June 25, Week 4

Today: Chapter 5, Applying Newton's Laws

Homework #4 is now available.

Friction

We use a simplified model of friction that works fairly well for flat, solid objects in contact with each other. In this model, the amount of friction depends on the type of materials and whether they objects are in motion (relative to each other).

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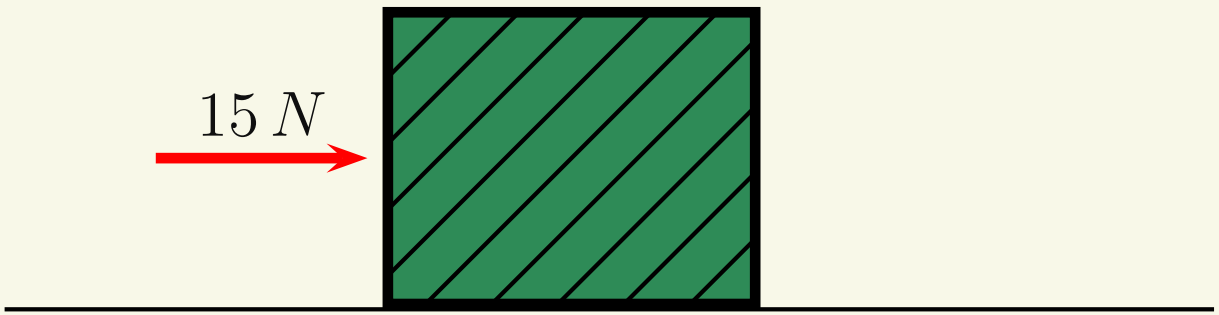
Static Friction - $\overrightarrow{\mathrm{f}}_s$, Force on a stationary object that keeps it at rest.

Static-Friction Exercise I

A 50-N crate is placed on a horizontal surface. A horizontal force of $15\ N$ is applied to the crate. It does not move. How much static friction is acting on the crate?



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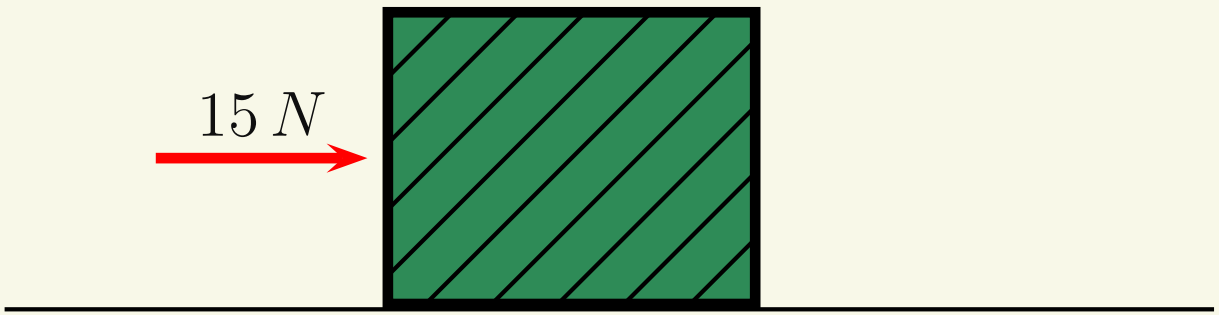

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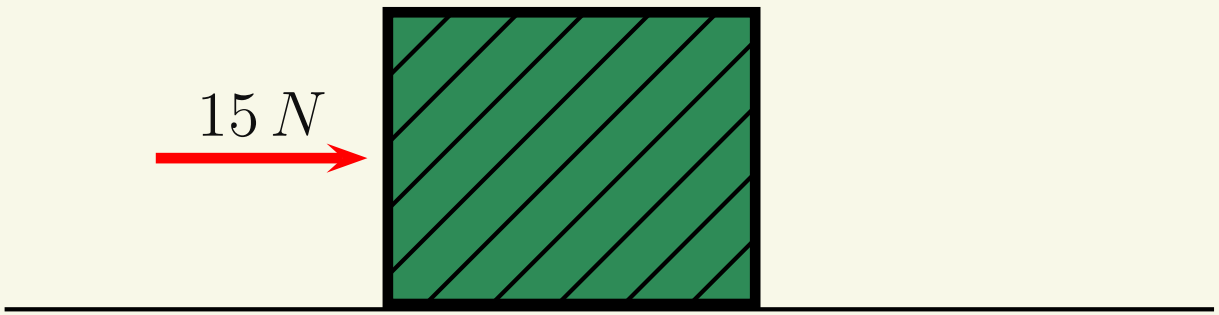

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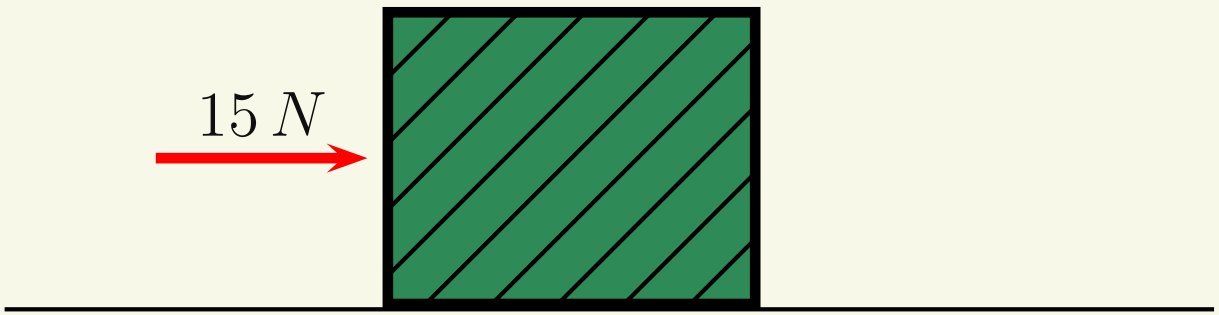

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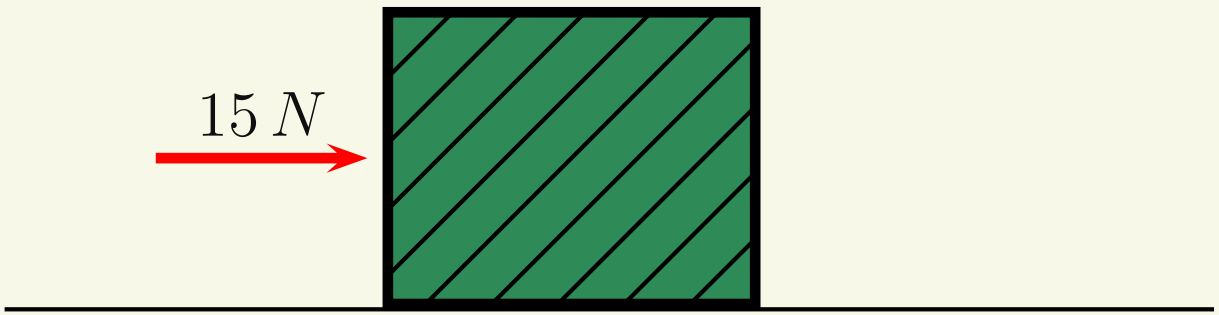

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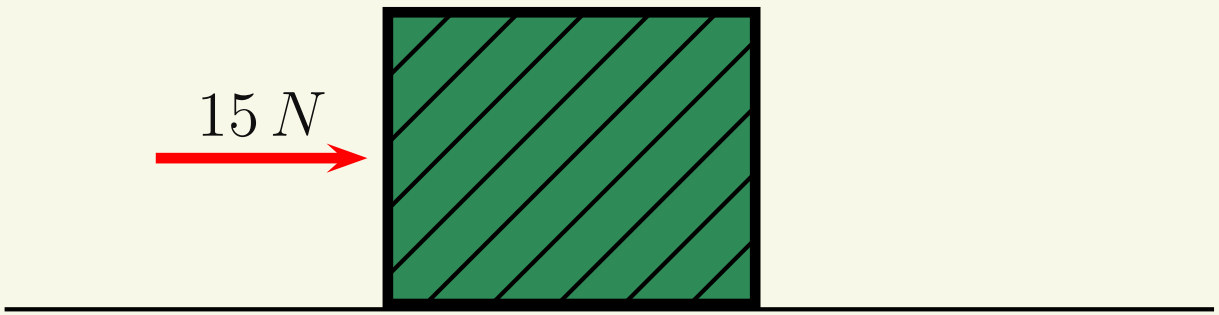

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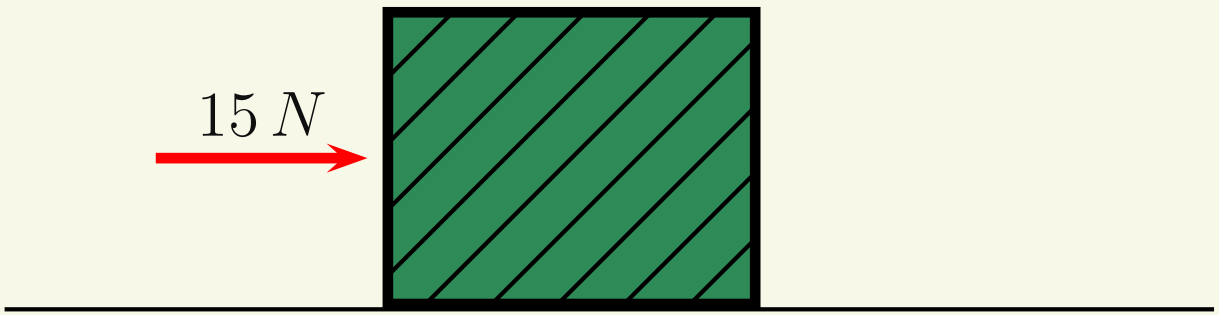

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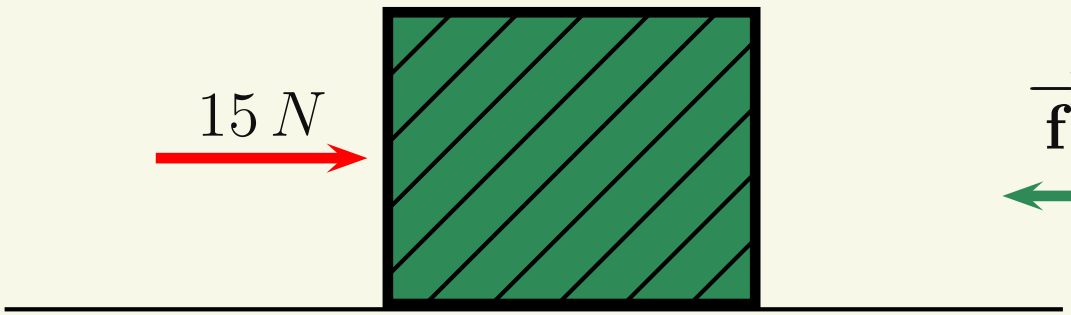

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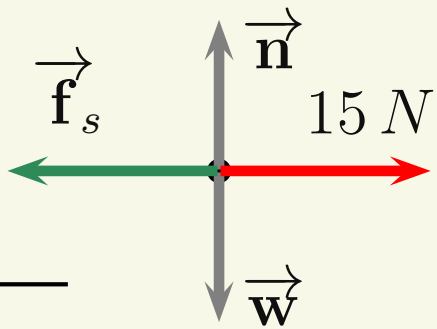

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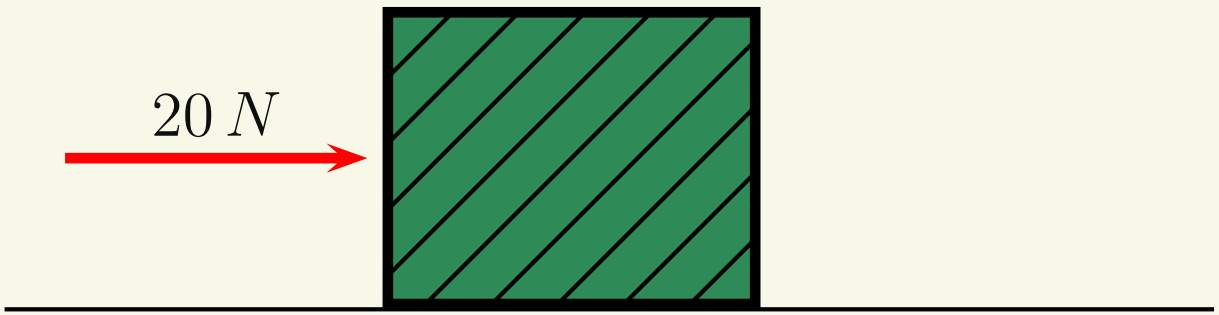

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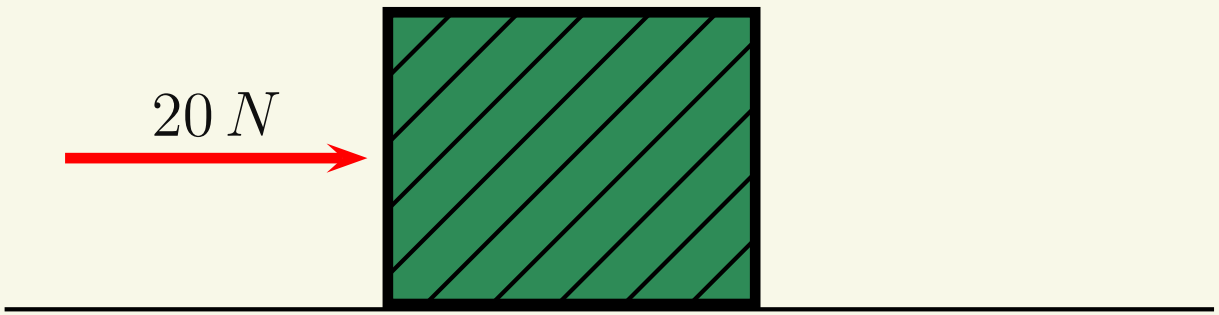

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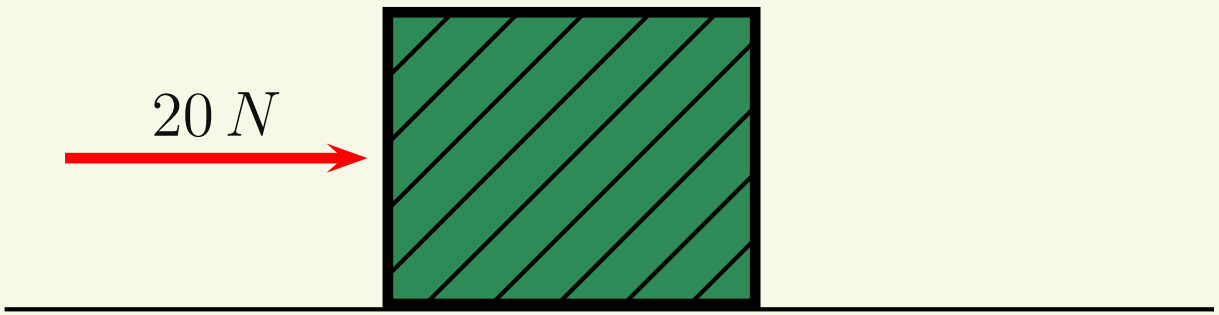

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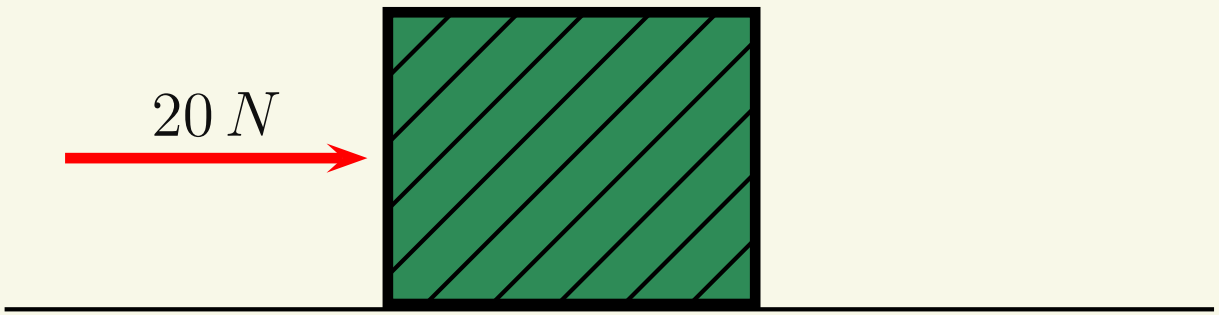

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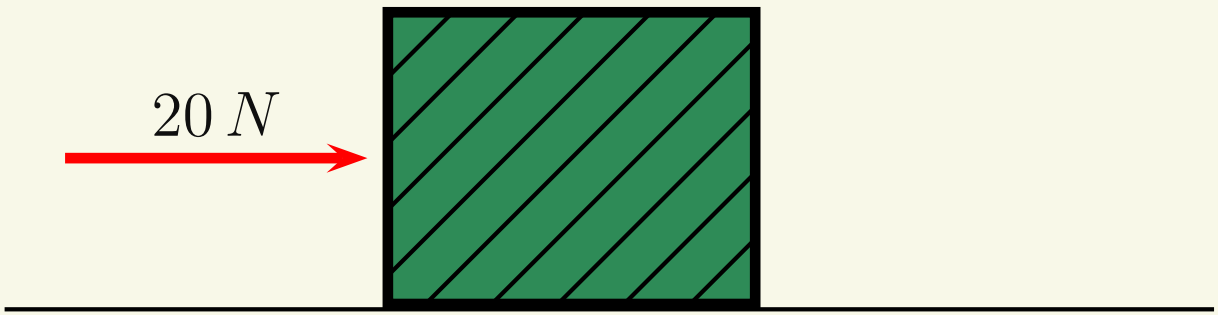

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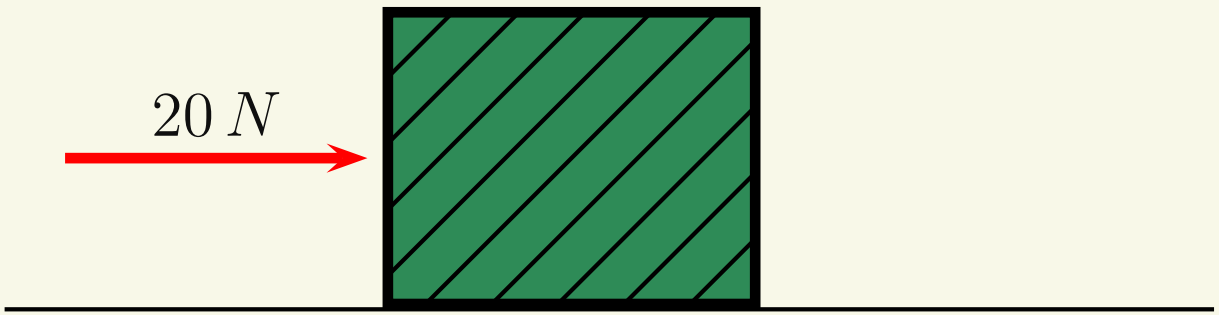

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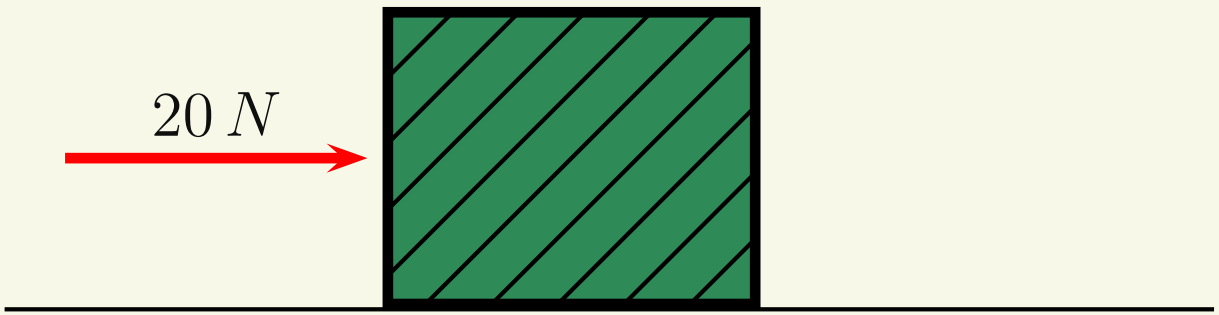

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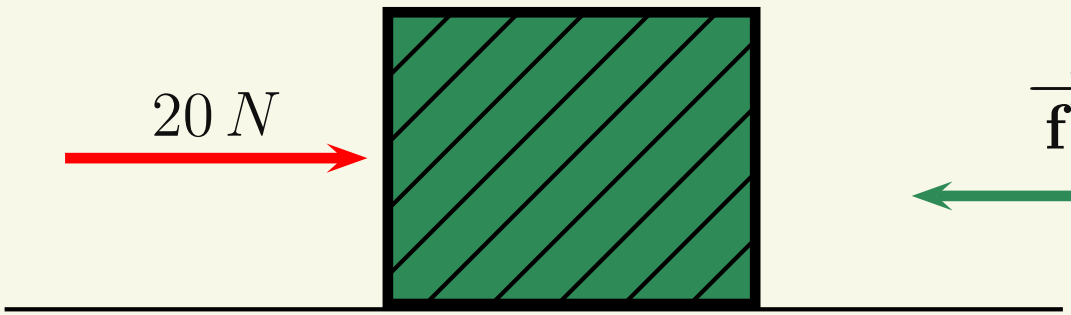

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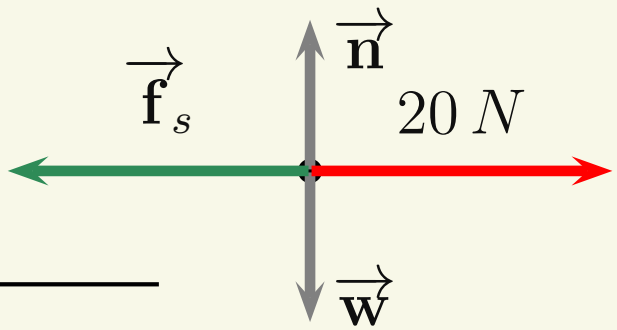

$$\sum F_x = 0 \Rightarrow f_s = 20\ N$$

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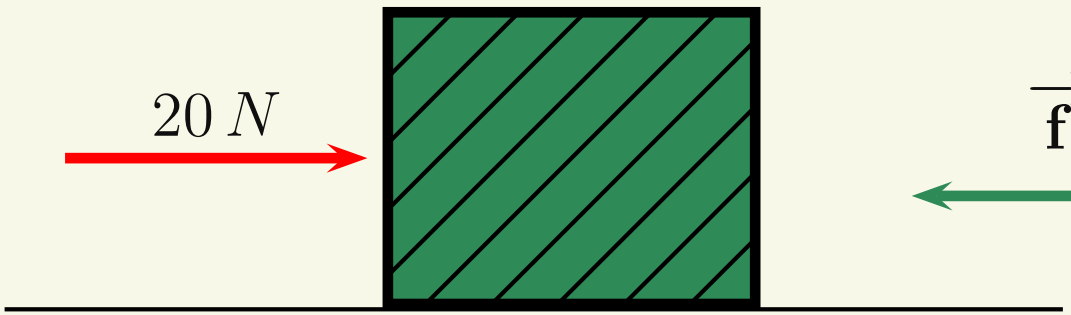

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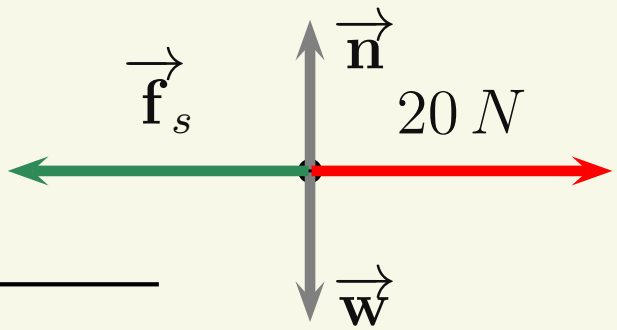

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Static friction can change in magnitude (and direction)!

Maximum Static Friction

The static friction has a maximum value

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TABLE 5.1 Coefficients of friction

Materials	Static μ_s	Kinetic μ_k	Rolling μ_r
Rubber on concrete	1.00	0.80	0.02
Steel on steel (dry)	0.80	0.60	0.002
Steel on steel (lubricated)	0.10	0.05	
Wood on wood	0.50	0.20	
Wood on snow	0.12	0.06	
Ice on ice	0.10	0.03	

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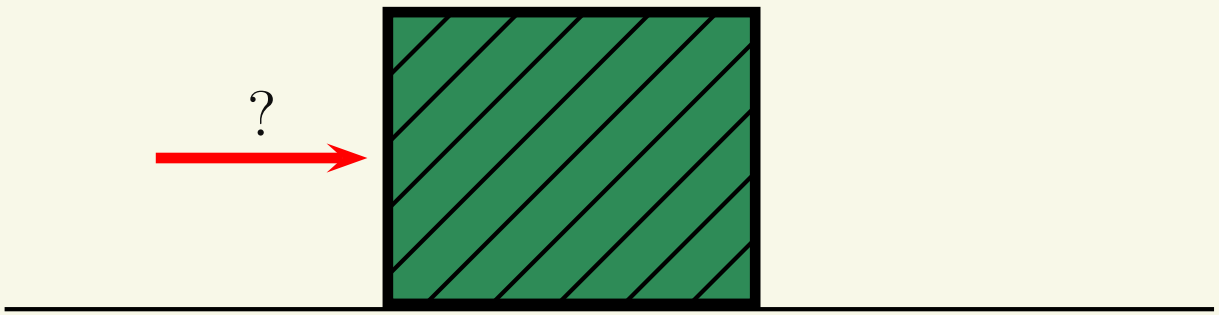

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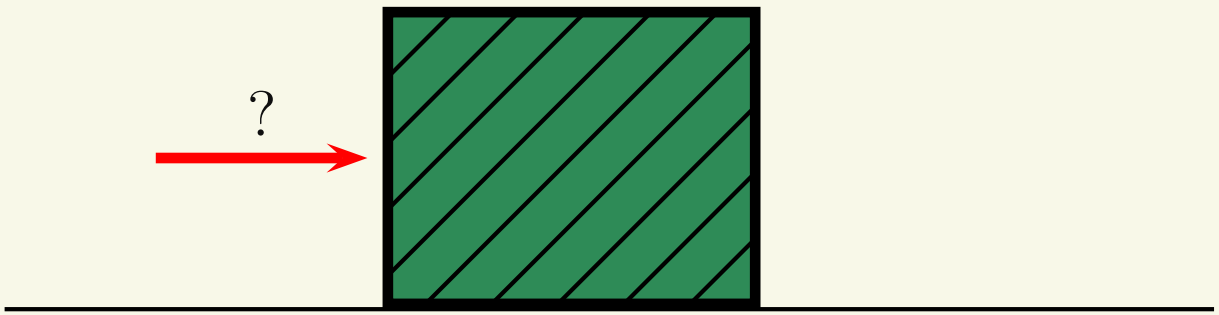

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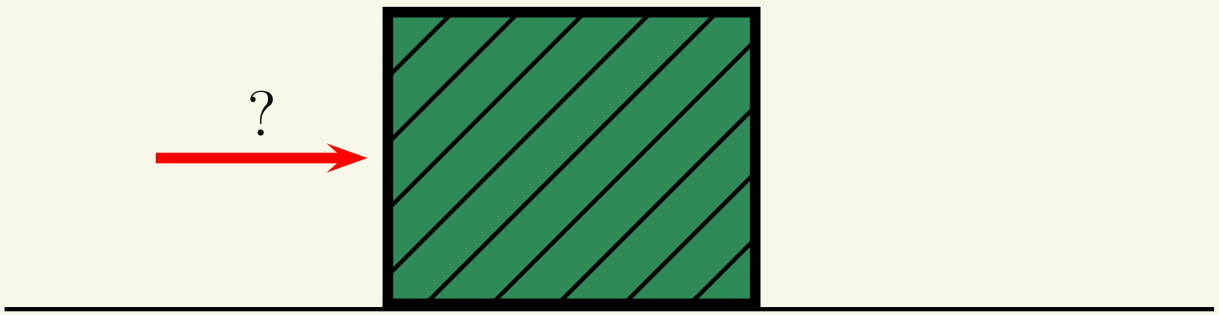

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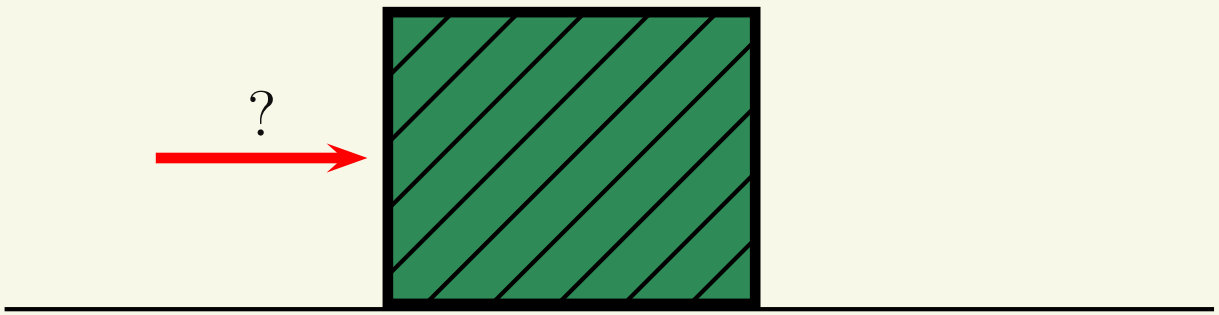

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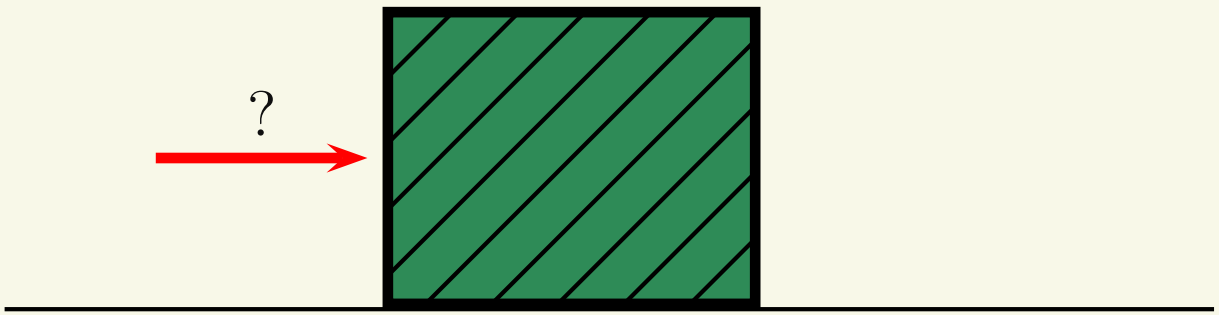

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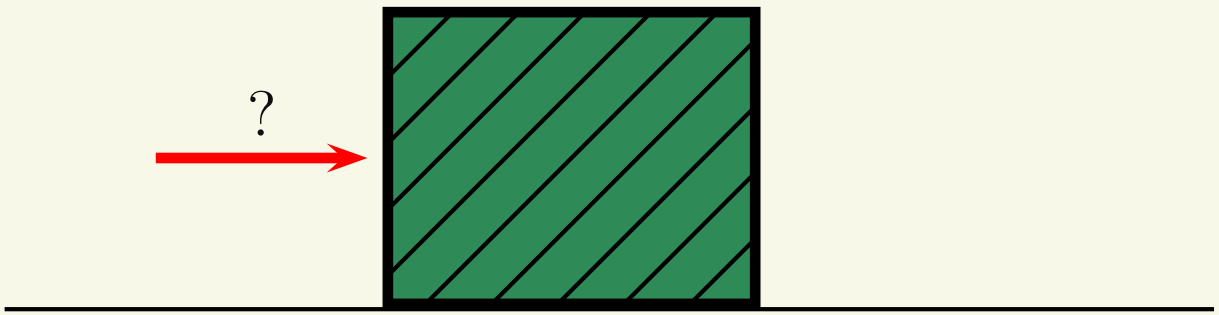

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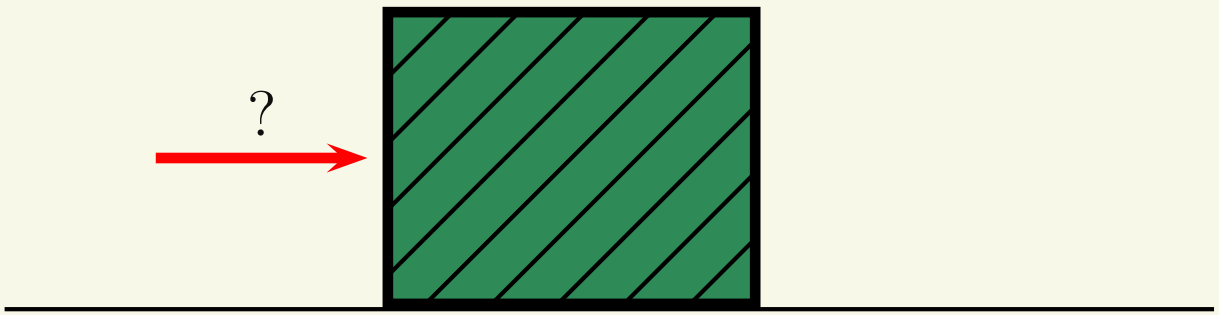

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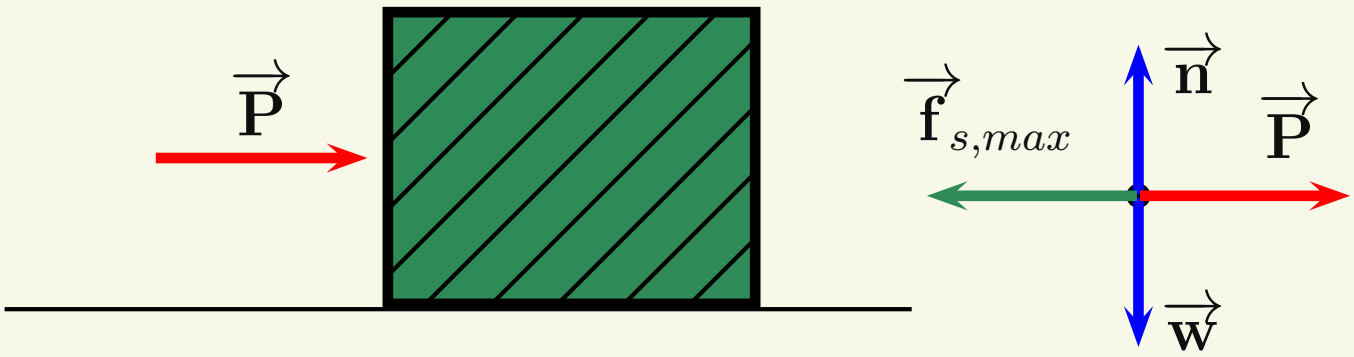

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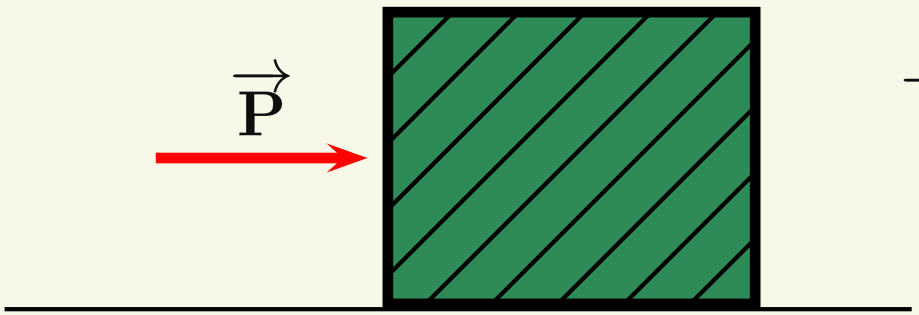

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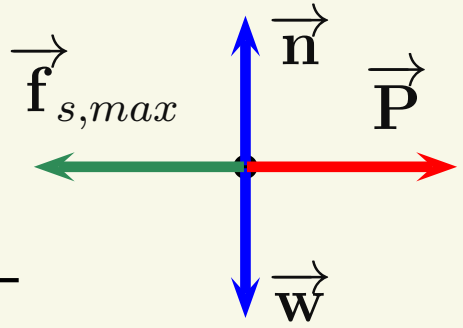

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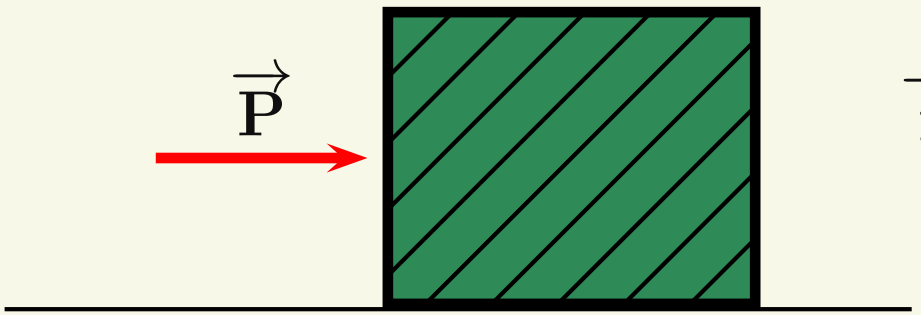

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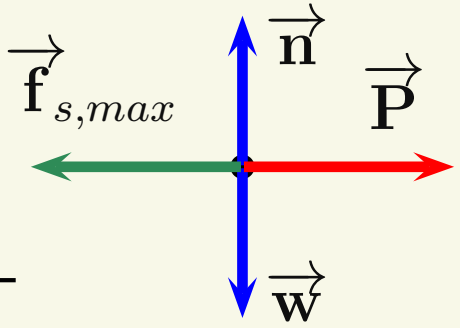

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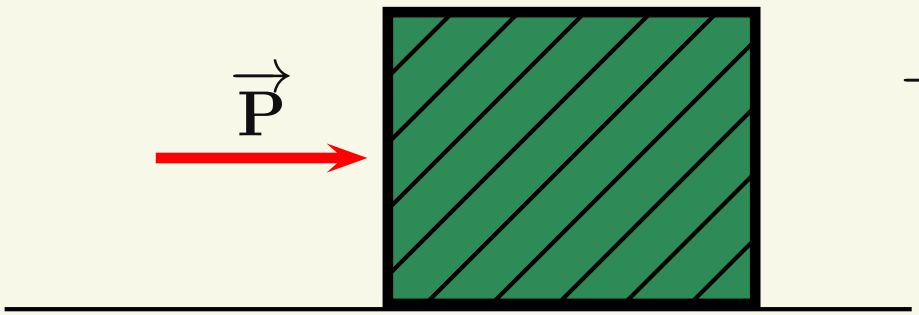

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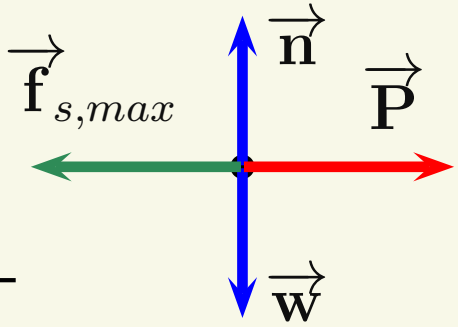

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$$\sum F_x = 0 \Rightarrow$$
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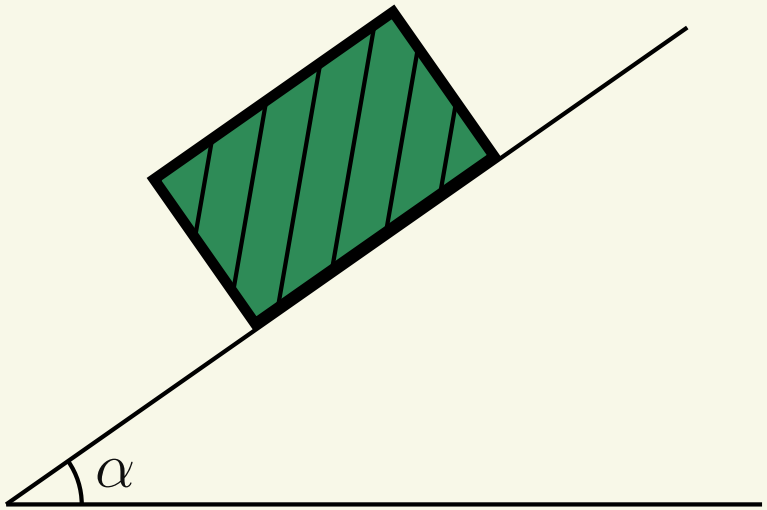

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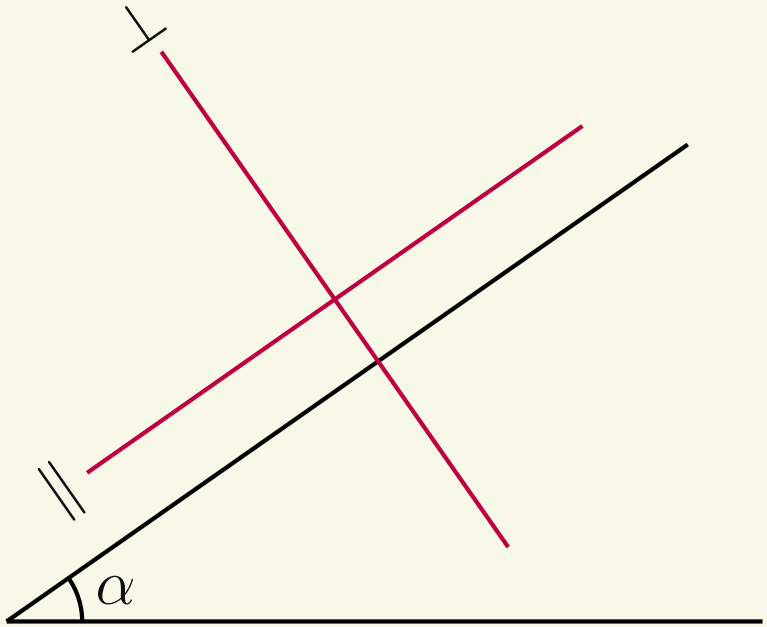

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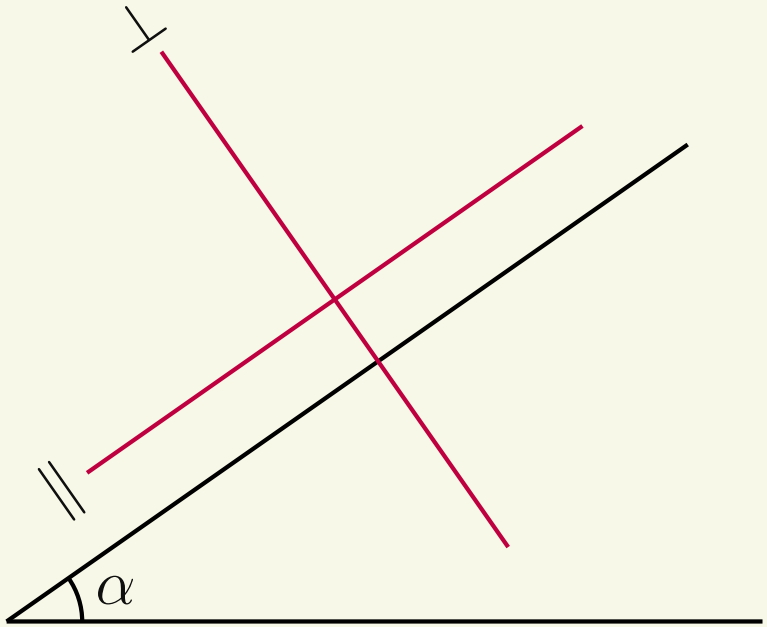

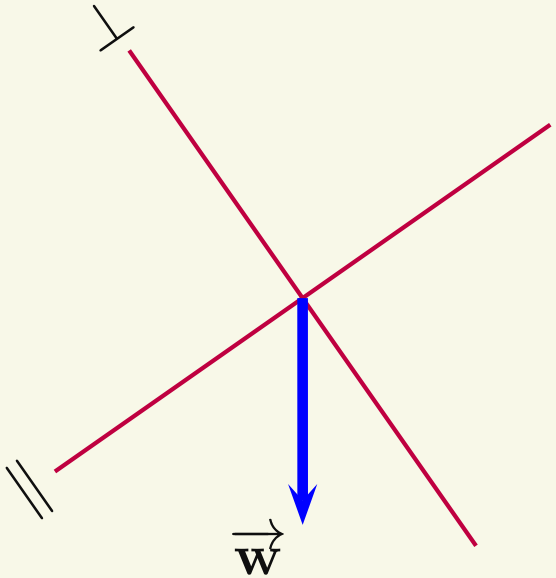

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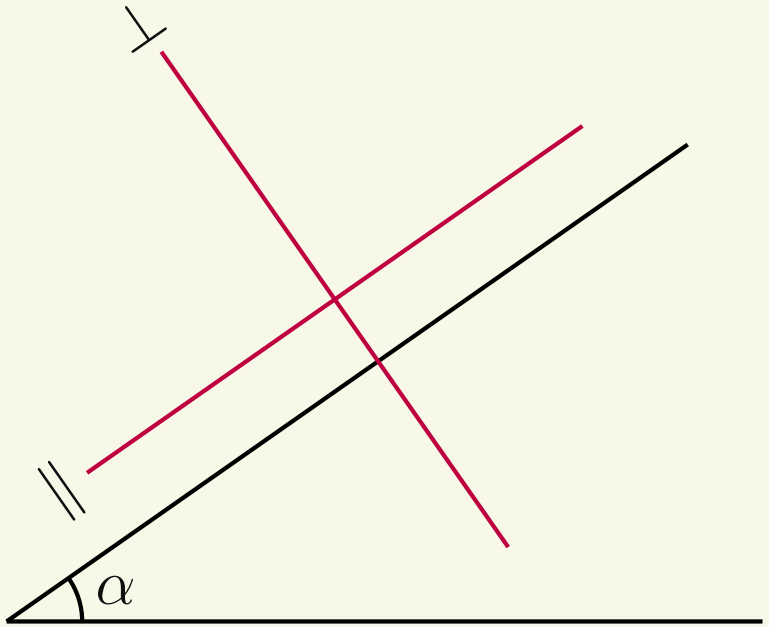

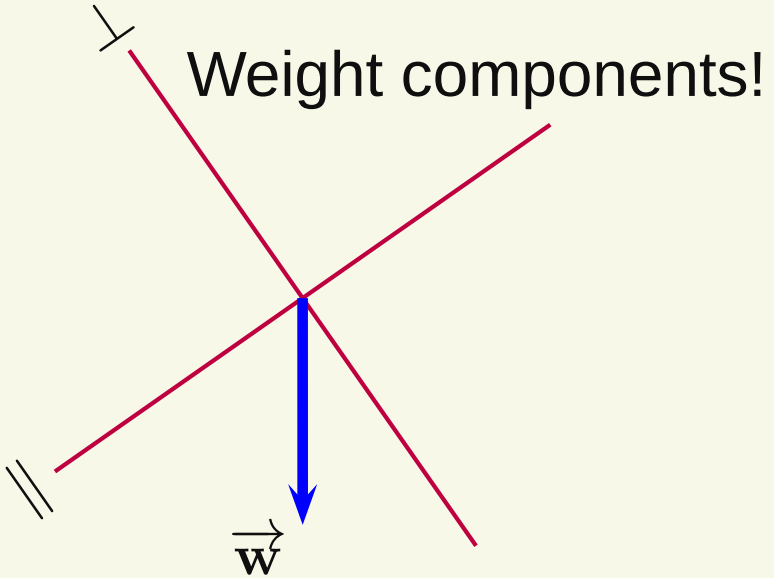

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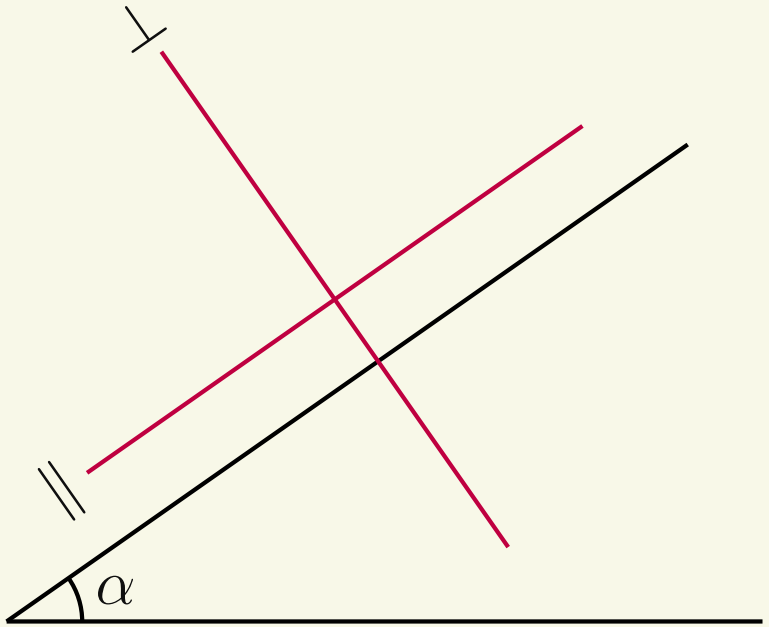

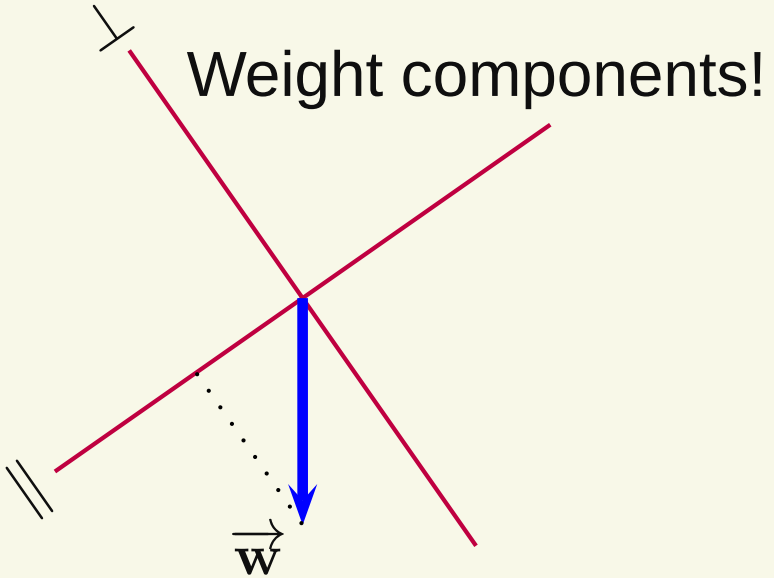

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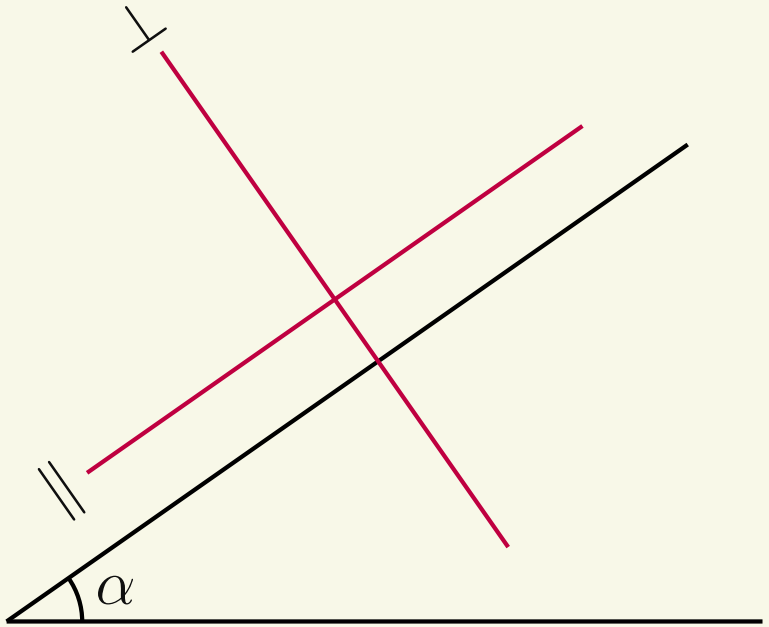

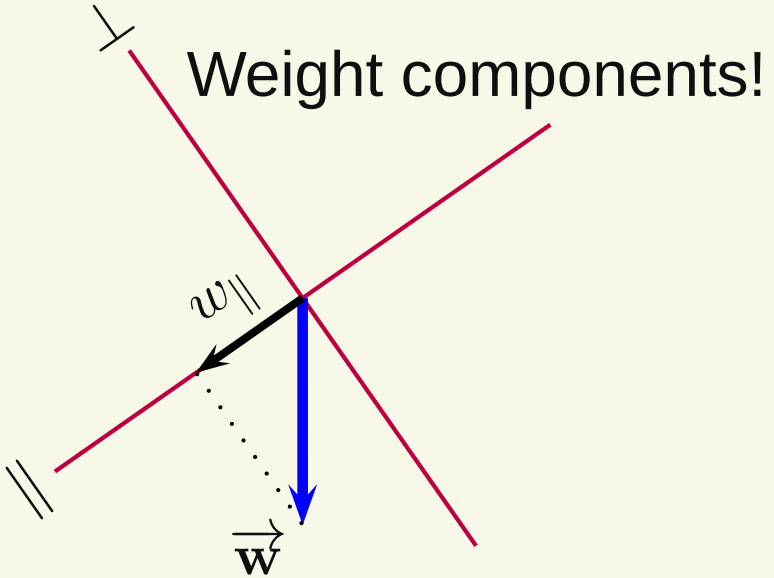

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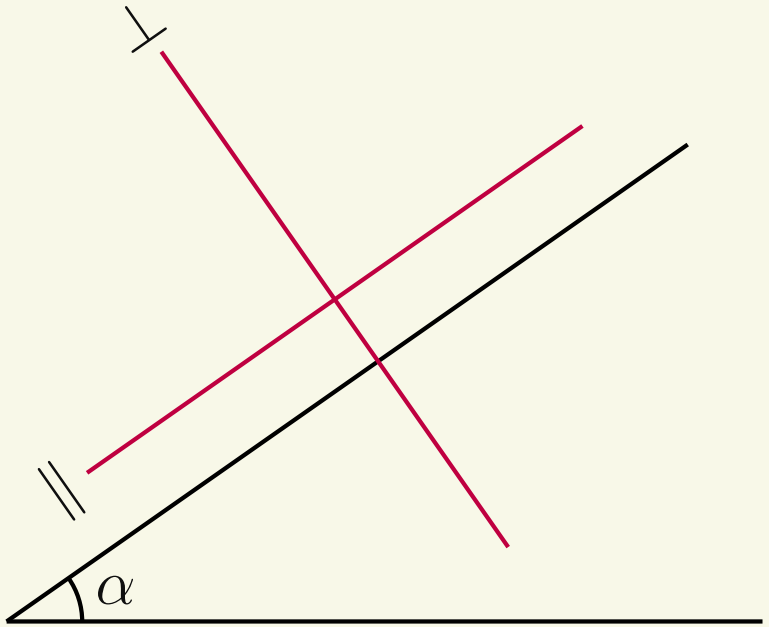

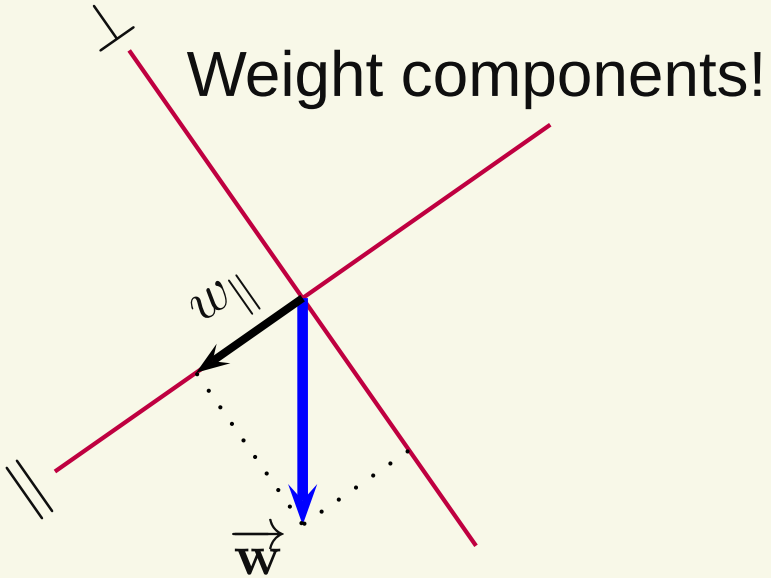

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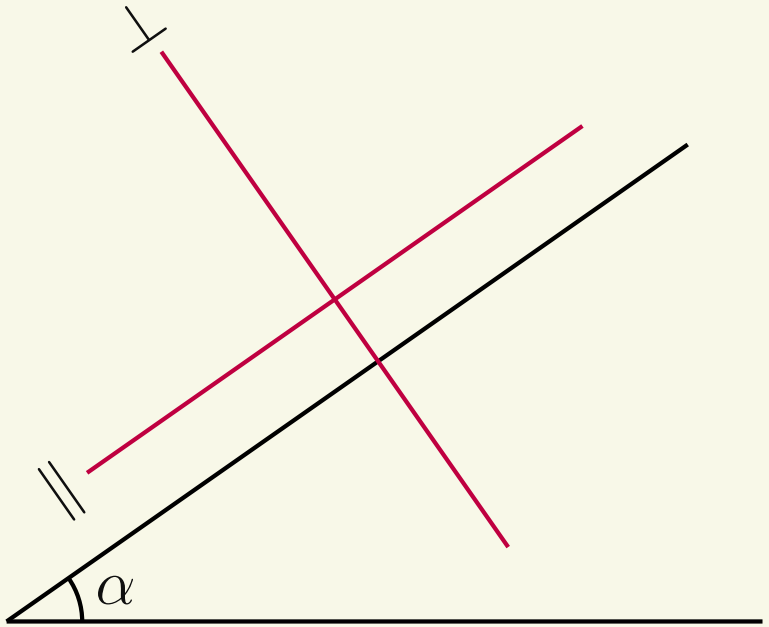

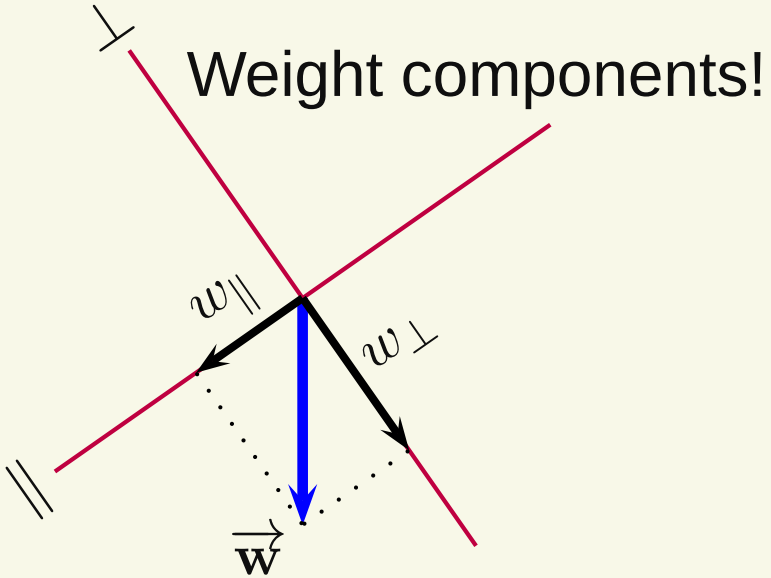

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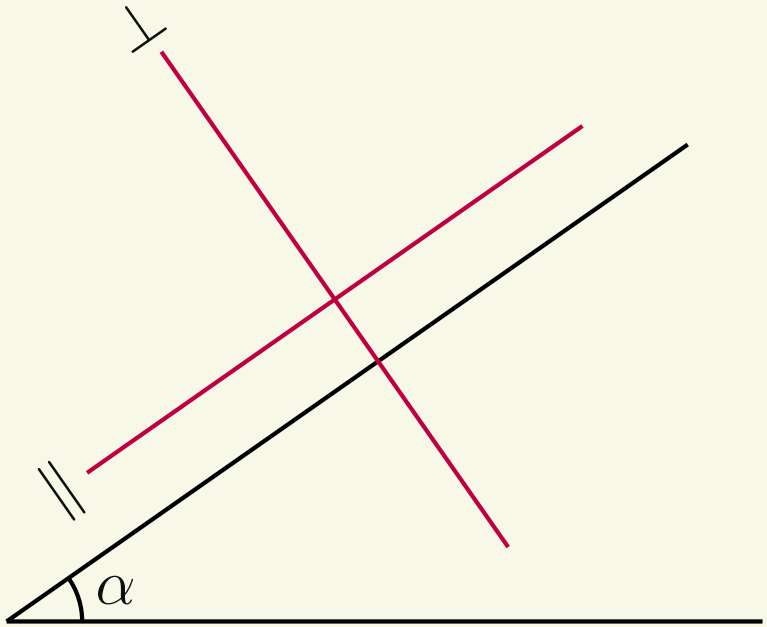

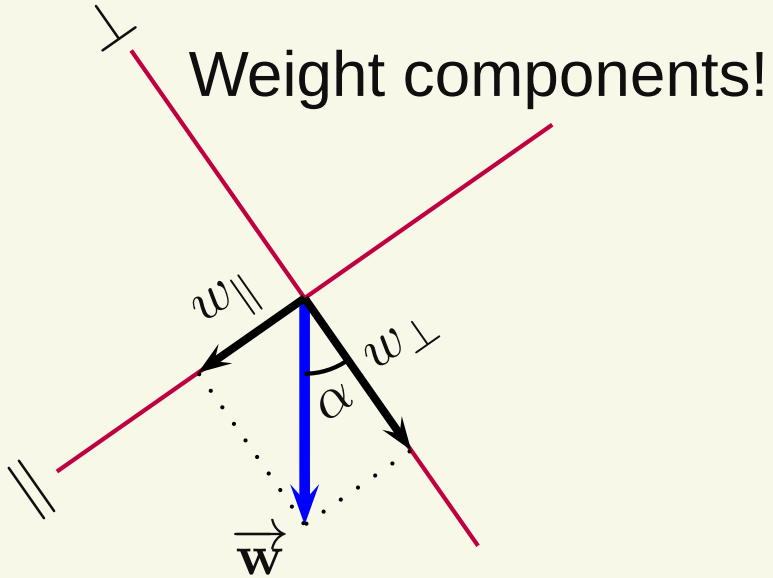

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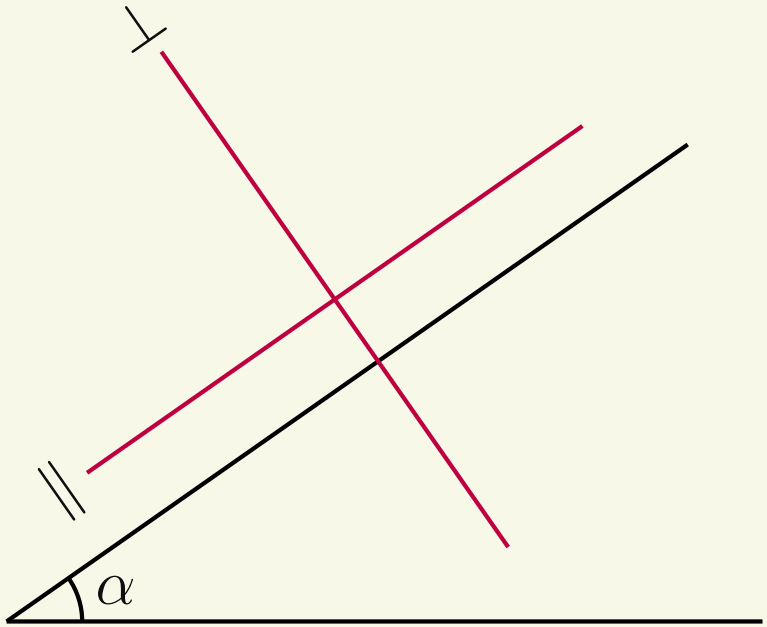

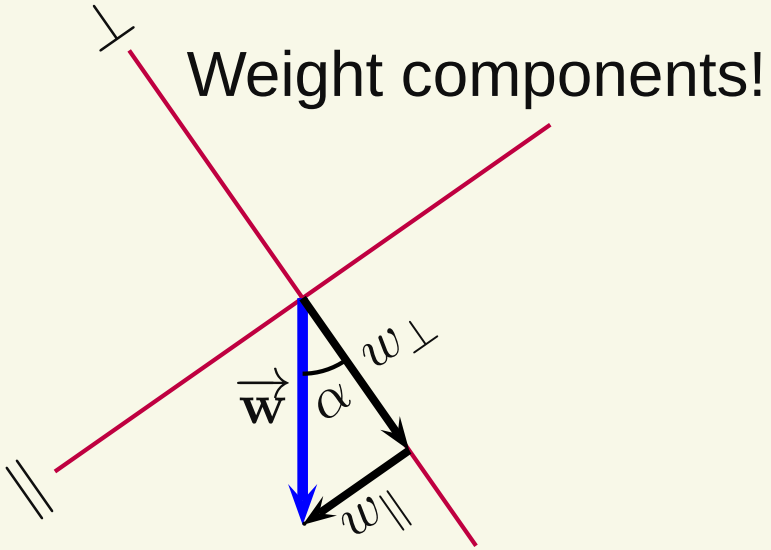

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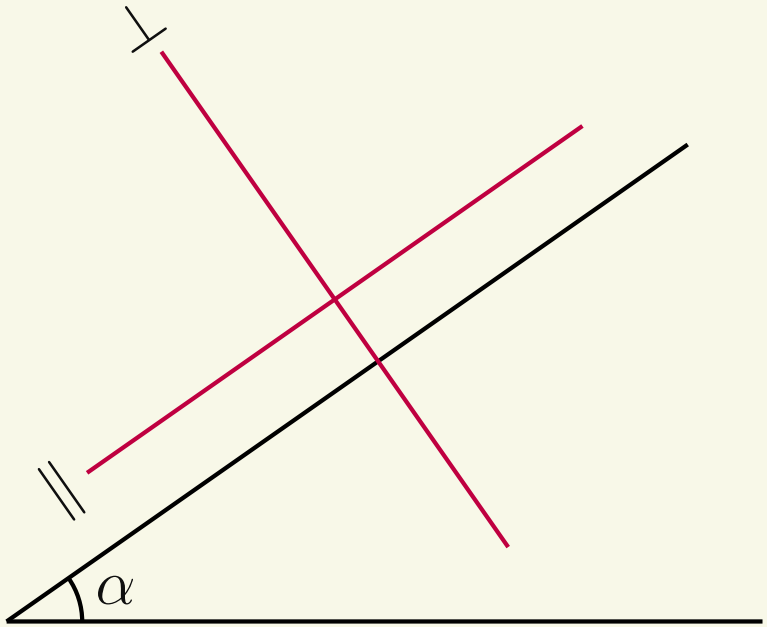

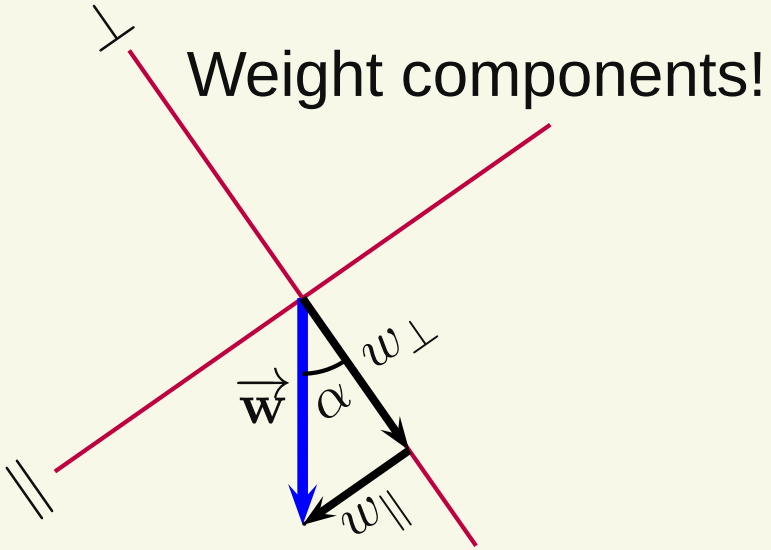

$$w_\parallel = w\sin\alpha = mg\sin\alpha$$
$$w_\perp = w\cos\alpha = mg\cos\alpha$$

Kinetic Friction

Kinetic Friction - $\overrightarrow{\mathbf{f}}_k$, sliding friction.

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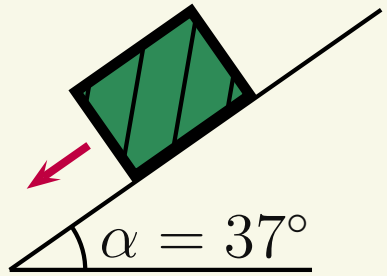
TABLE 5.1 Coefficients of friction

Materials	Static μ_s	Kinetic μ_k	Rolling μ_r
Rubber on concrete	1.00	0.80	0.02
Steel on steel (dry)	0.80	0.60	0.002
Steel on steel (lubricated)	0.10	0.05	
Wood on wood	0.50	0.20	
Wood on snow	0.12	0.06	
Ice on ice	0.10	0.03	

Kinetic Friction Example

A wooden block is sliding down a $37°$ wooden incline. What is its acceleration?



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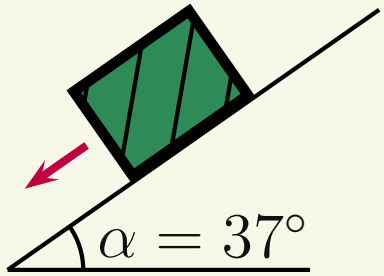

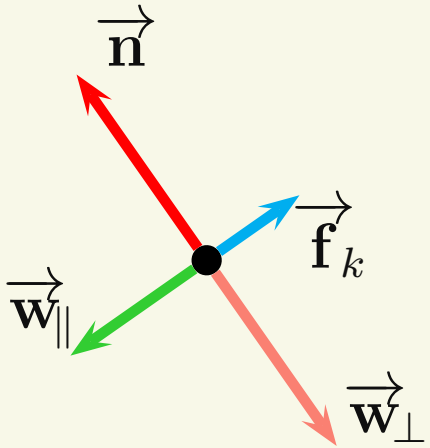

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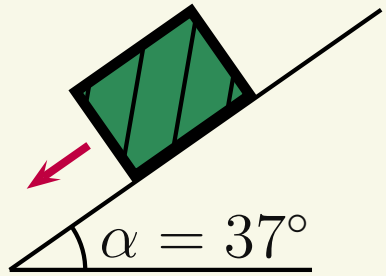
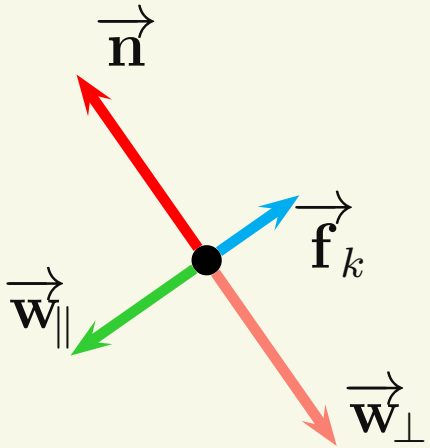


$$a = g\left(\sin\alpha - \mu_k \cos\alpha\right) = 4.33\, m/s^2$$



$$\sum F_{\perp} = ma_{\perp} \Rightarrow n - w_{\perp} = 0$$

$$\Rightarrow n = w_{\perp} = mg\cos\alpha$$

$$\sum F_{\parallel} = ma_{\perp} \Rightarrow w_{\parallel} - f_k = Ma$$

$$\Rightarrow mg\sin\alpha - \mu_k mg\cos\alpha = ma$$