March 4, Week 8

Today: Chapter 6, Work

Exam #2, Friday, March 8

Practice Exam on Website

Review Session, Thursday, March 7, 5:15pm Room 114 Regener Hall

If interested in Physics 110, come talk to me

Beyond Newton’s Laws

While Newton’s Laws are *a* way to explain motion, they are not always the easiest or most intuitive way.

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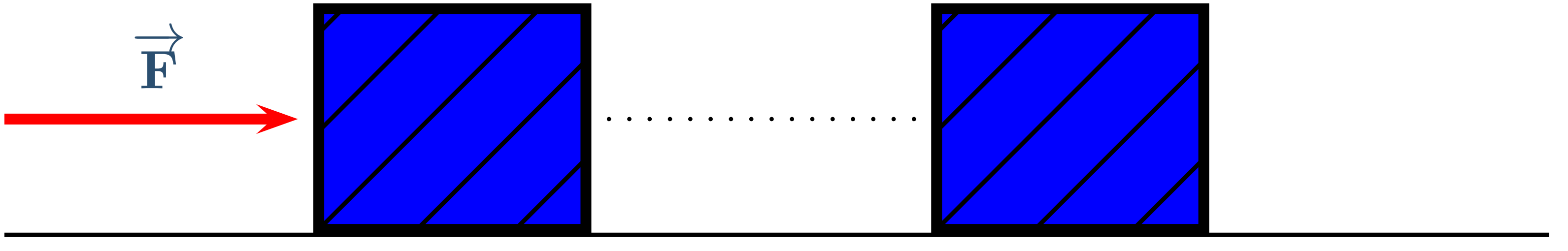

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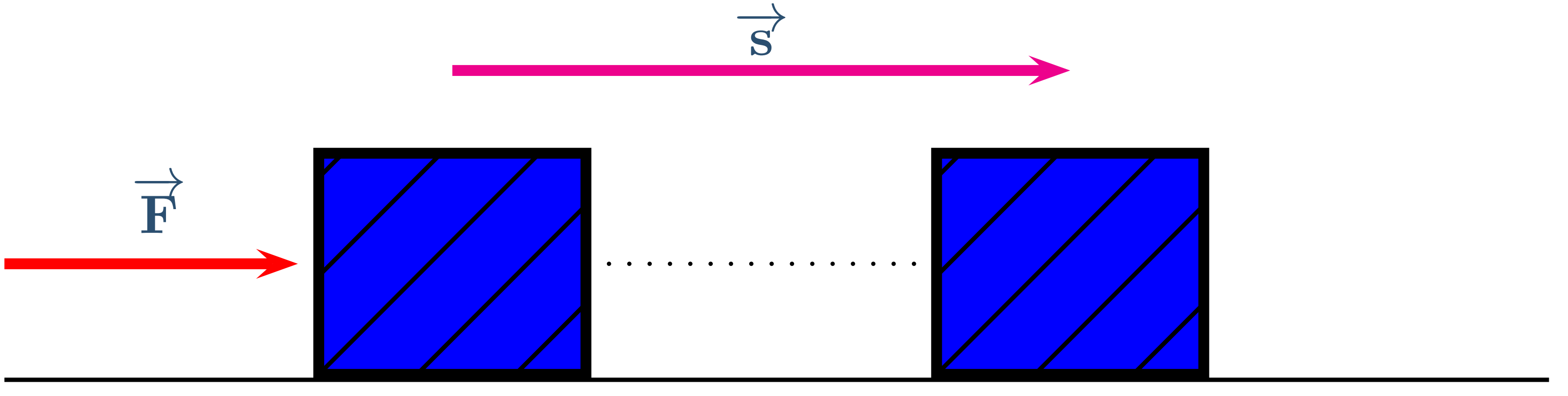

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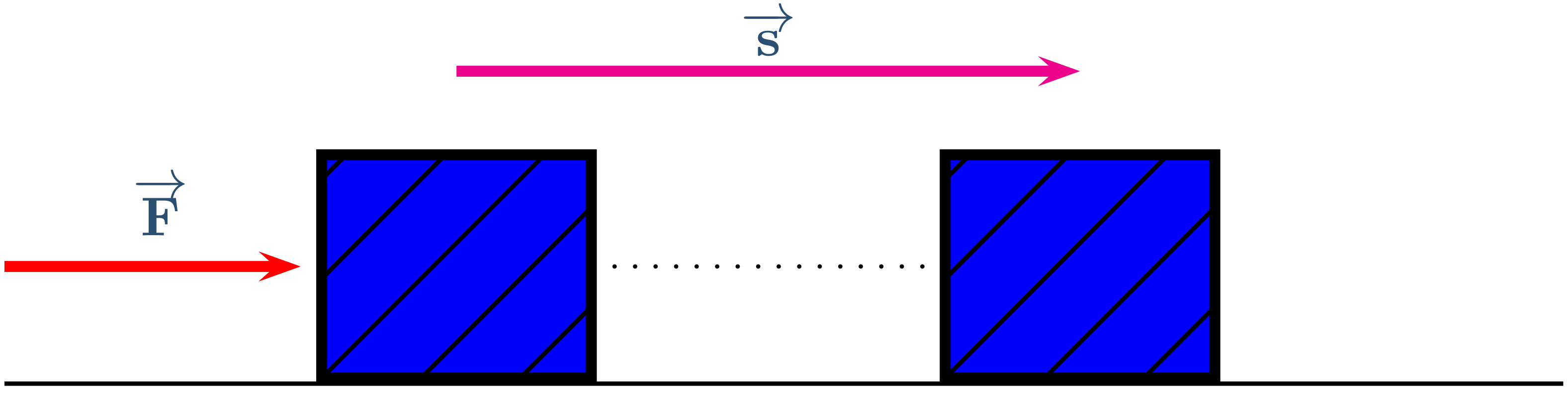

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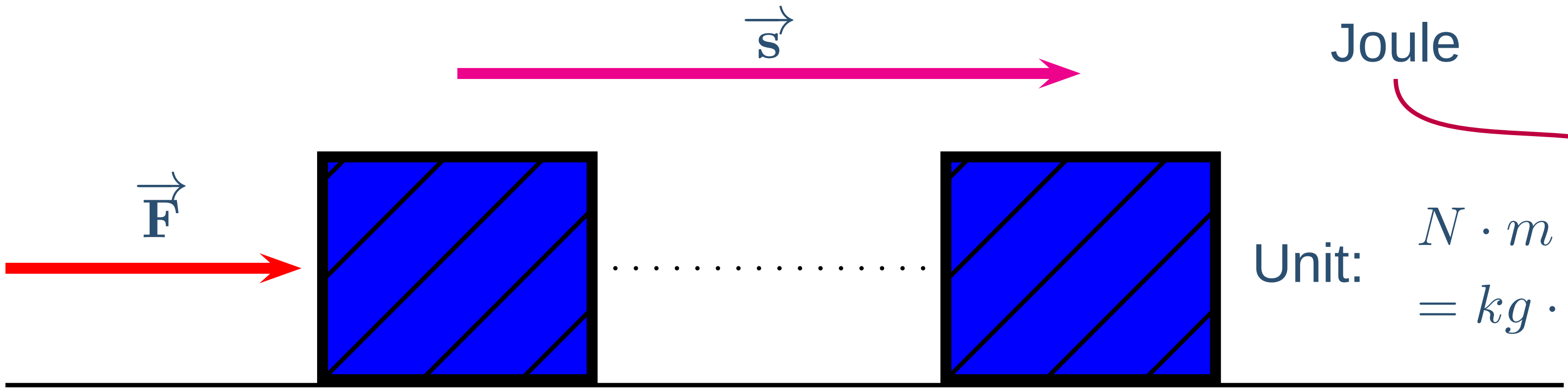
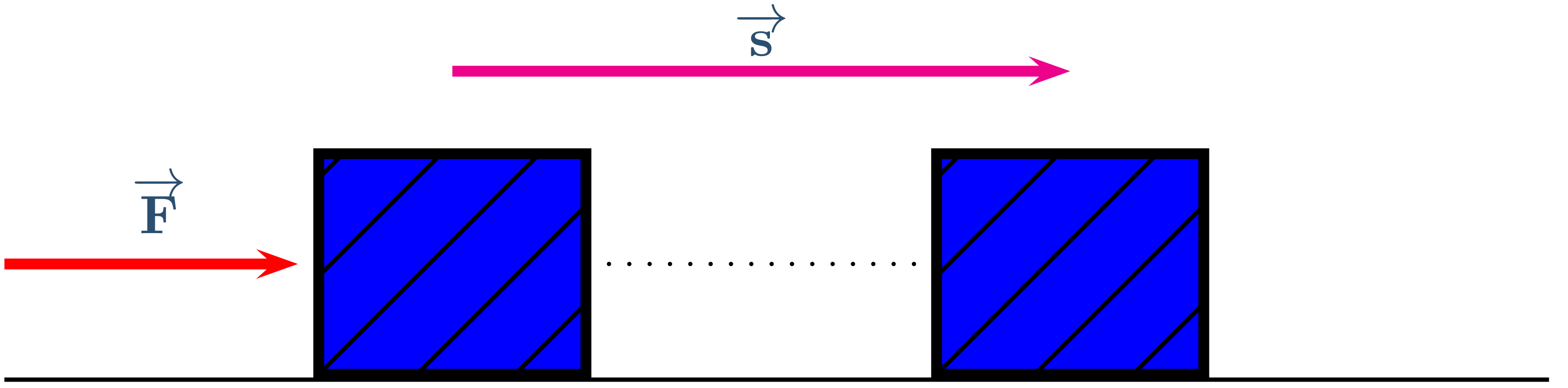


Joule

Unit: $N \cdot m = J$
$= kg \cdot m^2/s^2$

Restrictions

Work: $W = Fs$



This equation is correct only in the situation that:

Restrictions

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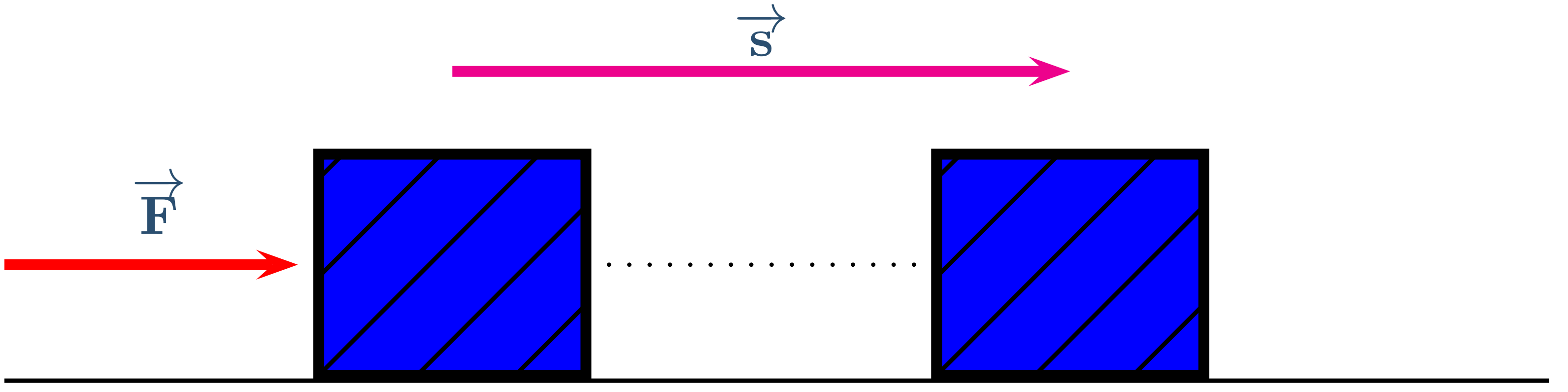

This equation is correct only in the situation that:

$\overrightarrow{\mathbf{F}}$ is constant

Restrictions

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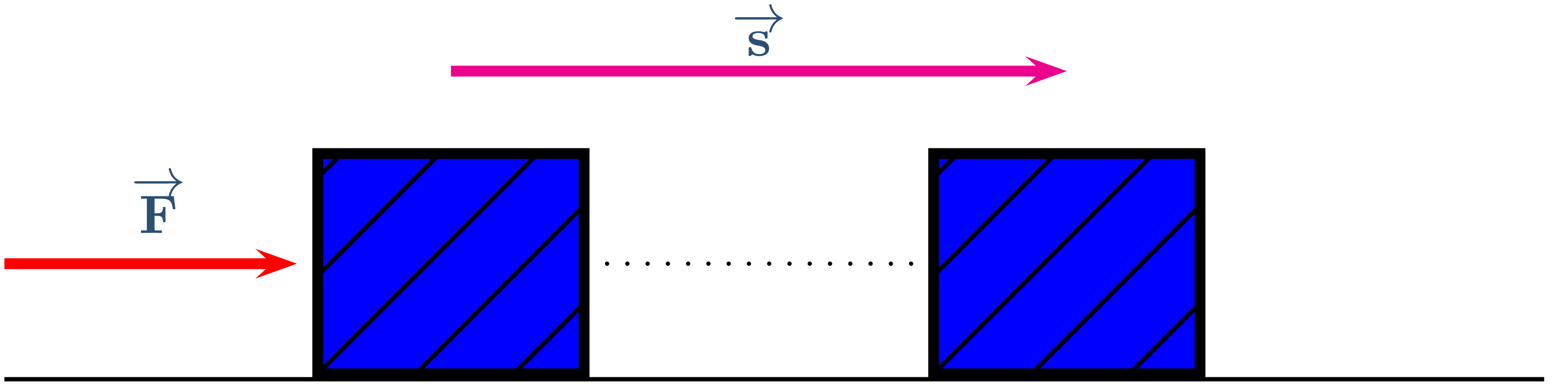

This equation is correct only in the situation that:

$\vec{\mathbf{F}}$ is constant

$\vec{\mathbf{s}}$ is a straight line

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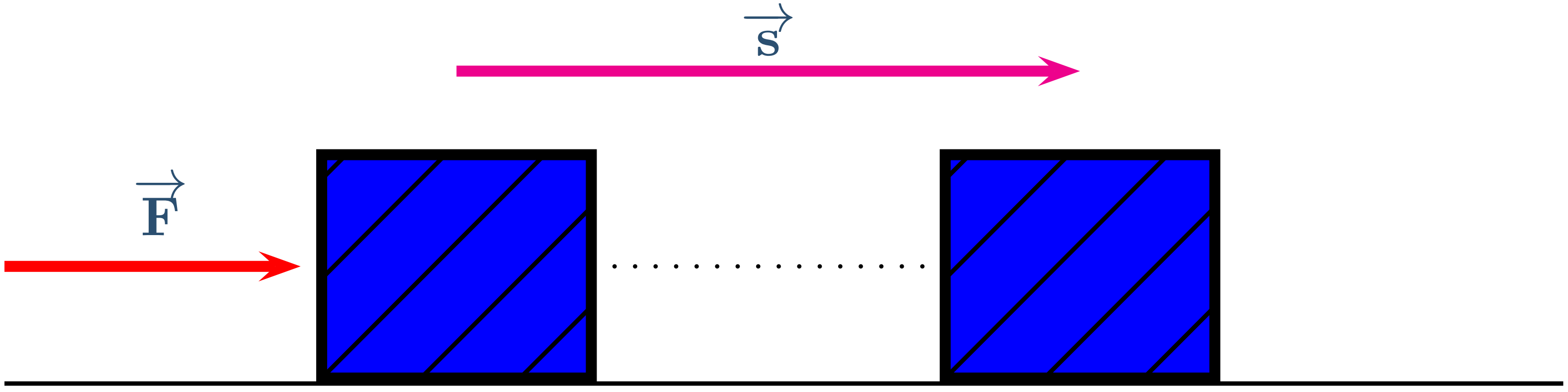

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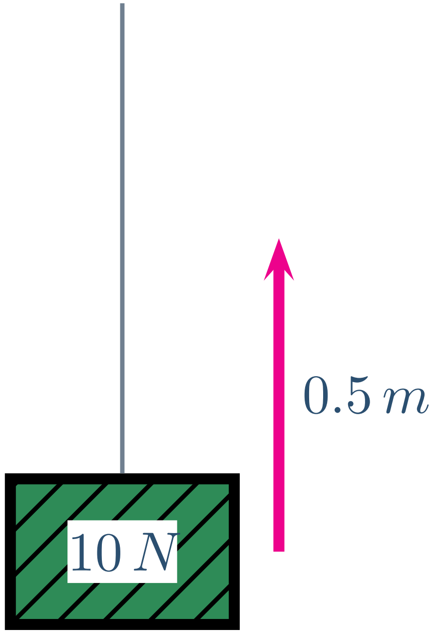
Work Exercise I

A $10\,N$ block is pulled $0.5\,m$ upwards with constant speed by a massless rope. How much work is done by the tension force?



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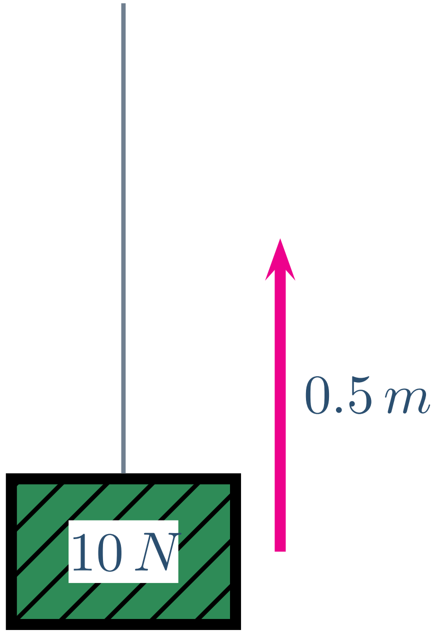

(a) $0\,J$

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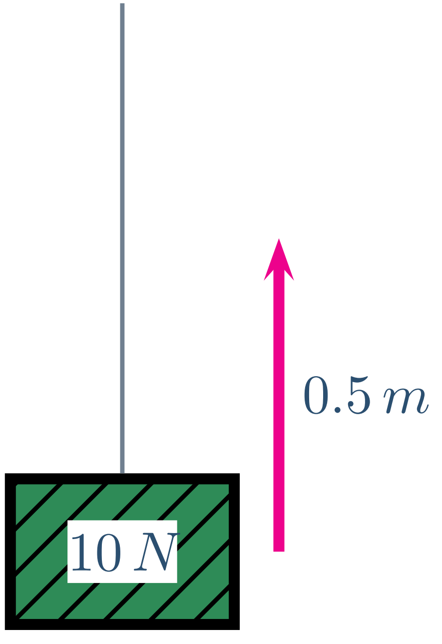

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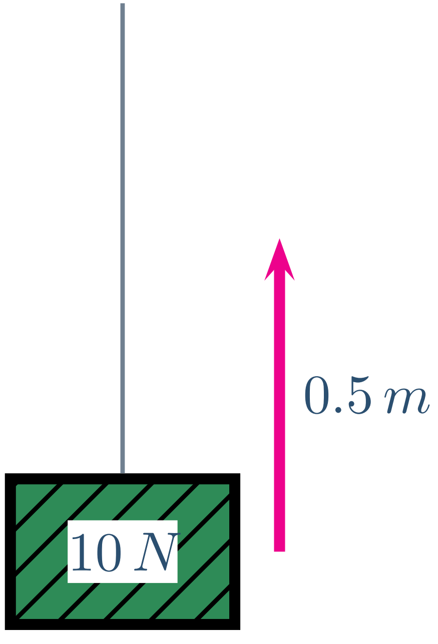

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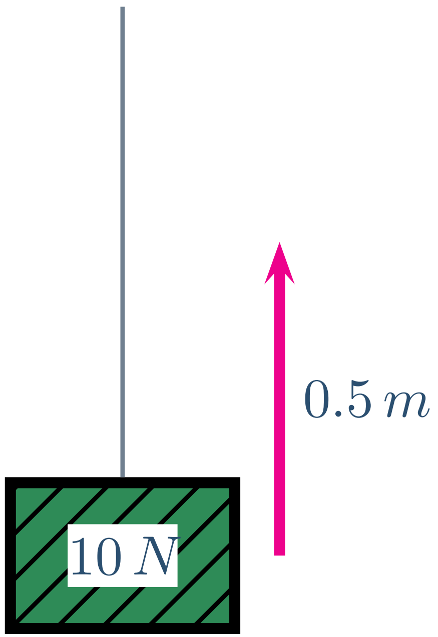

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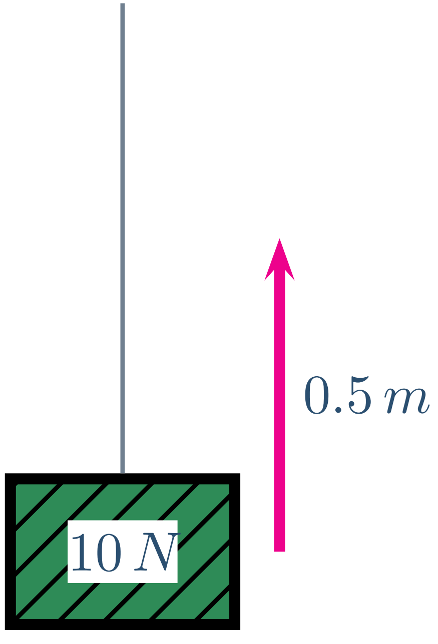

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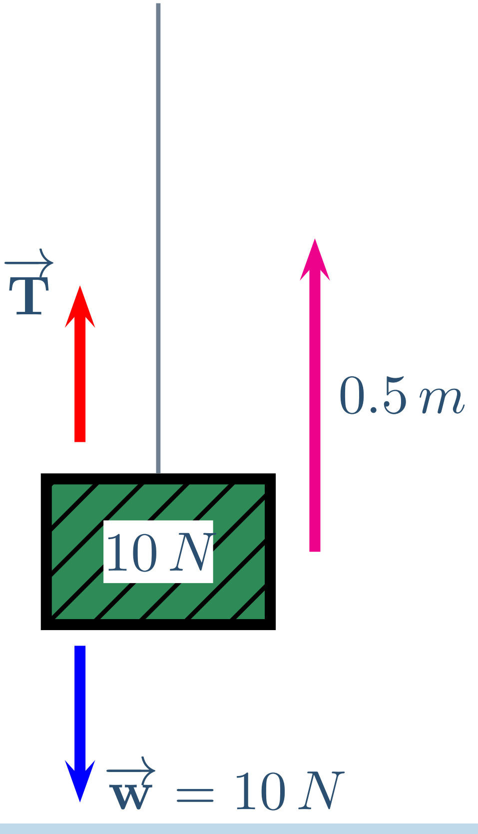

(a) $0\,J$

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$$\sum F_y = ma_y \Rightarrow$$

$$T - 10\,N = 0 \Rightarrow T = 10\,N$$

$$W = Ts = (10\,N)(0.5\,m)$$

Perpendicular Force

A force perpendicular to the displacement does no work.

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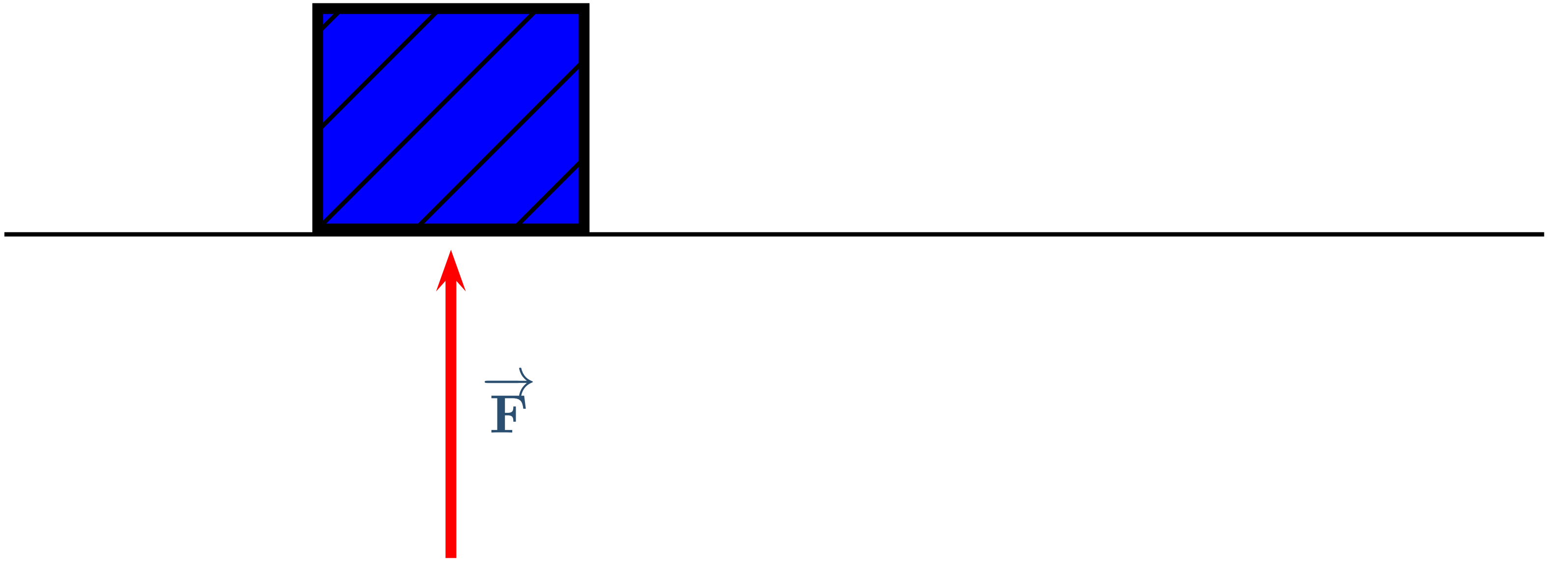

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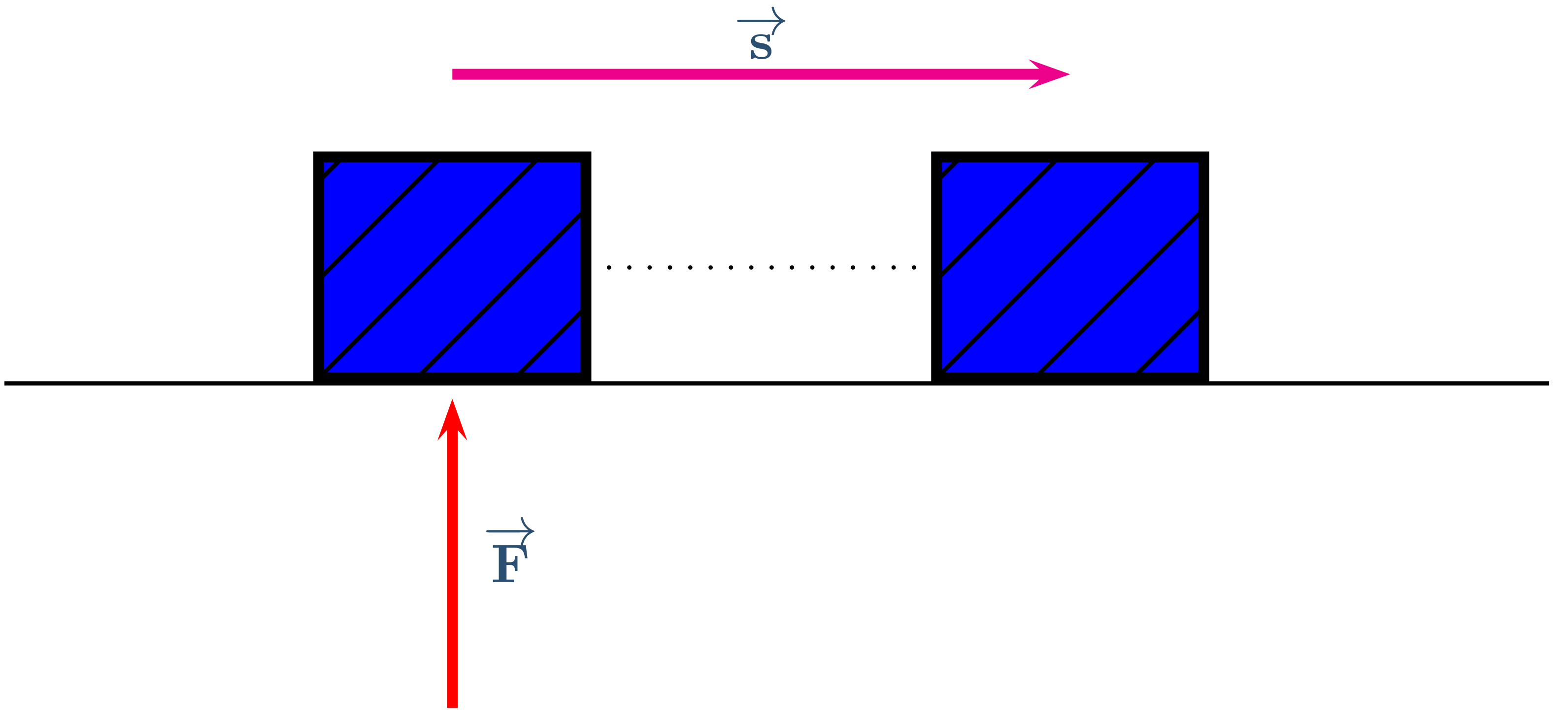

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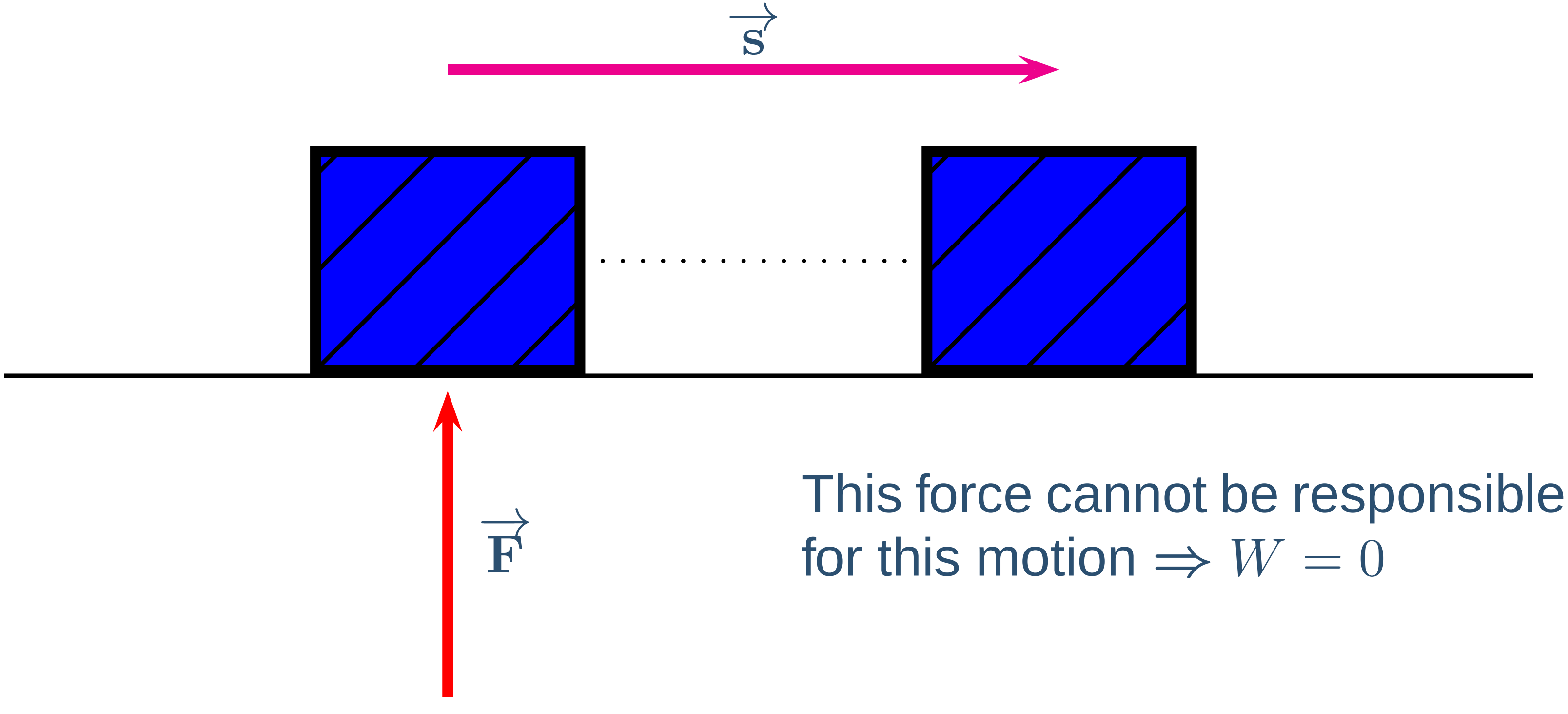

This force cannot be responsible for this motion $\Rightarrow W = 0$

Arbitrary Direction

Only the component of the force parallel to the displacement does work.

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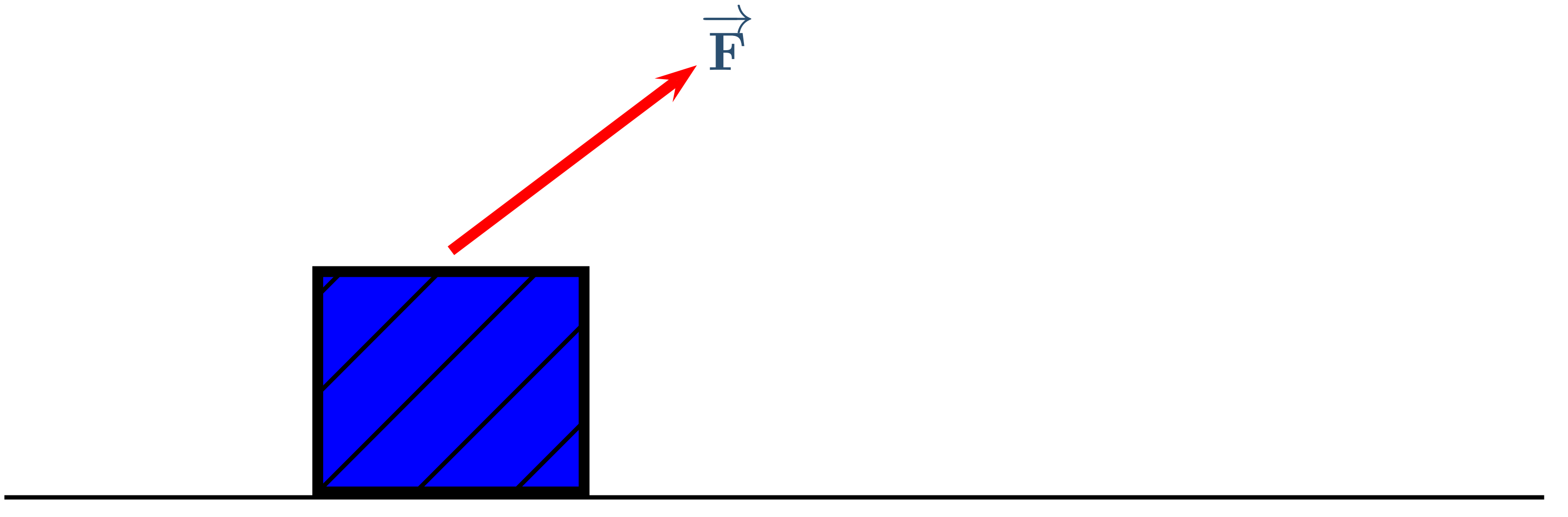

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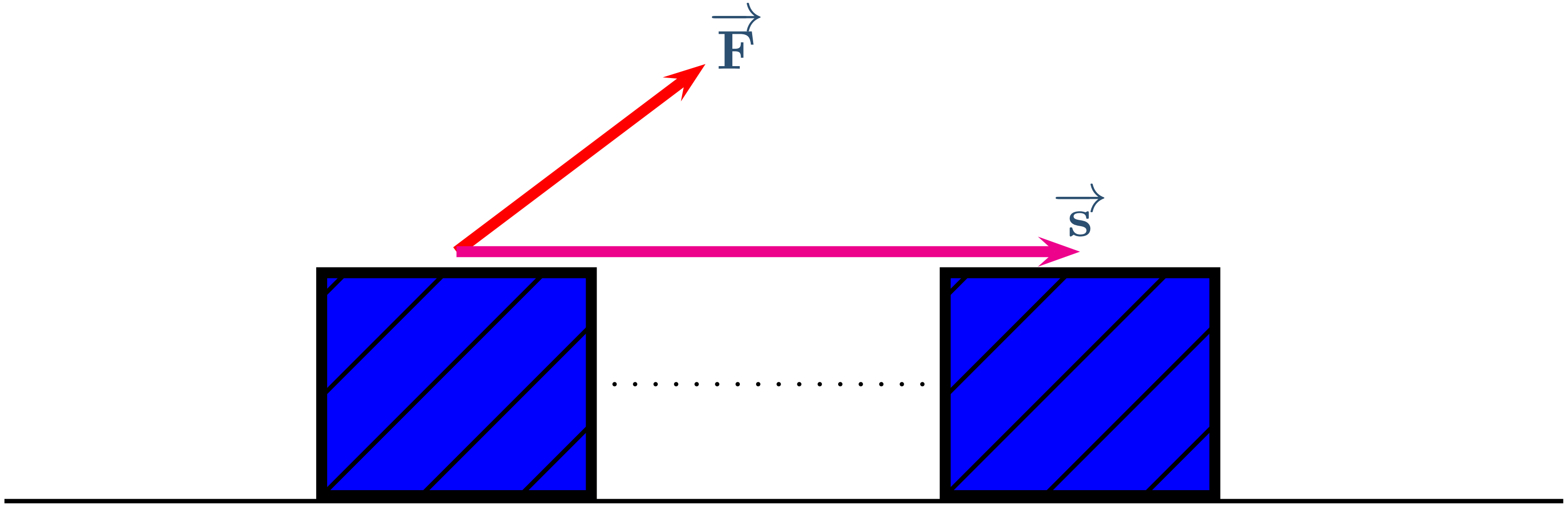

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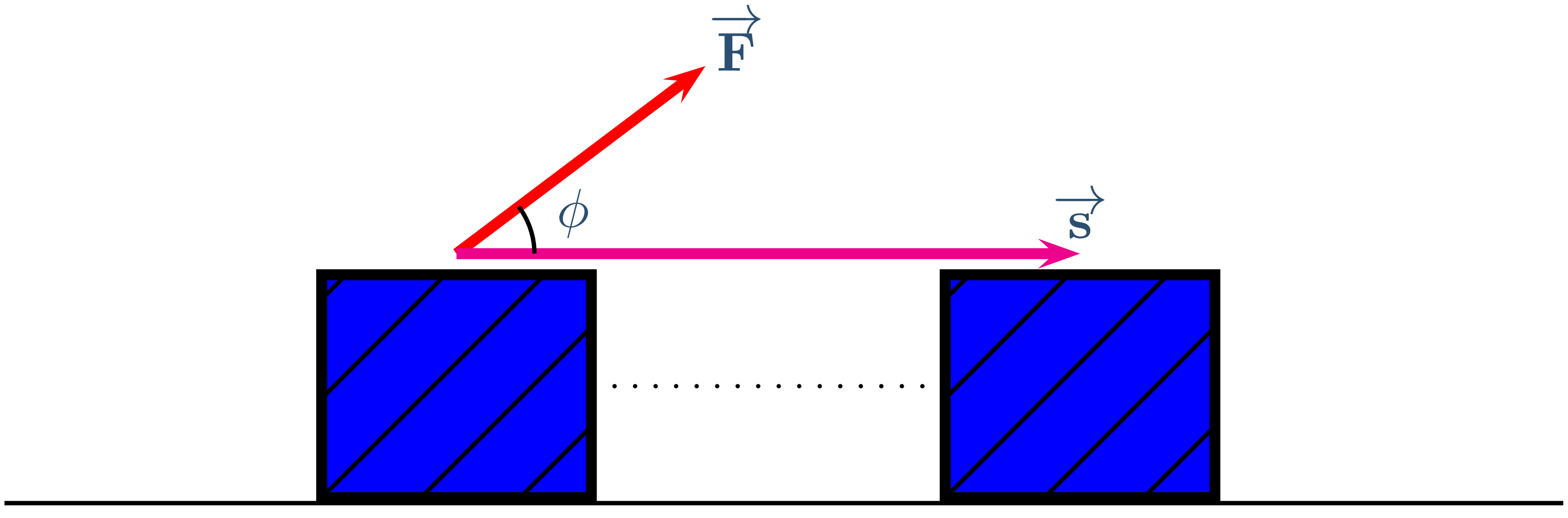

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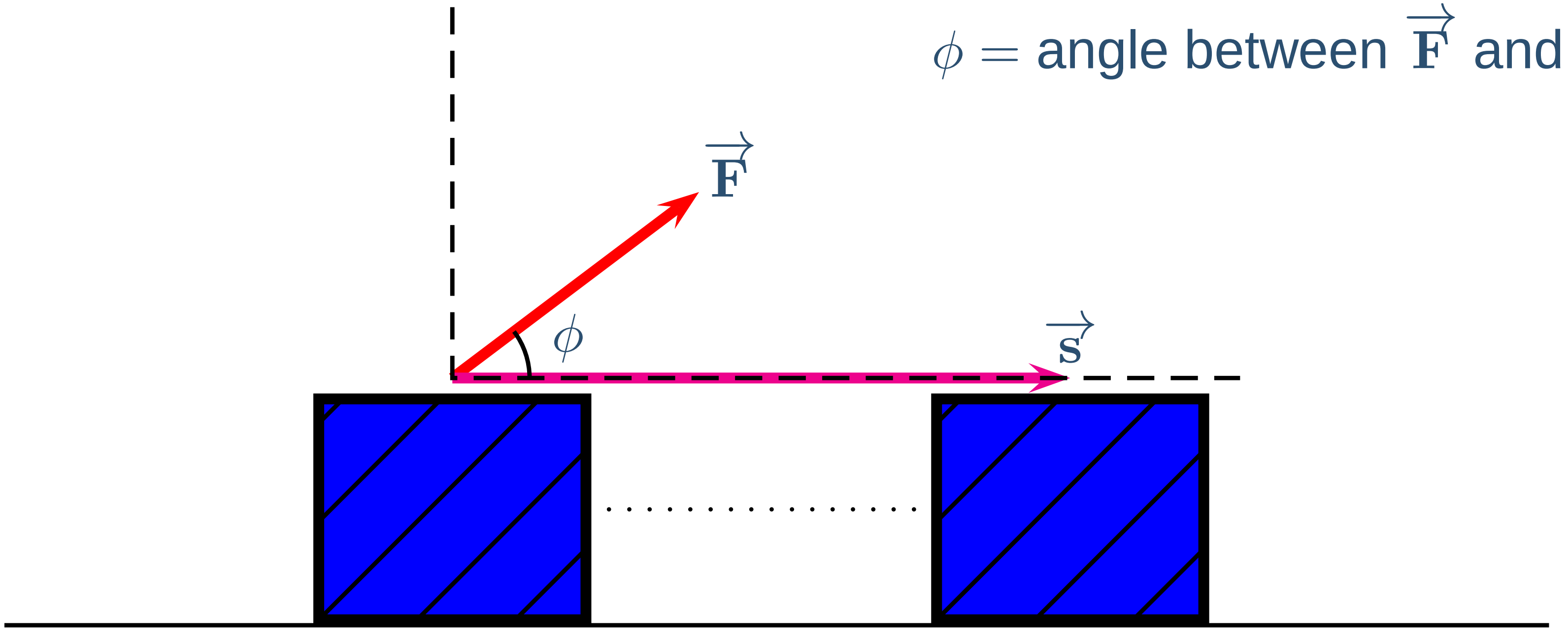

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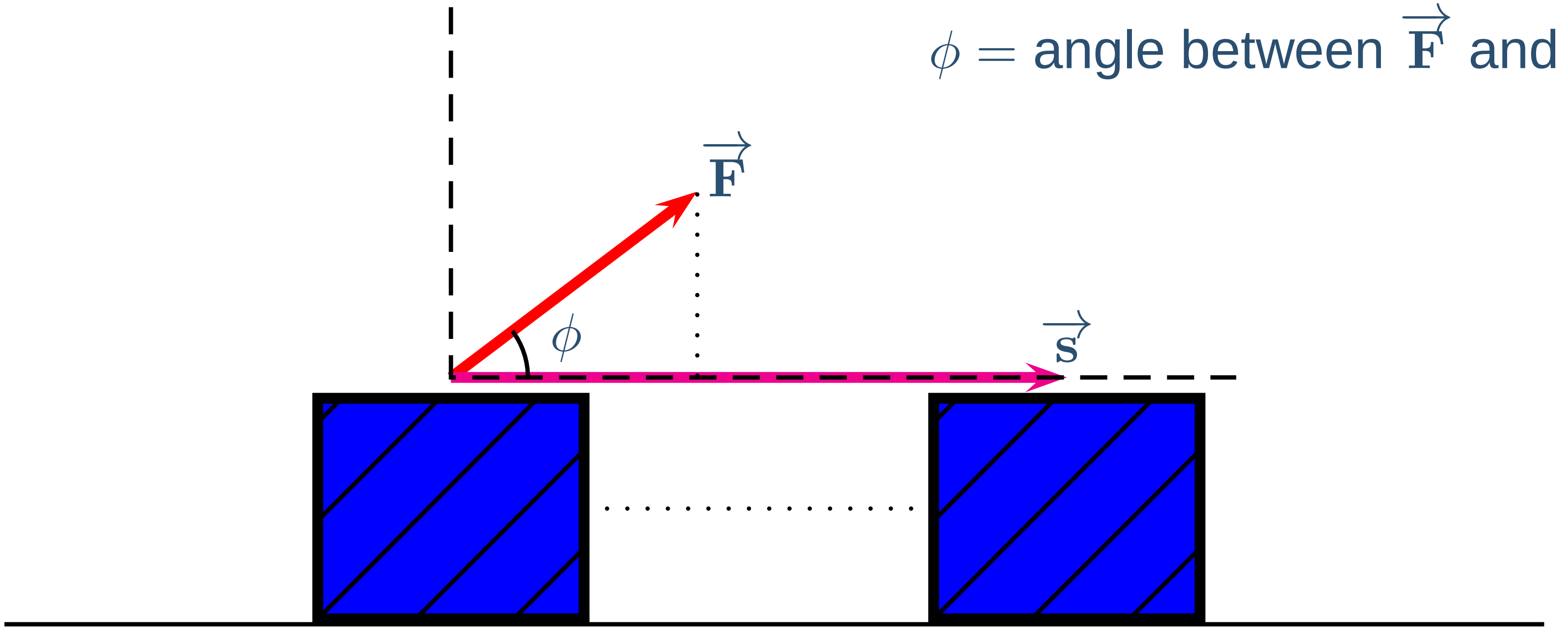

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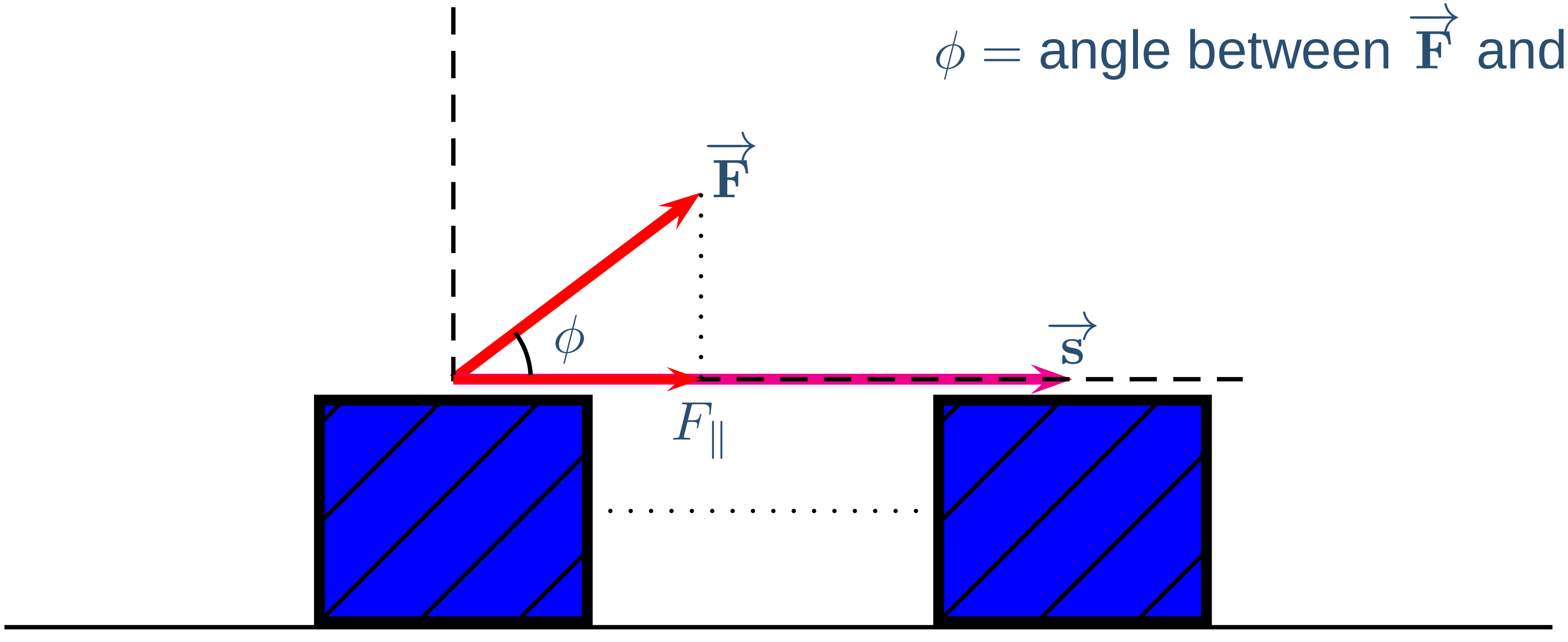

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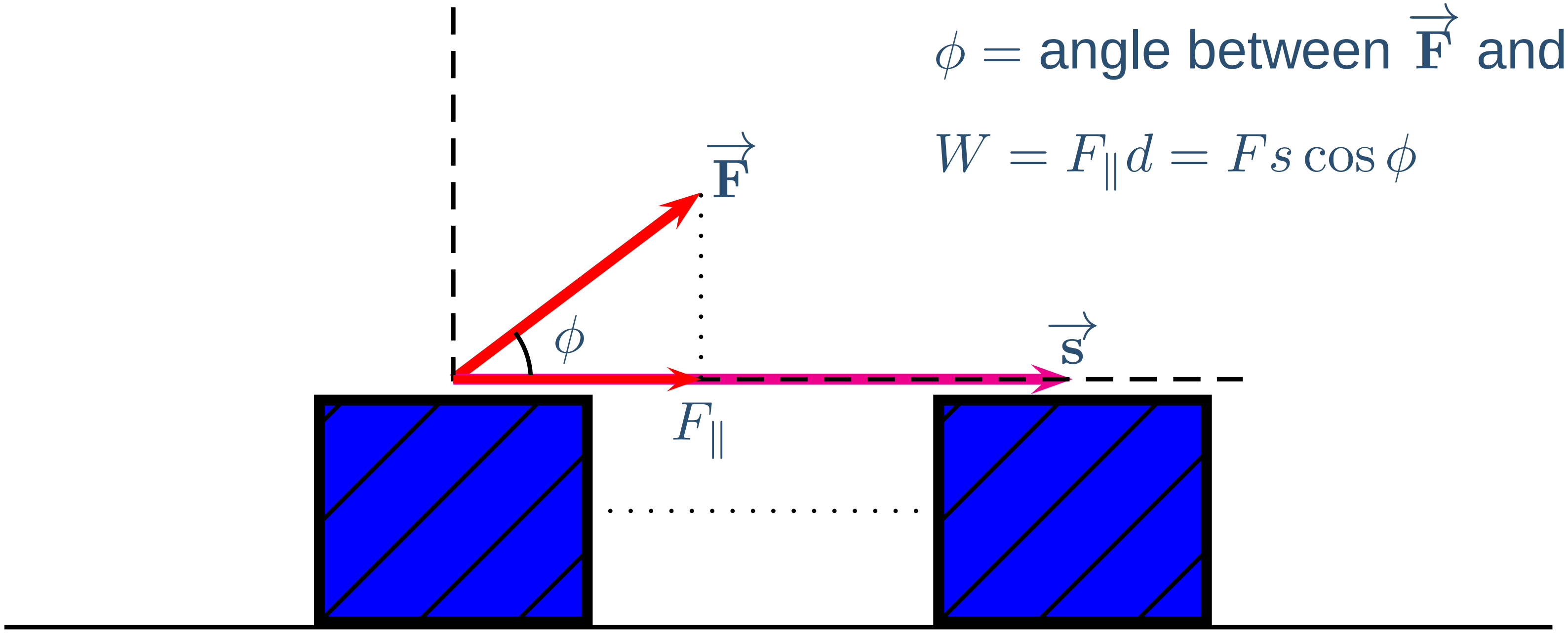

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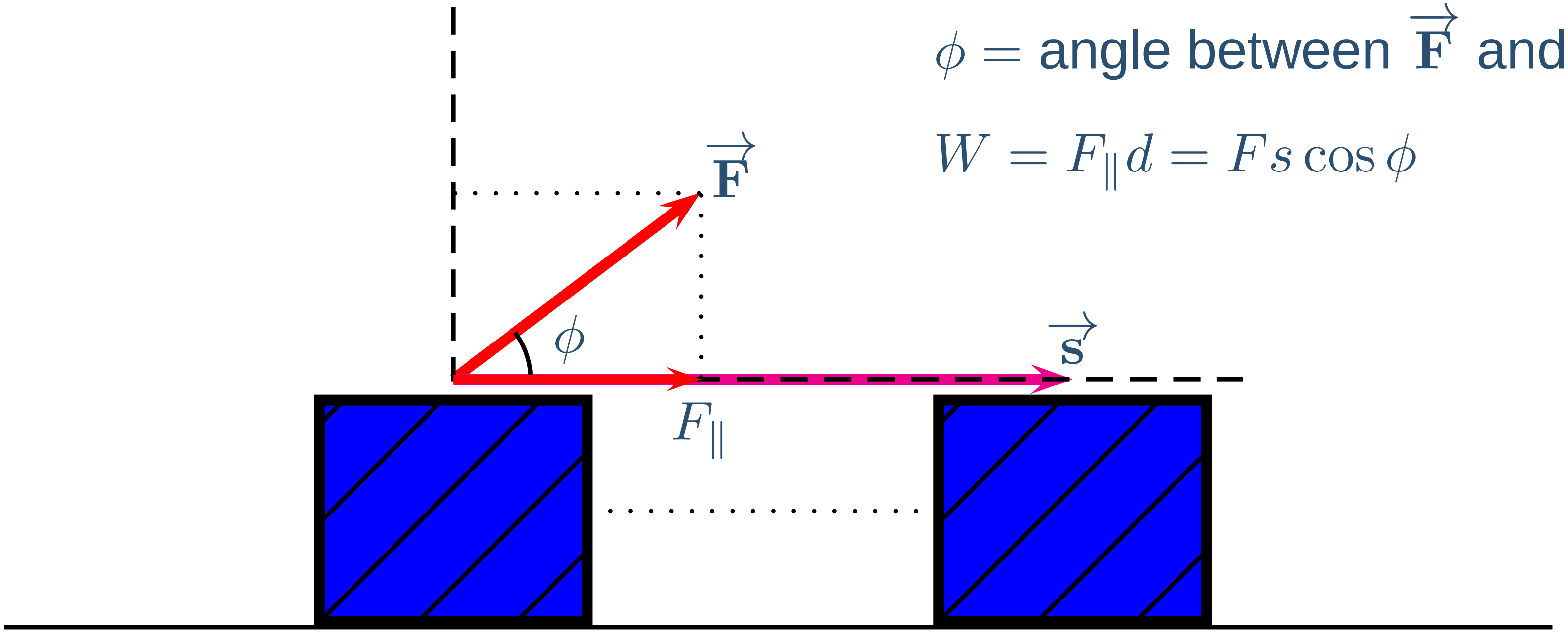

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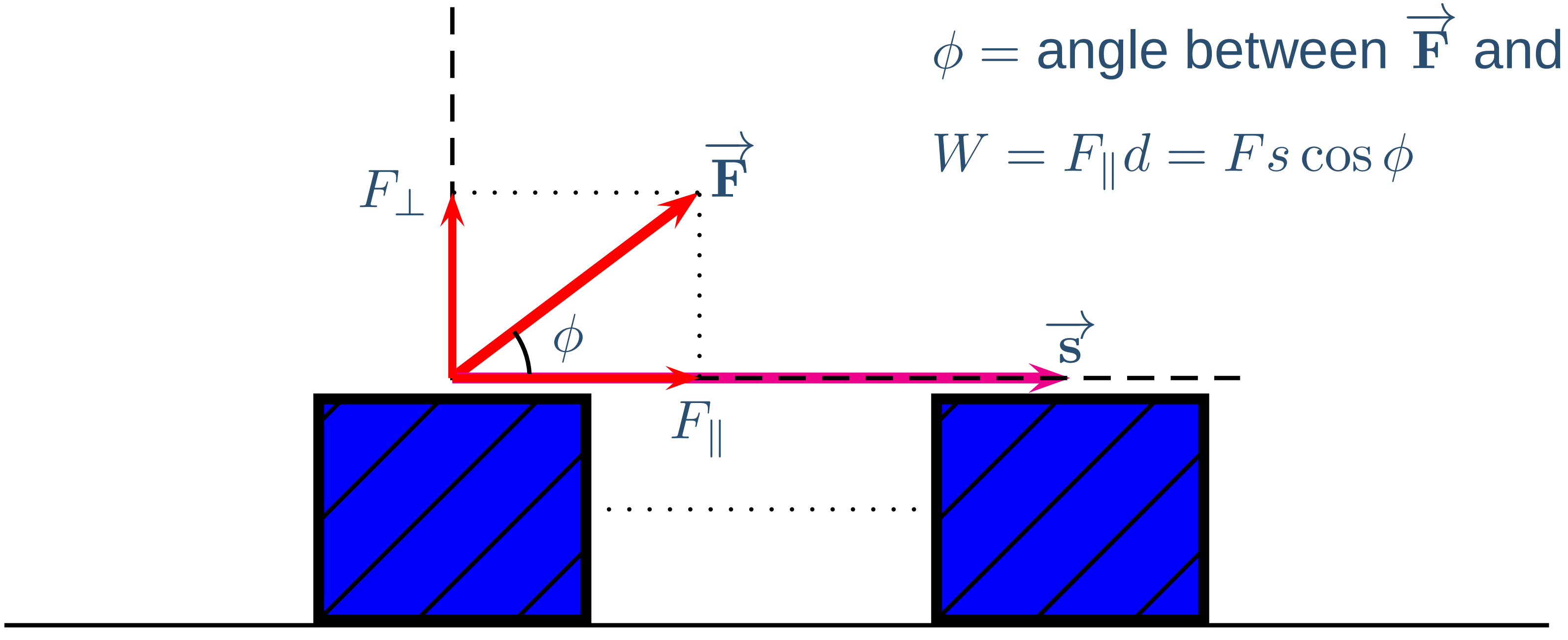

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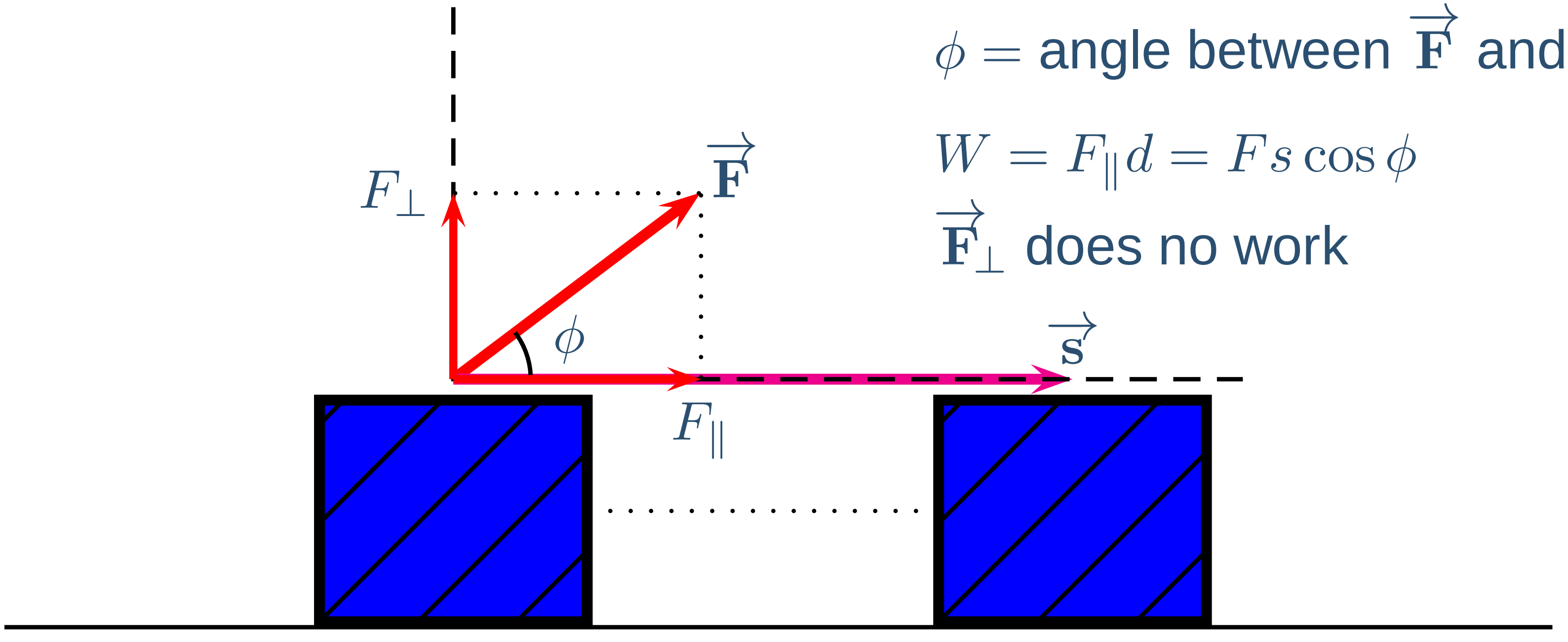

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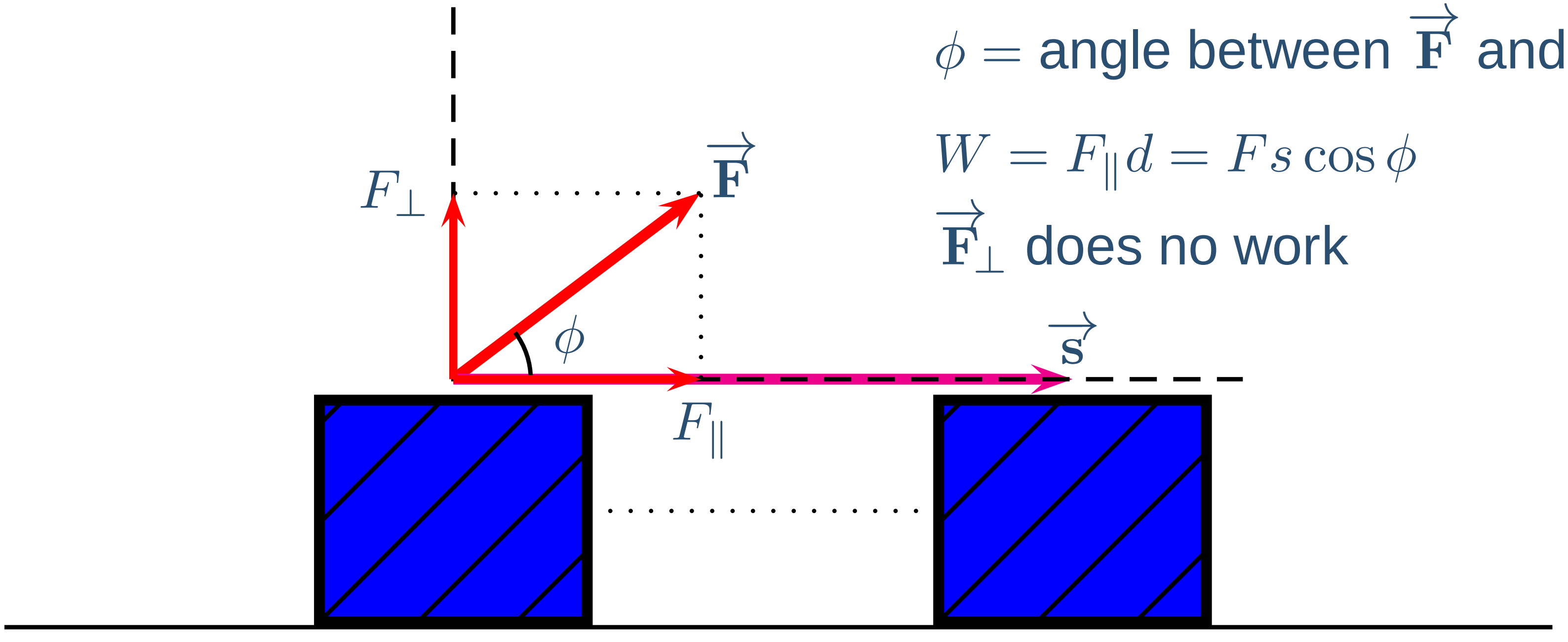

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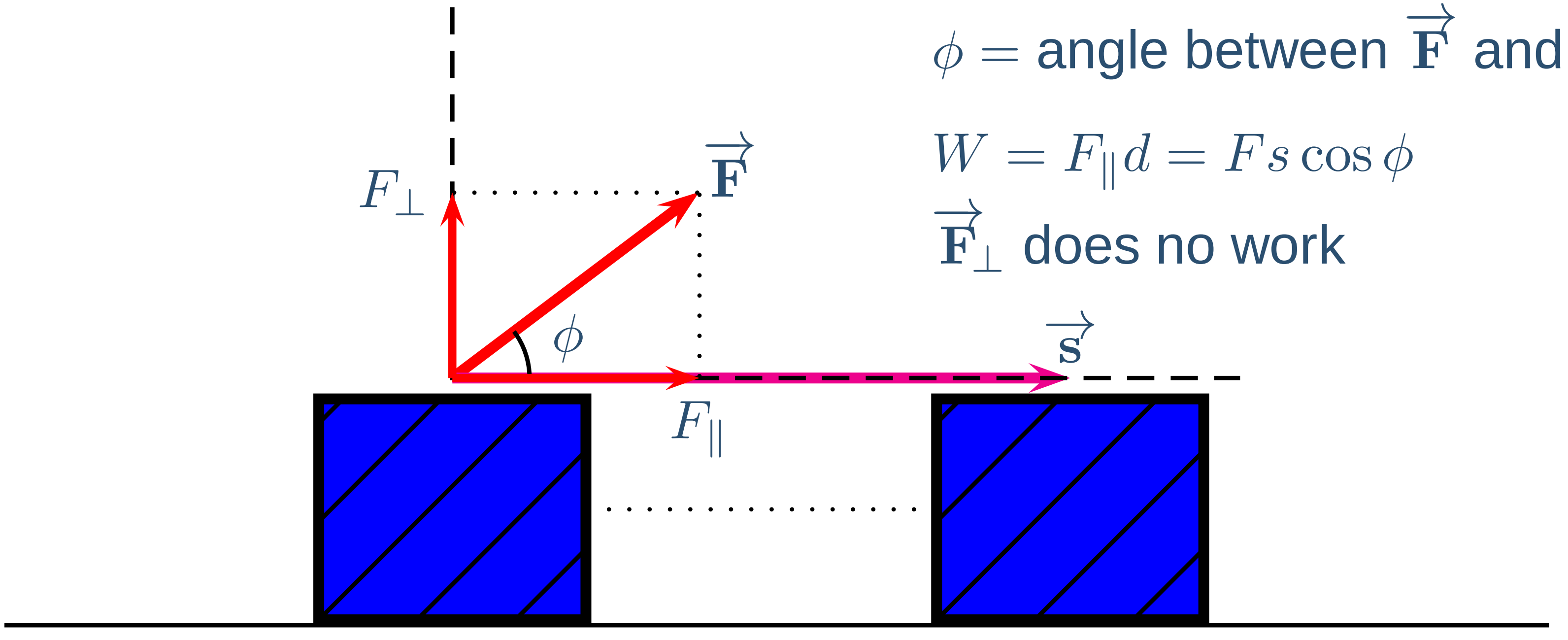

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$$W = Fs\cos\phi$$

Only correct for Constant force & Straight-line displacement

Work Exercise II

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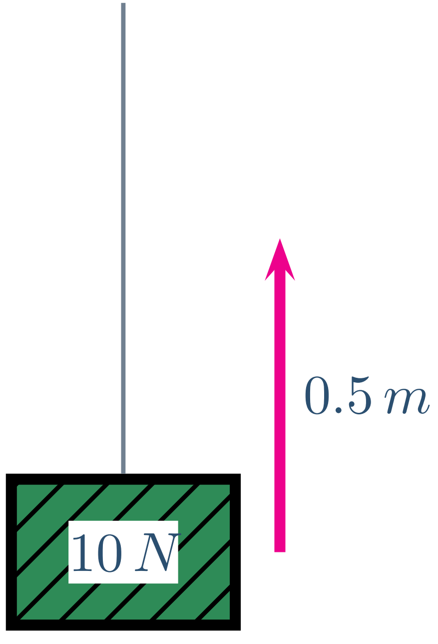

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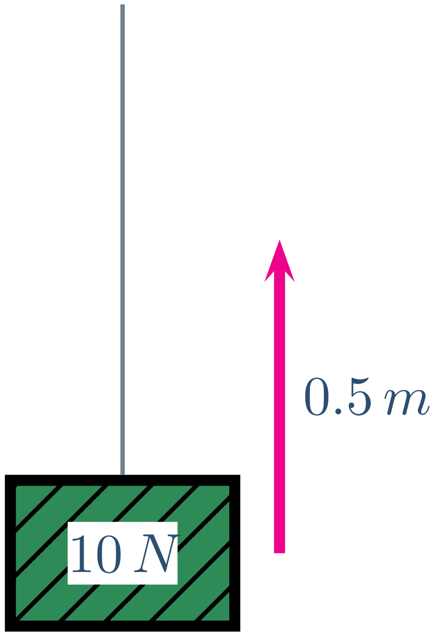

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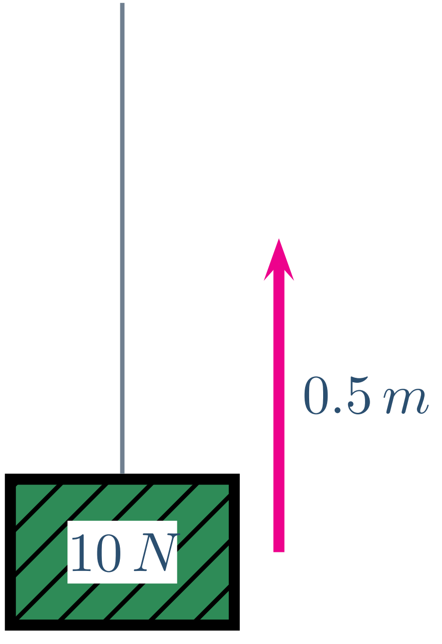

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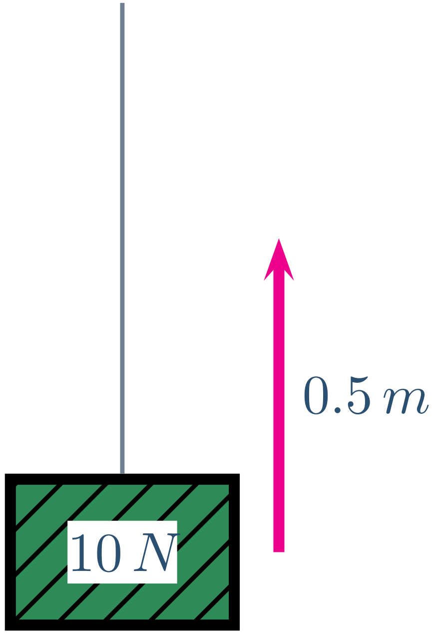

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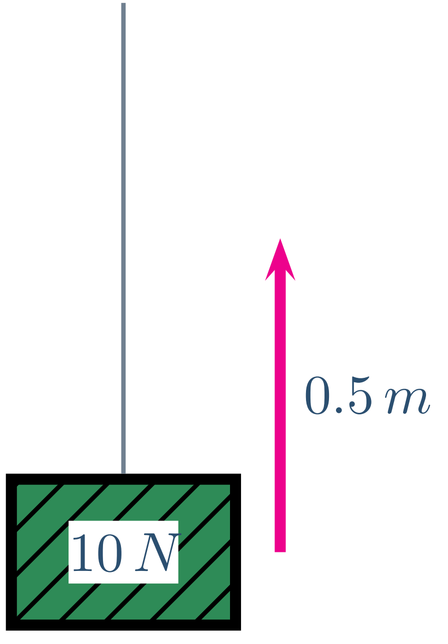

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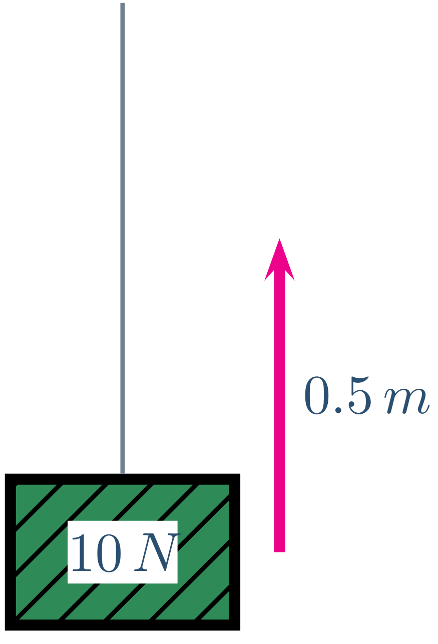

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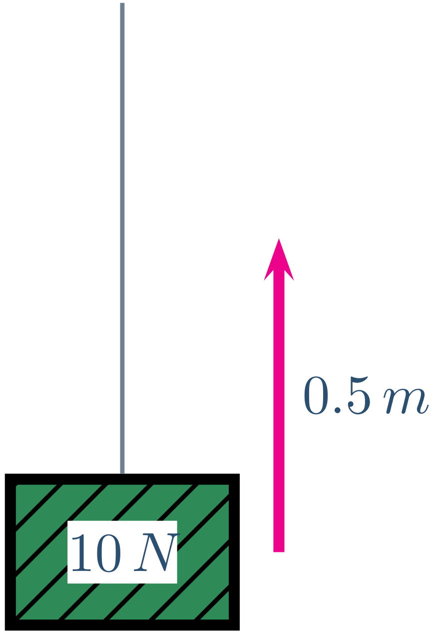

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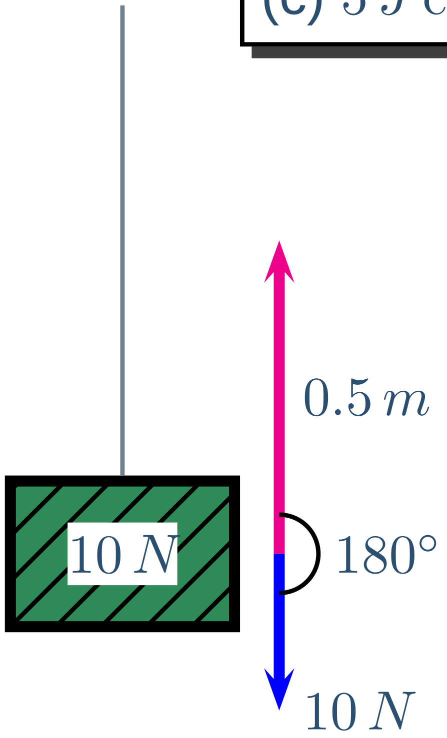


$$W = Fs\cos\phi \Rightarrow$$

$$W = (10\,N)(0.5\,m)\cos 180°$$

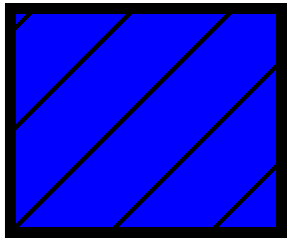
Negative work slows an object down

or by 3rd Law:

$$W_{\text{Done to object}} = -W_{\text{Done by object}}$$

Work Exercise III

If the two constant forces below have equal magnitude, which of them does more work during the displacement shown?



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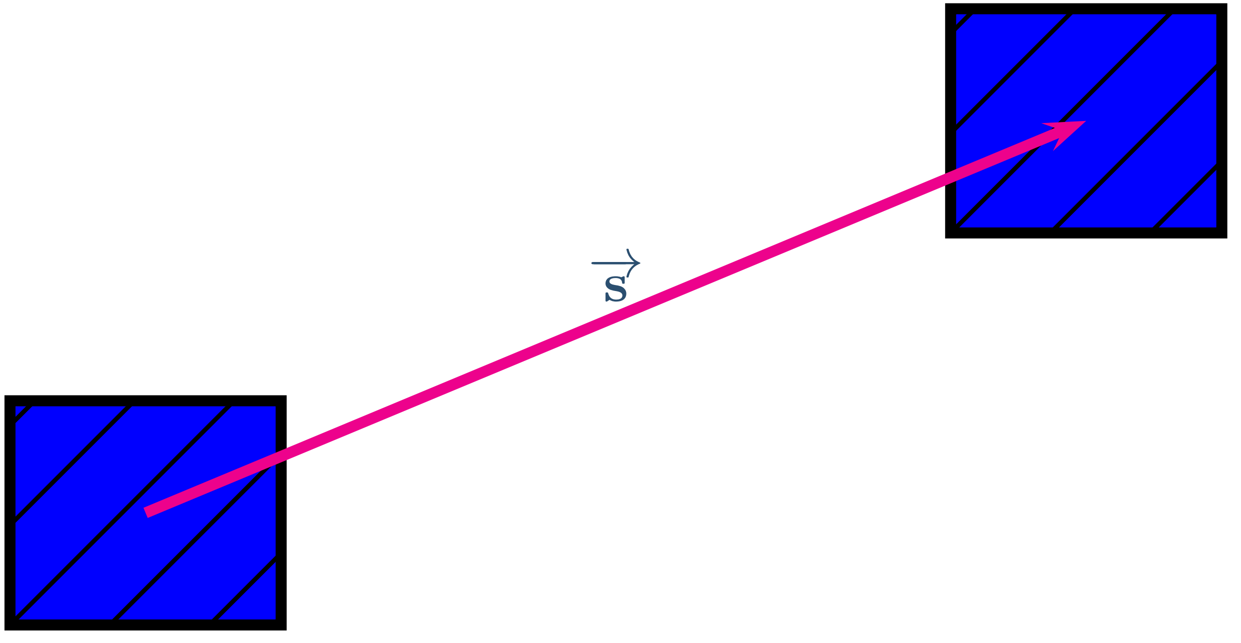

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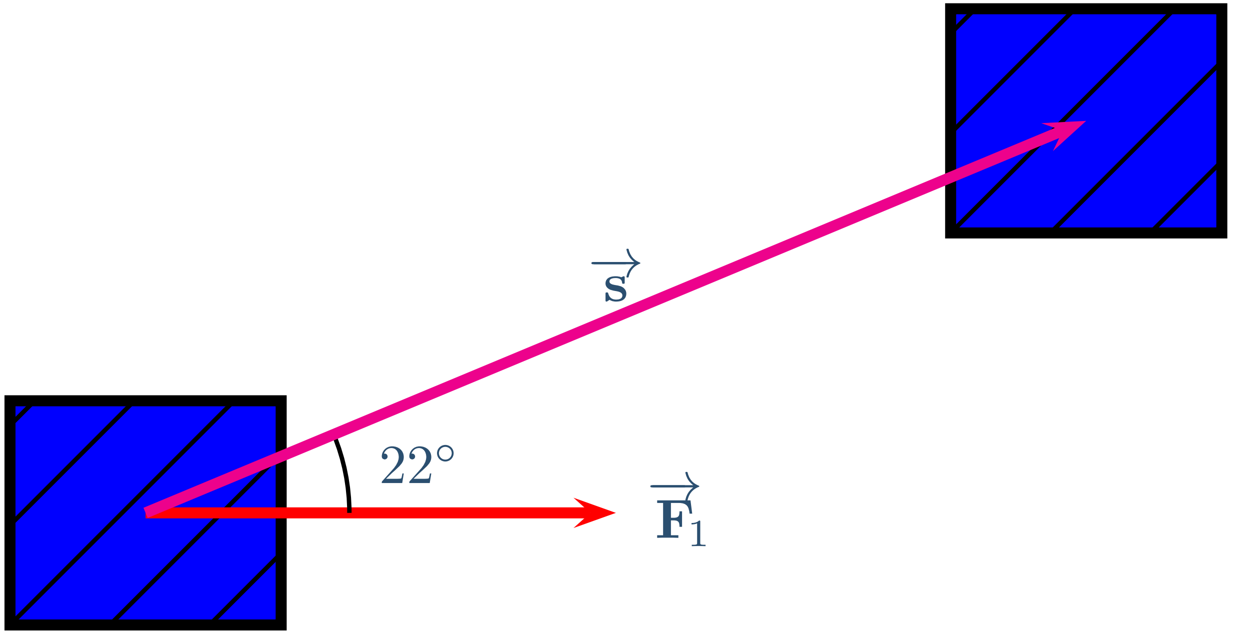

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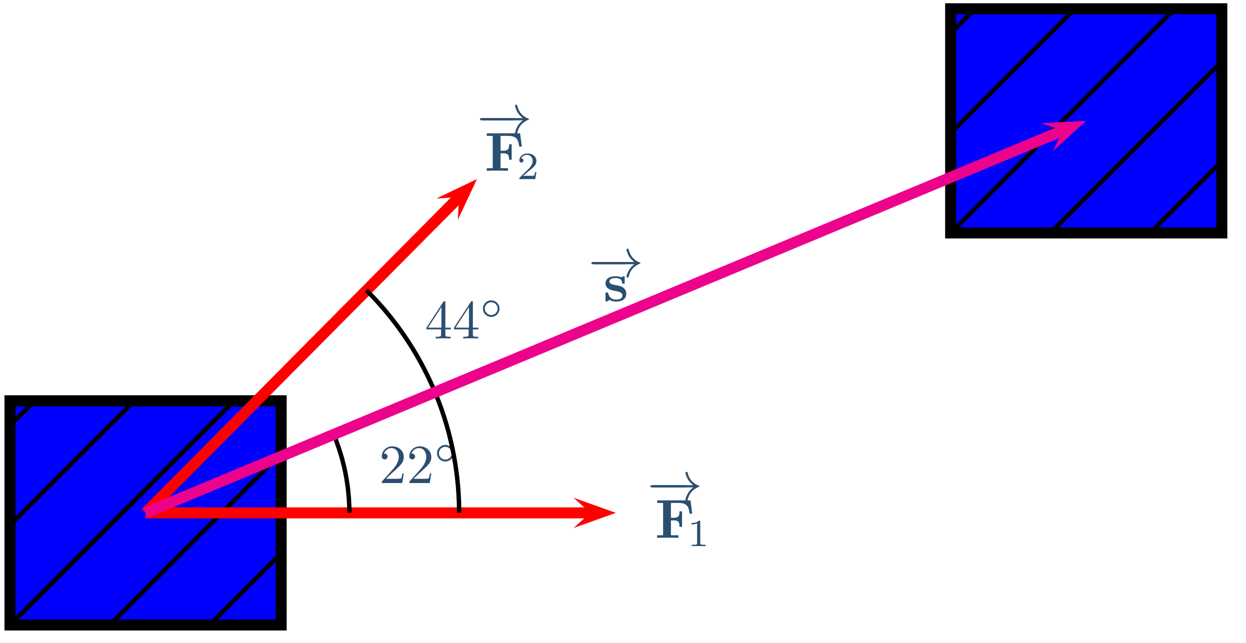

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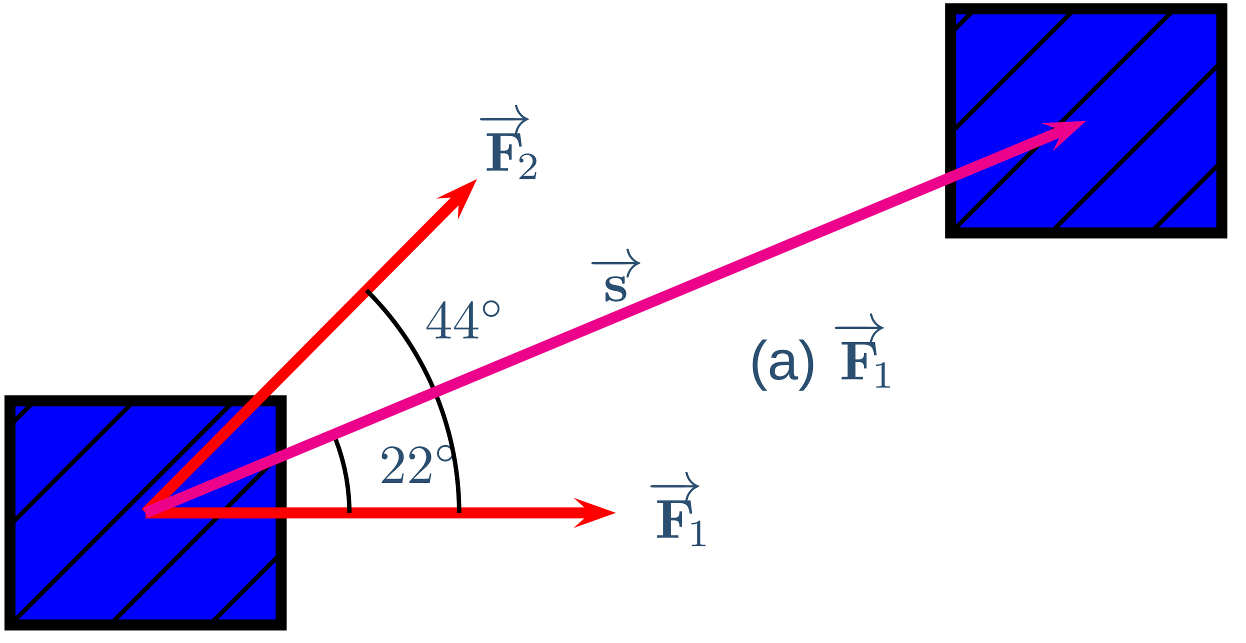

(a) $\overrightarrow{\mathbf{F}}_1$

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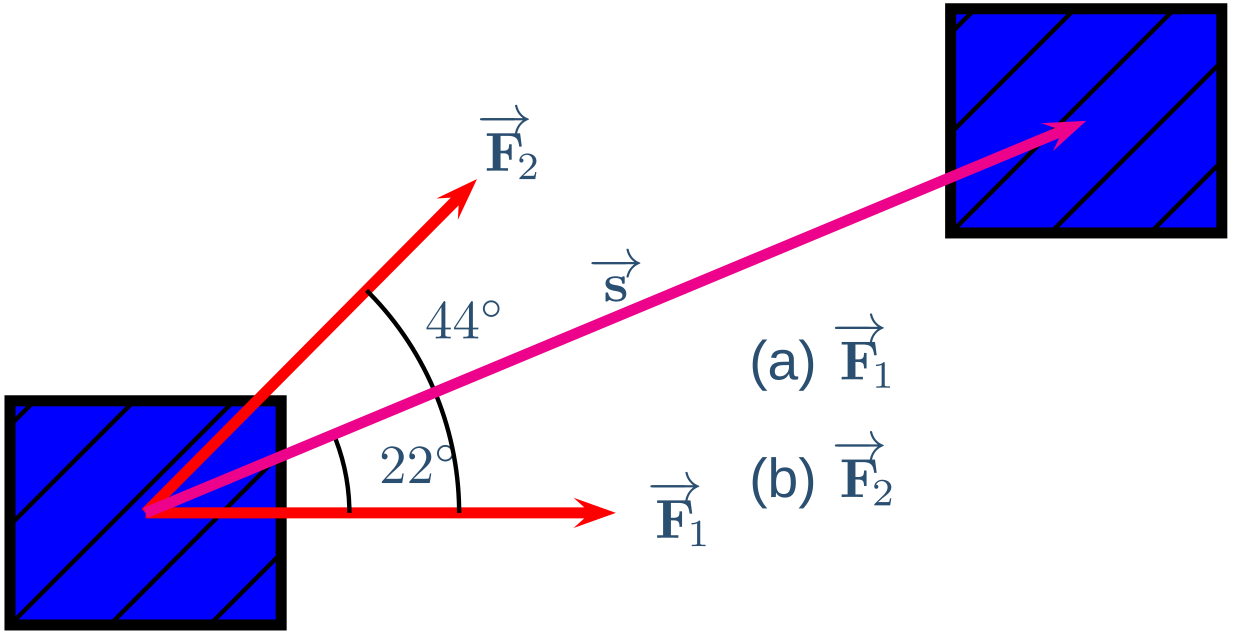

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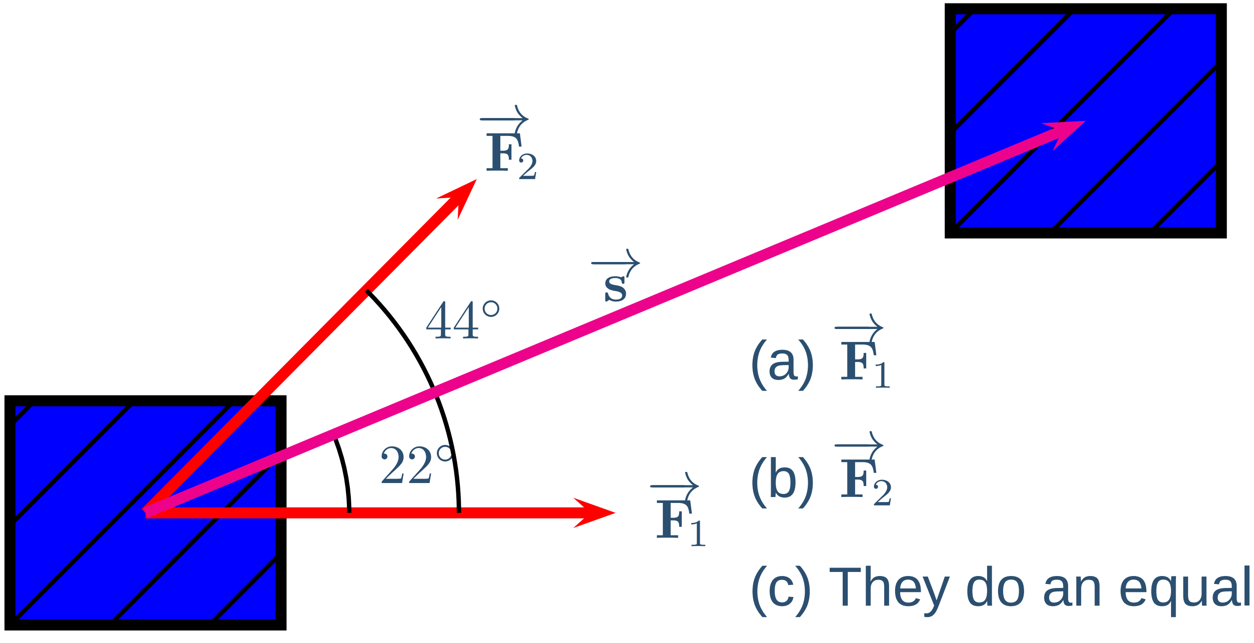

(a) $\overrightarrow{\mathbf{F}}_1$

(b) $\overrightarrow{\mathbf{F}}_2$

(c) They do an equal amount of work

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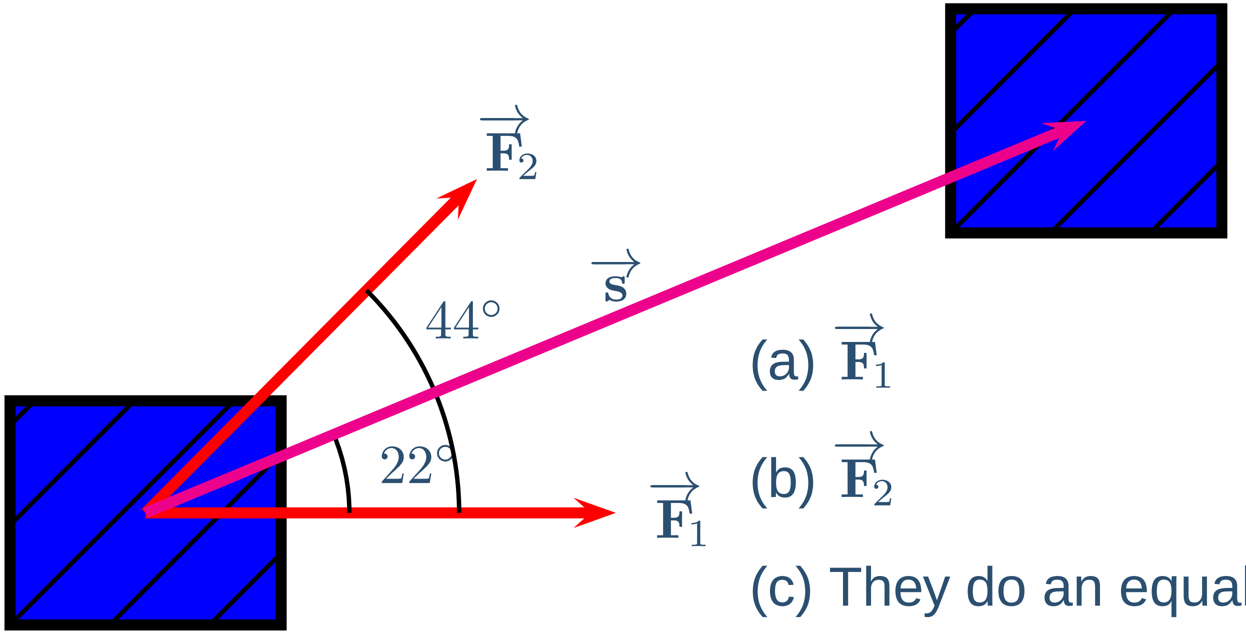

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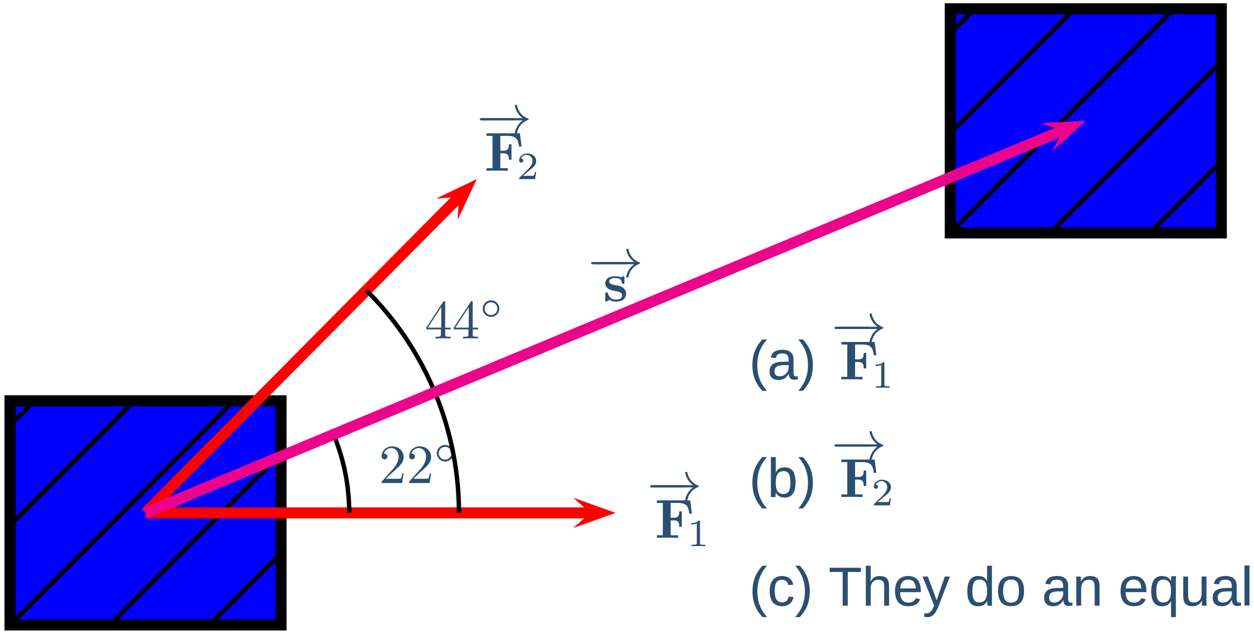

(a) $\vec{F}_1$

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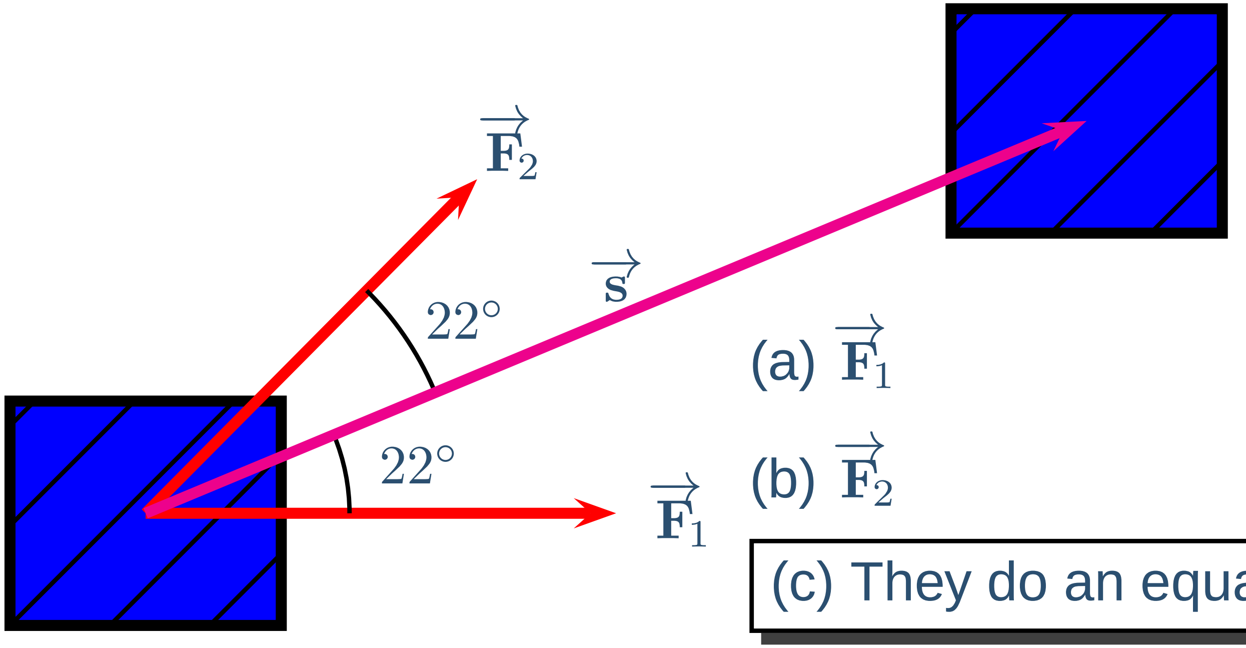
(e) Intentionally left blank

Work Exercise III

If the two constant forces below have equal magnitude, which of them does more work during the displacement shown?



(a) $\vec{\mathbf{F}}_1$

(b) $\vec{\mathbf{F}}_2$

(c) They do an equal amount of work

(d) Not enough information to determine

(e) Intentionally left blank

For both forces, the angle *between* is $22°$

The Dot Product

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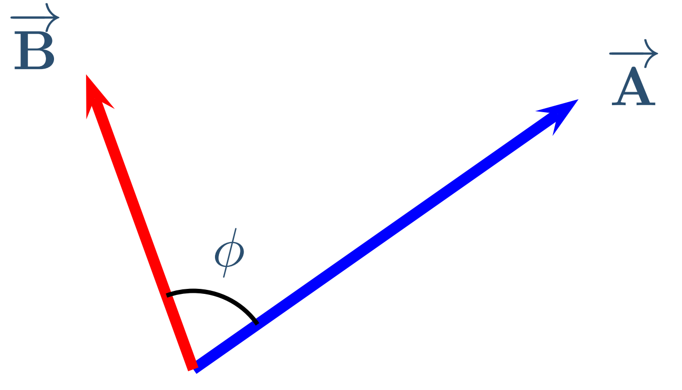

$$\vec{\mathbf{A}} \cdot \vec{\mathbf{B}} = AB\cos\phi$$

The Dot Product II

Like with work, the dot product gives us the parallel component of one vector relative to another, and therefore, how much two vectors “overlap".

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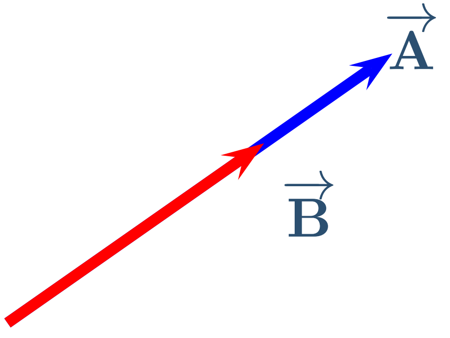

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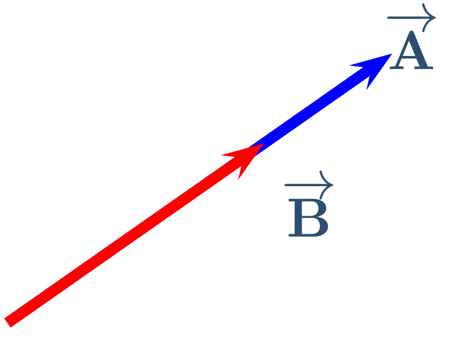

$$\overrightarrow{\mathbf{A}} \cdot \overrightarrow{\mathbf{B}} = AB\cos 0^\circ = AB$$

$\Rightarrow$ maximum overlap

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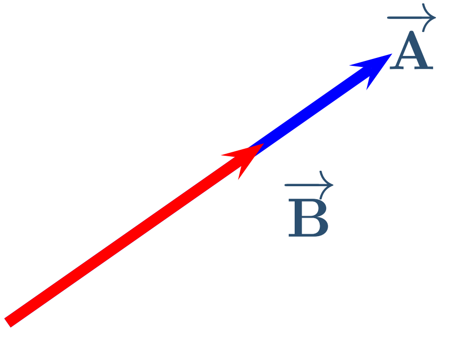

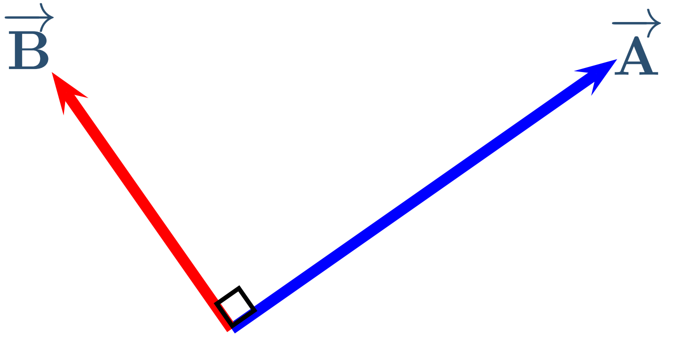

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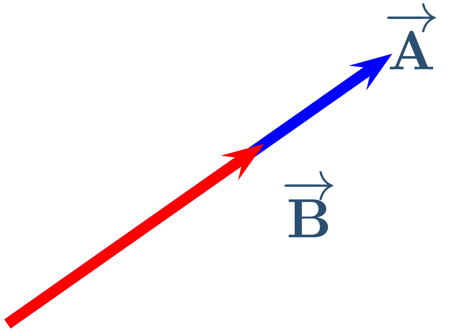

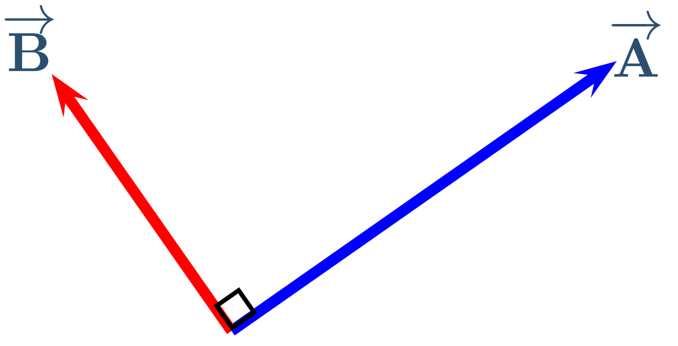

$$\overrightarrow{\mathbf{A}} \cdot \overrightarrow{\mathbf{B}} = AB\cos 0° = AB$$

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$$\overrightarrow{\mathbf{A}} \cdot \overrightarrow{\mathbf{B}} = AB\cos 90° = 0$$

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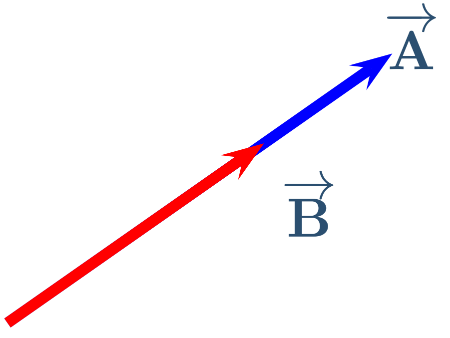

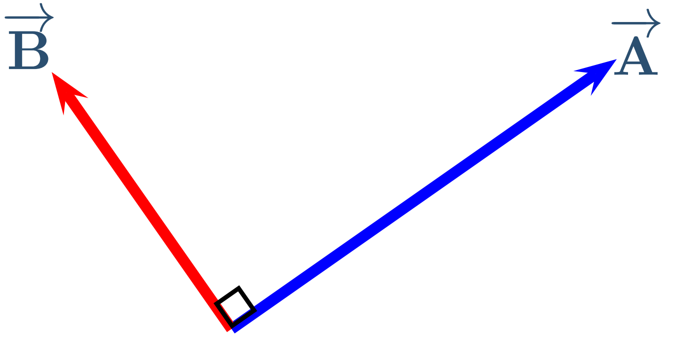

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For constant force and straight-line displacement: $\boxed{W = \overrightarrow{\mathbf{F}} \cdot \overrightarrow{\mathbf{s}}}$

Component Dot Product

The dot product can also be written in terms of the components of the individual vectors.

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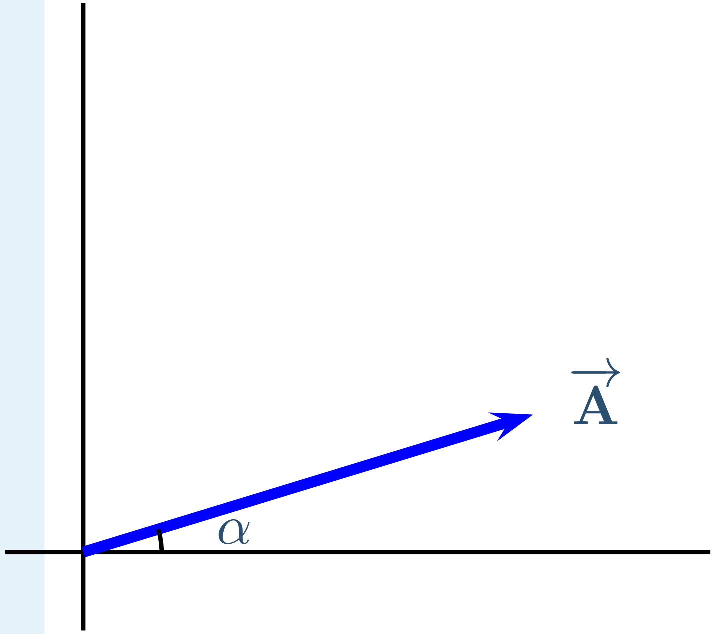

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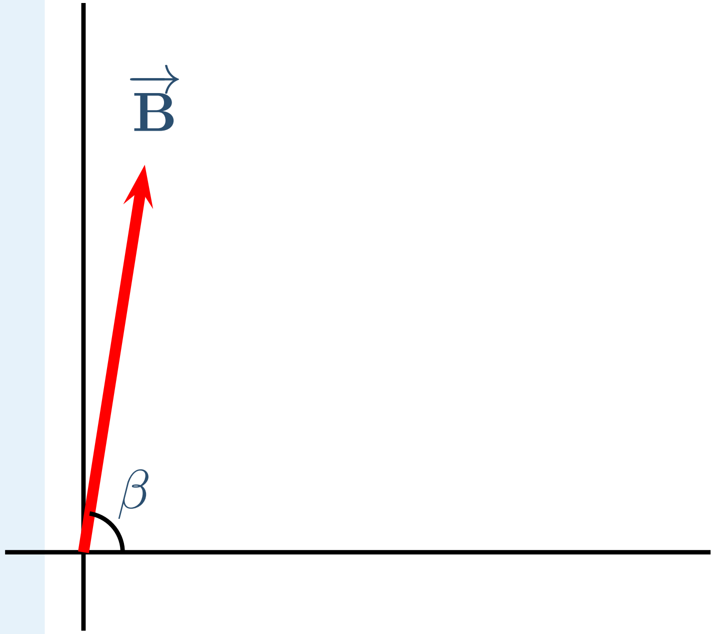

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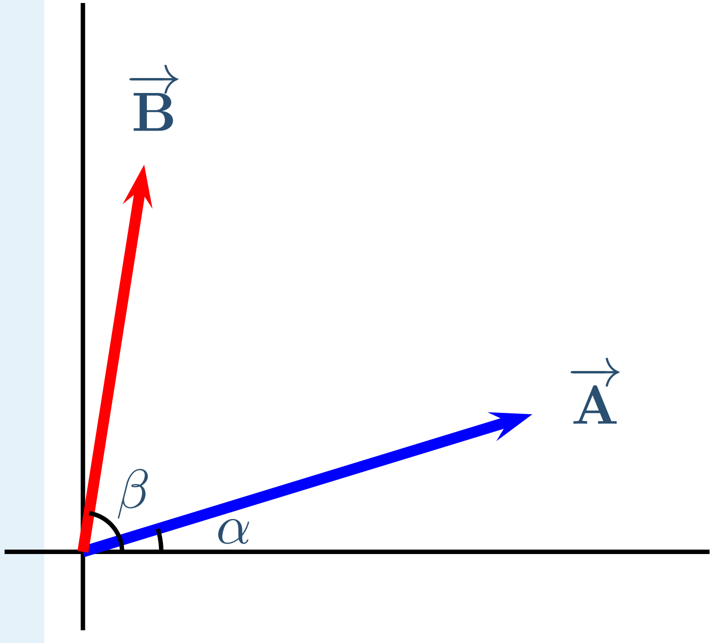

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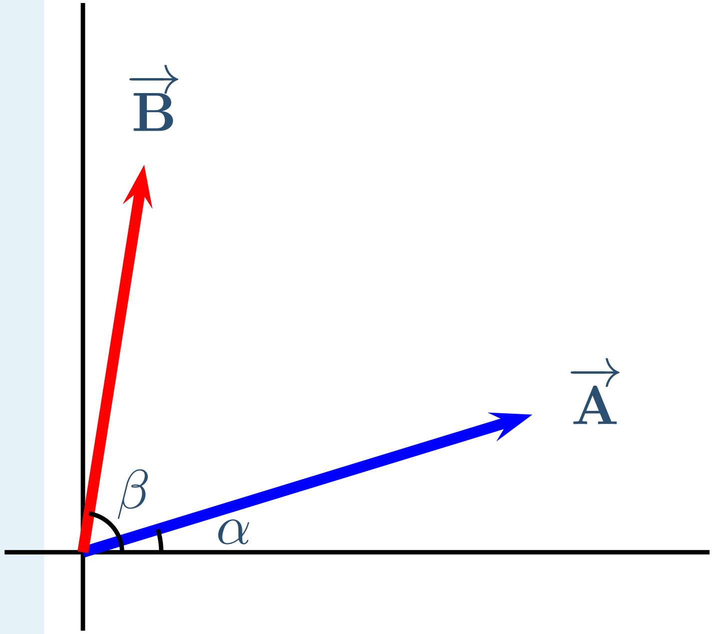

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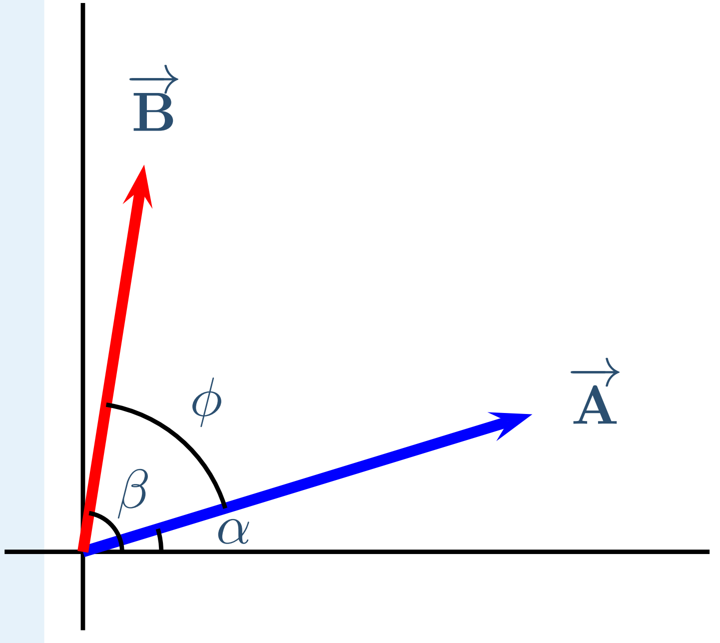

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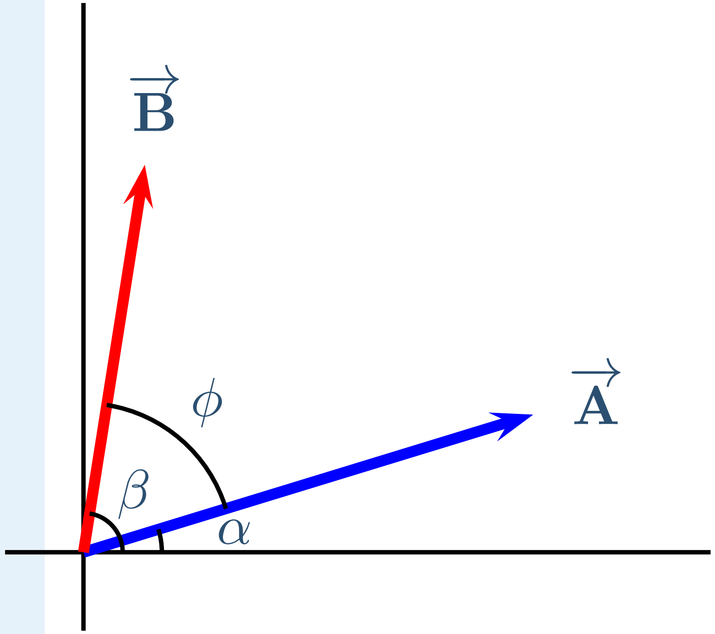

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$$\phi = \beta - \alpha$$

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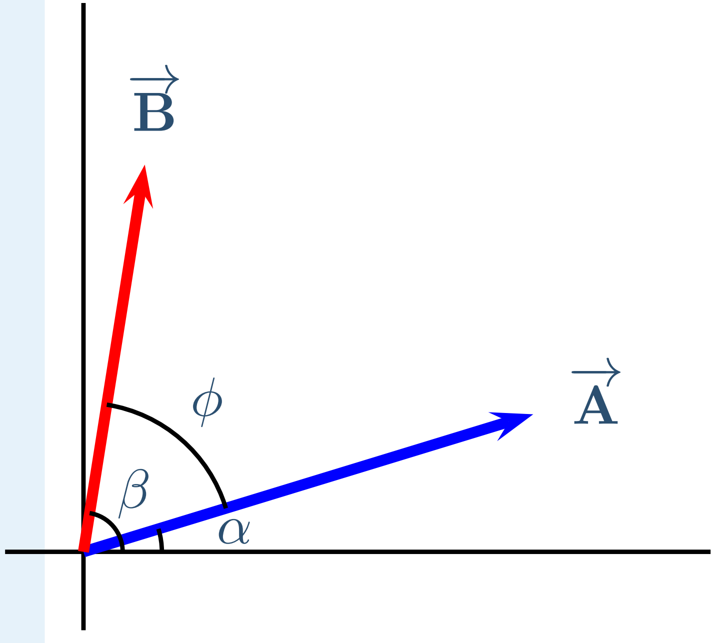

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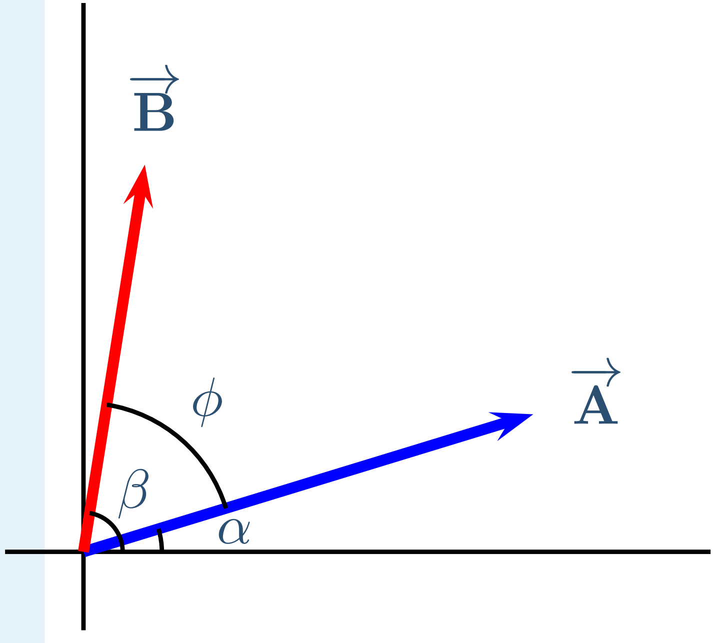

$$\vec{\mathbf{A}} \cdot \vec{\mathbf{B}} = AB\cos\phi$$

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$$AB(\cos\beta\cos\alpha + \sin\beta\sin\alpha) =$$

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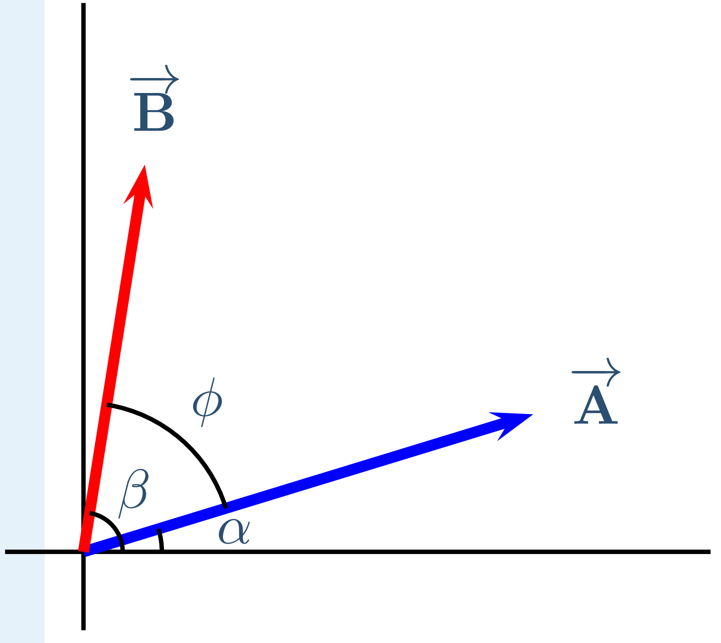

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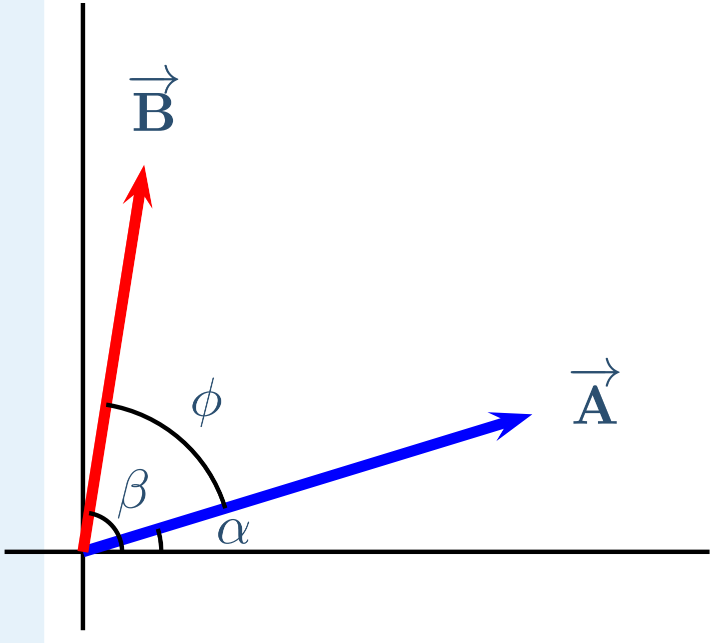

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$$\boxed{\vec{\mathbf{A}} \cdot \vec{\mathbf{B}} = A_x B_x + A_y B_y}$$

Total Work

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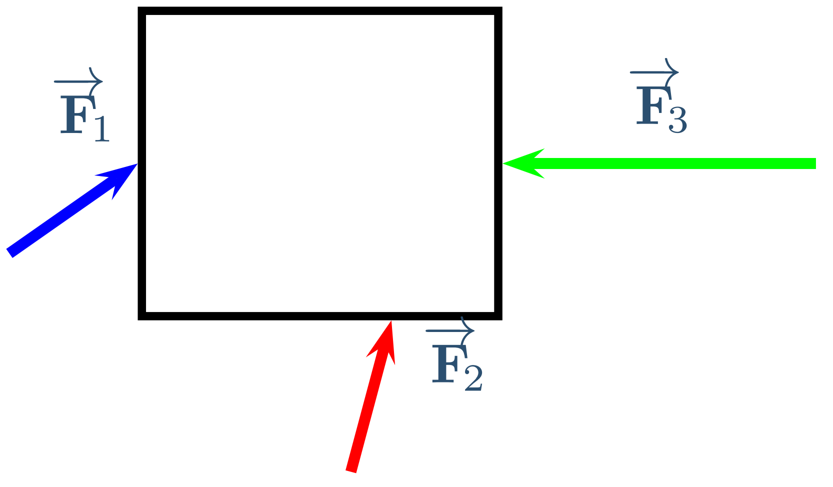
So total work done by a collection of forces is given by the sum of the individual works.



$$W_{total} = W_1 + W_2 + W_3 + \ldots$$