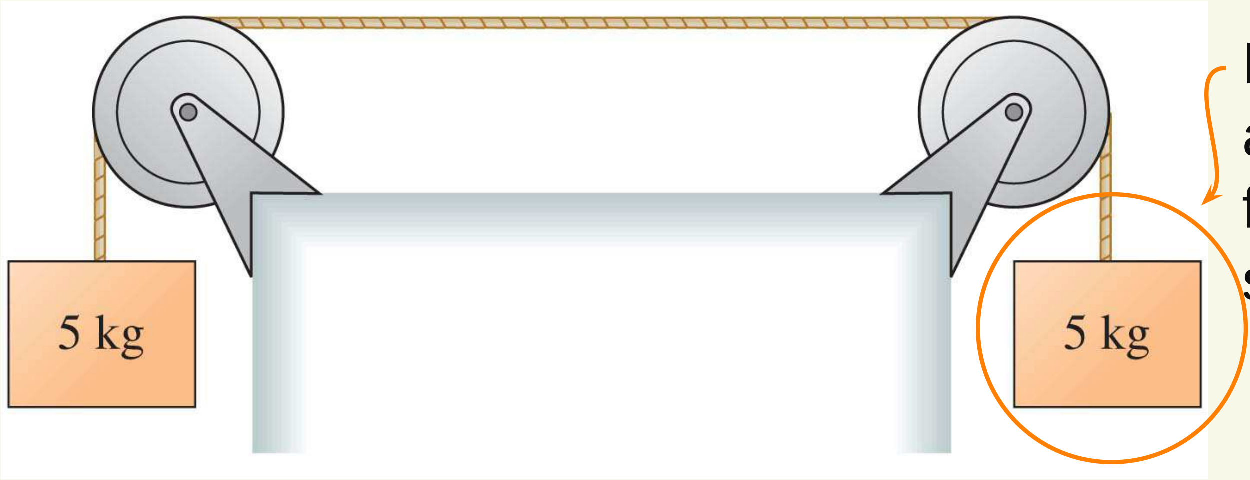

Identify only tension and weight $\Rightarrow$ same f.b.d. as before $\Rightarrow$ same tension.

(a) $0\,N$

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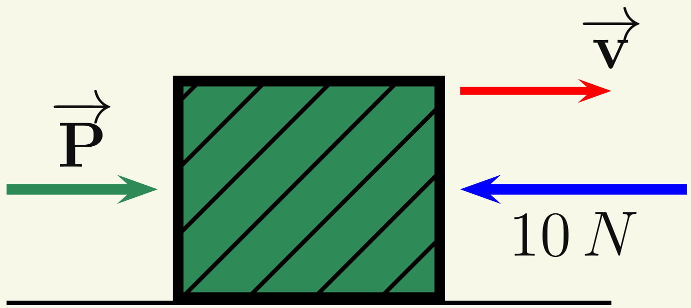
A man pushes a crate across the floor with a constant speed. If there is $10\,N$ of friction acting on the crate, which of the following statements about the man's pushing force, $\overrightarrow{\mathbf{P}}$, is correct?



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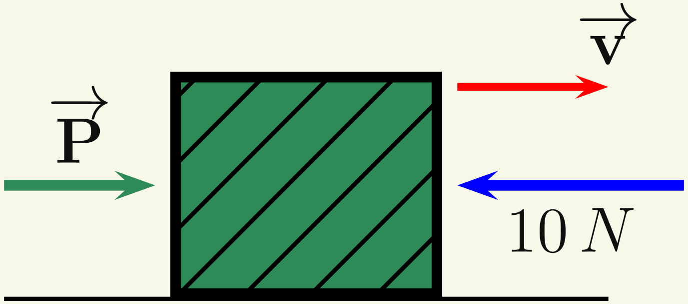

(a) P must be much larger than $10\,N$

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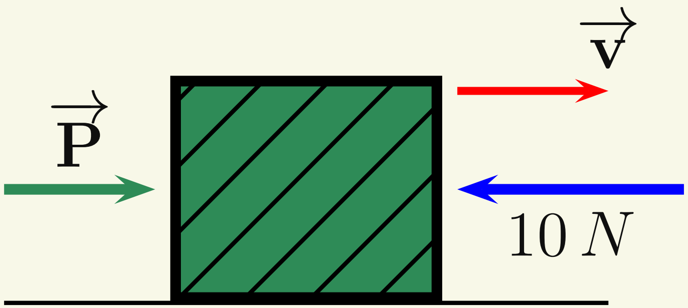

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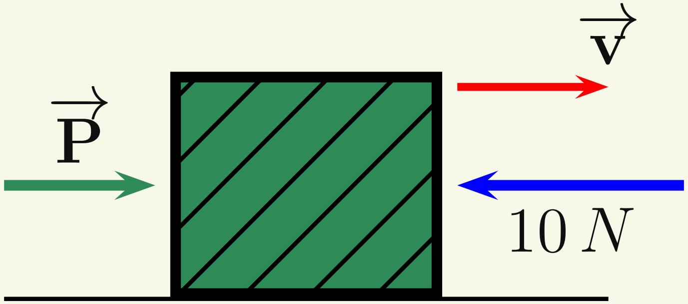

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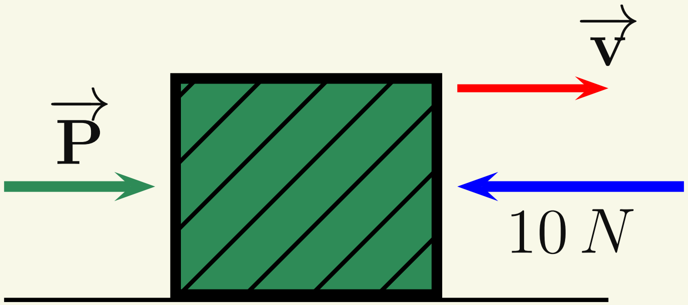

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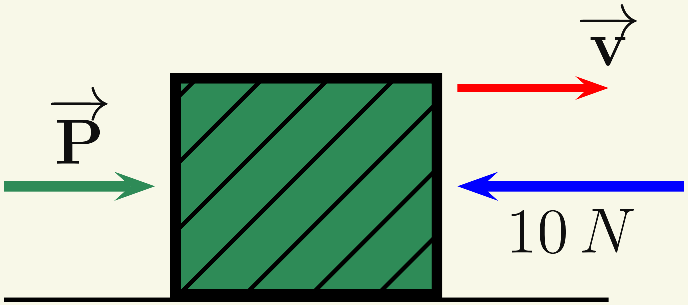

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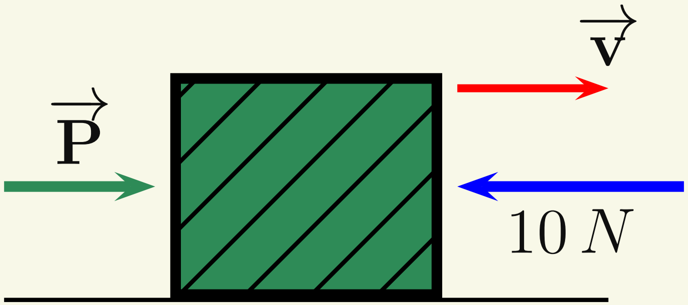

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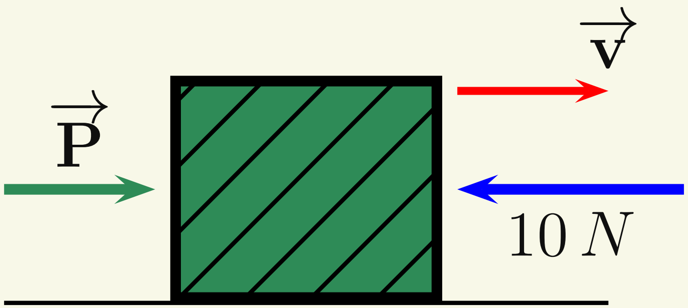

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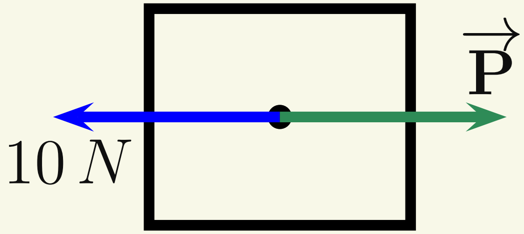

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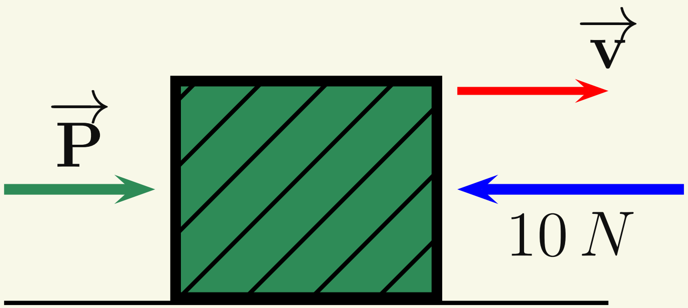

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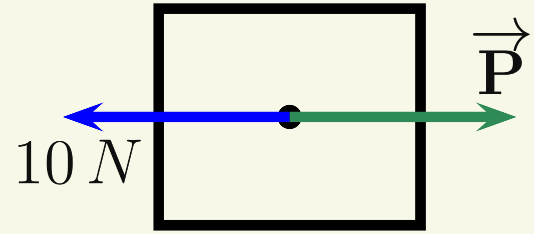

Constant speed $\Rightarrow$ uniform motion

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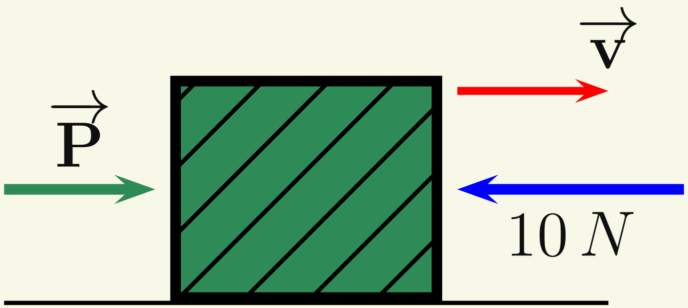

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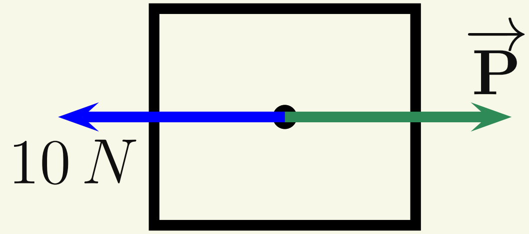

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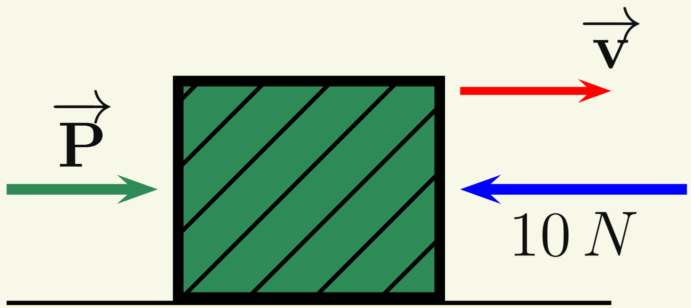

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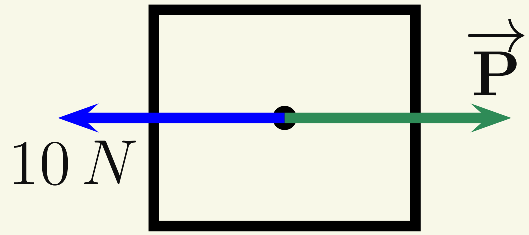

Constant speed $\Rightarrow$ uniform motion $\Rightarrow \sum \vec{\mathbf{F}} = 0$

$$\sum F_x = 0 \Rightarrow P_x + f_{k,x} = 0$$
$$\Rightarrow P - 10\,N = 0 \Rightarrow P = 10\,N$$

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The first law tells us that if $\Sigma\overrightarrow{\mathbf{F}} = 0$ then we have a constant $\overrightarrow{\mathbf{v}}$

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Constant $\overrightarrow{\mathbf{v}} \Rightarrow \overrightarrow{\mathbf{a}} = 0$.

So if $\Sigma\overrightarrow{\mathbf{F}} \neq 0 \Rightarrow$

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Measure of the amount of matter inside an object

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$$\overrightarrow{\mathbf{a}} = \frac{\Sigma \overrightarrow{\mathbf{F}}}{m}$$

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