March 6, Week 8

Today: Chapter 6, Work

Exam #2, Friday, March 8

Practice Exam Solutions on Website

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

Thursday office hours will be held in Room 109 of Regener Hall from 1:00-3:30.

If interested in Physics 110, come talk to me

Total Work

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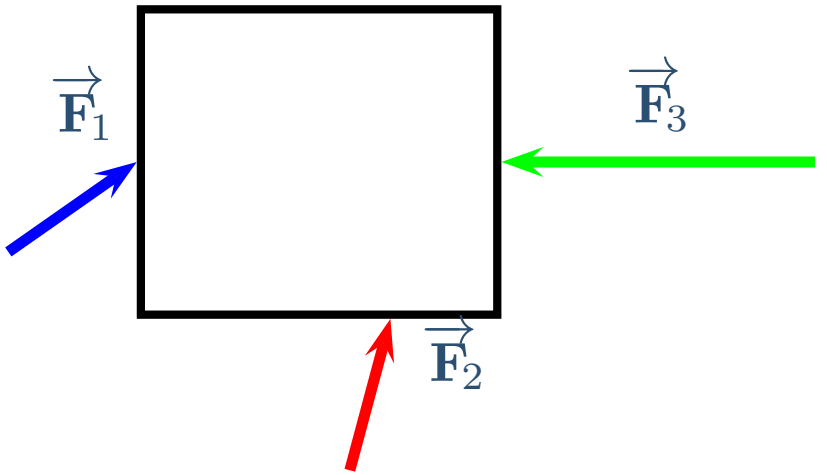
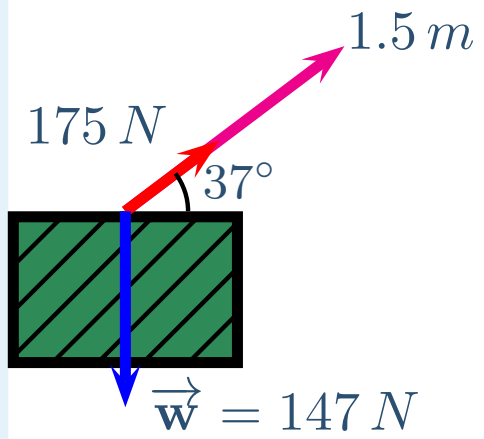
So total work done by a collection of forces is given by the sum of the individual works.



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

Total Work Exercise

A $15\,kg$ mass is lifted $1.5\,m$ at $37°$ by applying a constant $175\,N$ force also at $37°$. What is the *total* work done?



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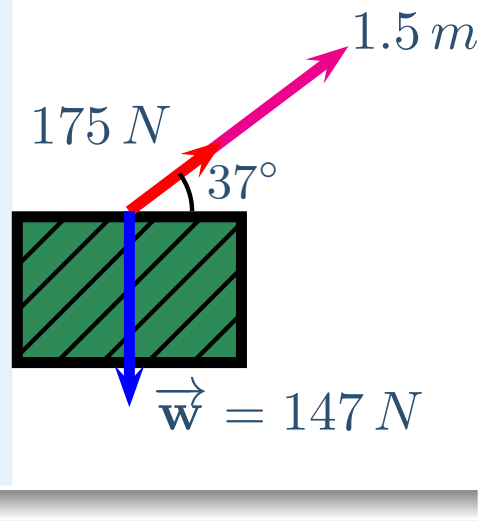

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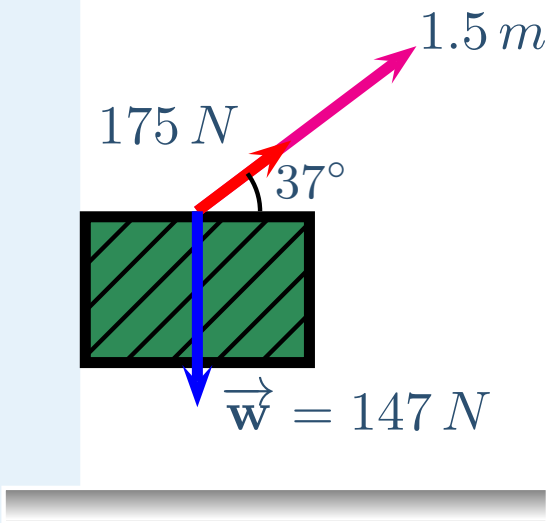

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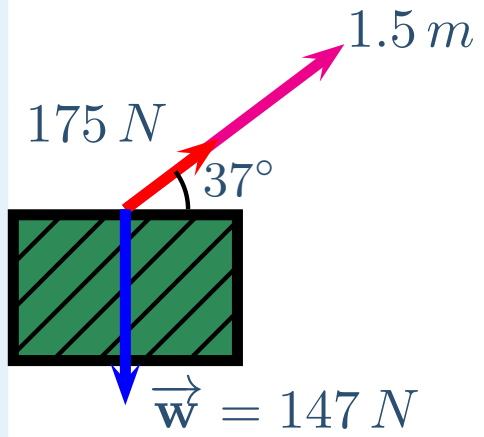

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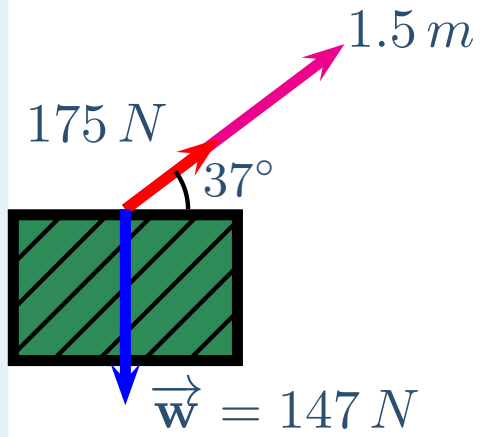

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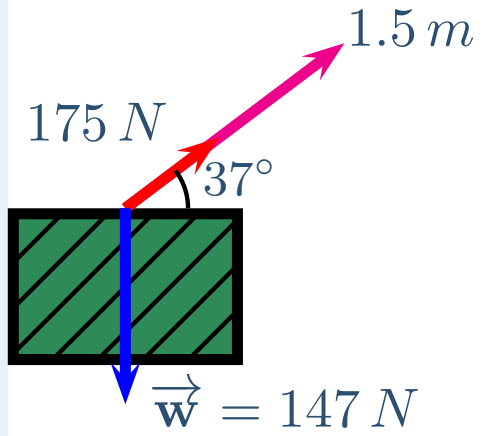

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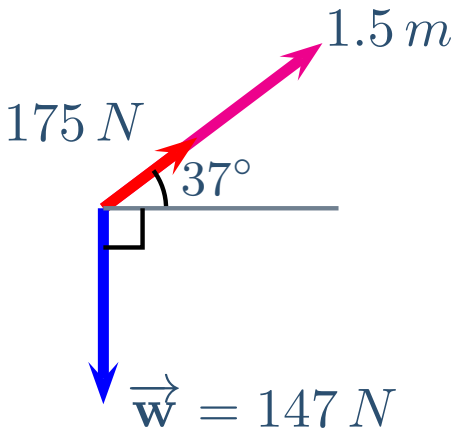
ϕ is the angle *between* the force and the displacement



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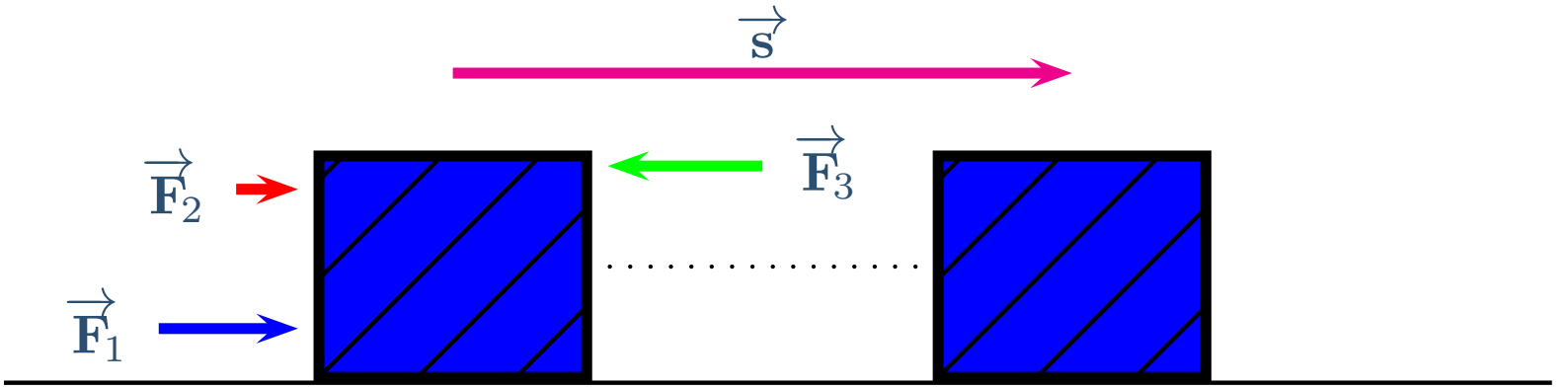

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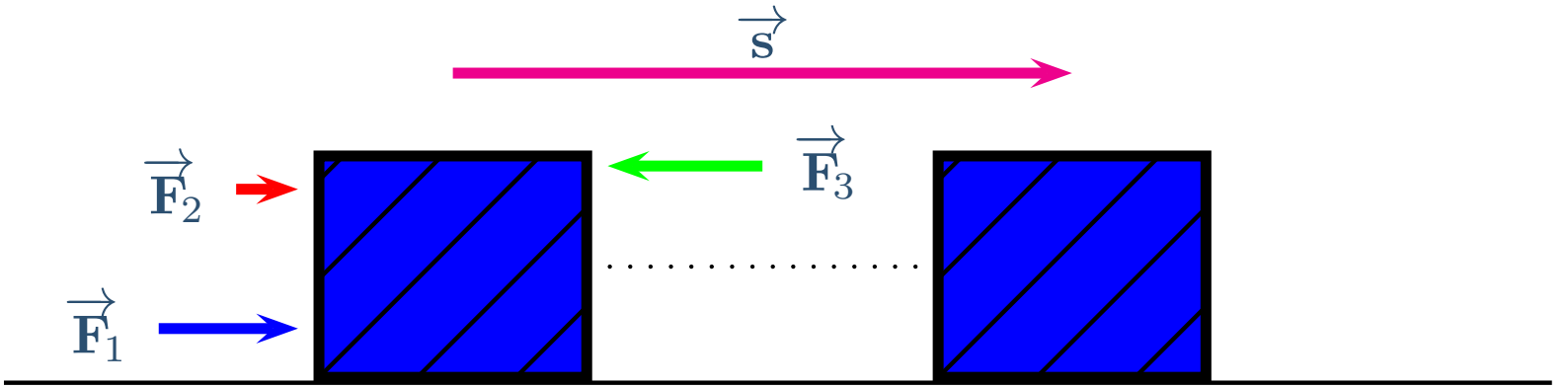

Forces all in a line

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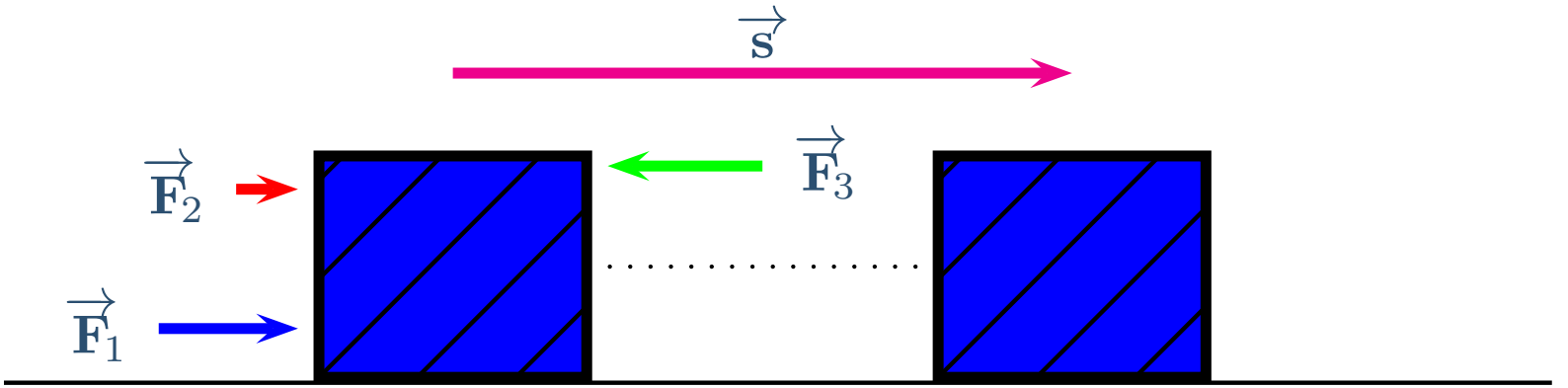

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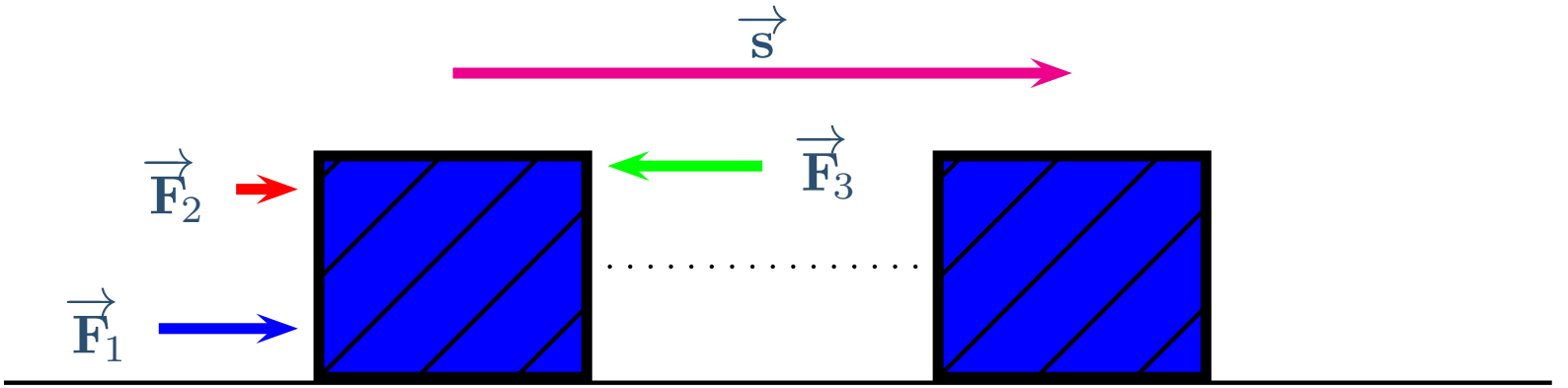

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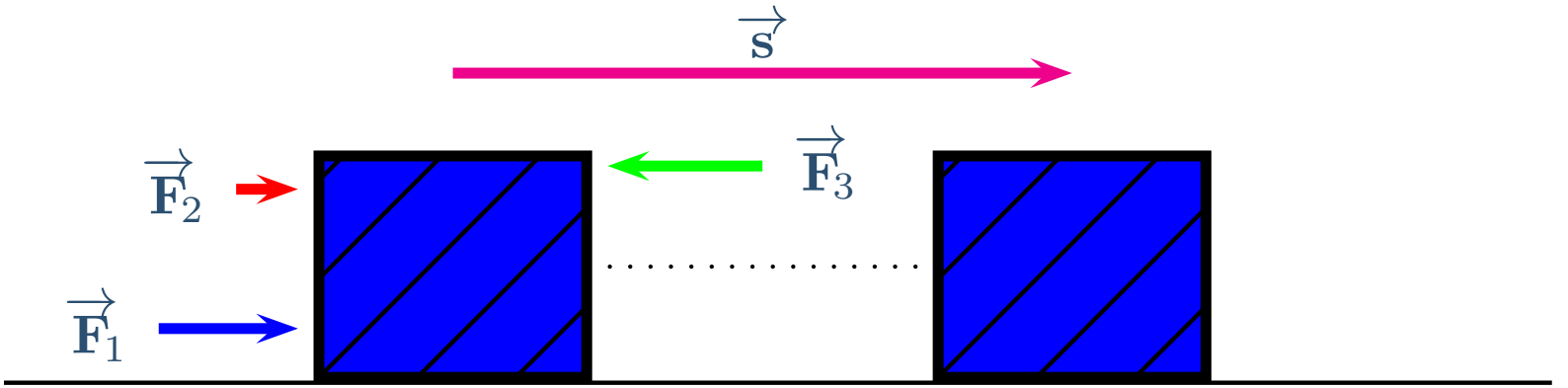

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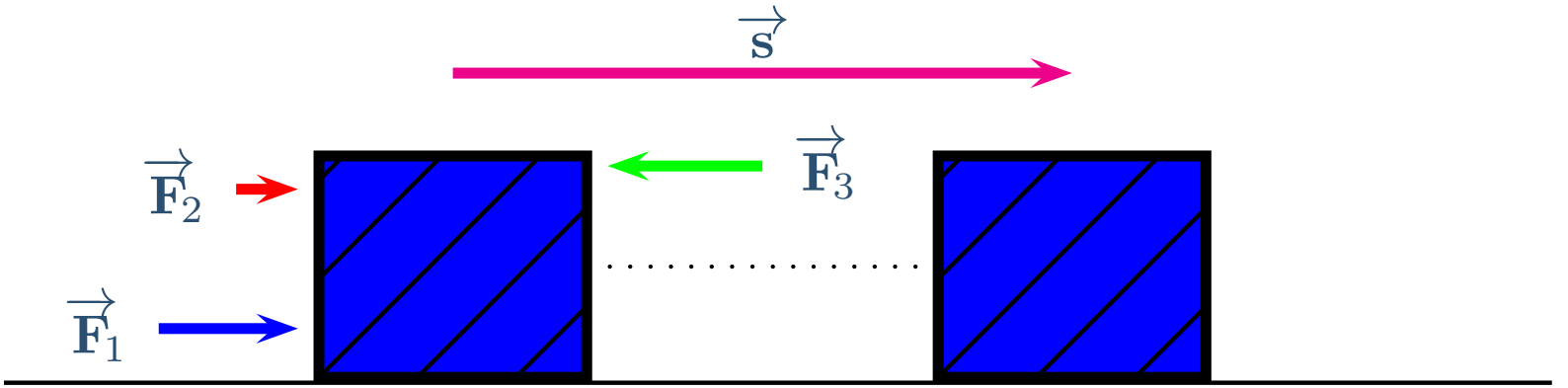

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Using $v_2^2 = v_1^2 + 2as \Rightarrow$ $\boxed{W_{total} = \frac{1}{2}mv_2^2 - \frac{1}{2}mv_1^2}$

Work-Energy Theorem II

It can be shown that for constant forces in *ANY* direction that:

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Example: A $15\,kg$ box is lifted, from rest, by applying a $175\,N$ force at $37°$. How fast will the box be going after it has moved $1.5\,m$?

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Scalars cannot determine direction

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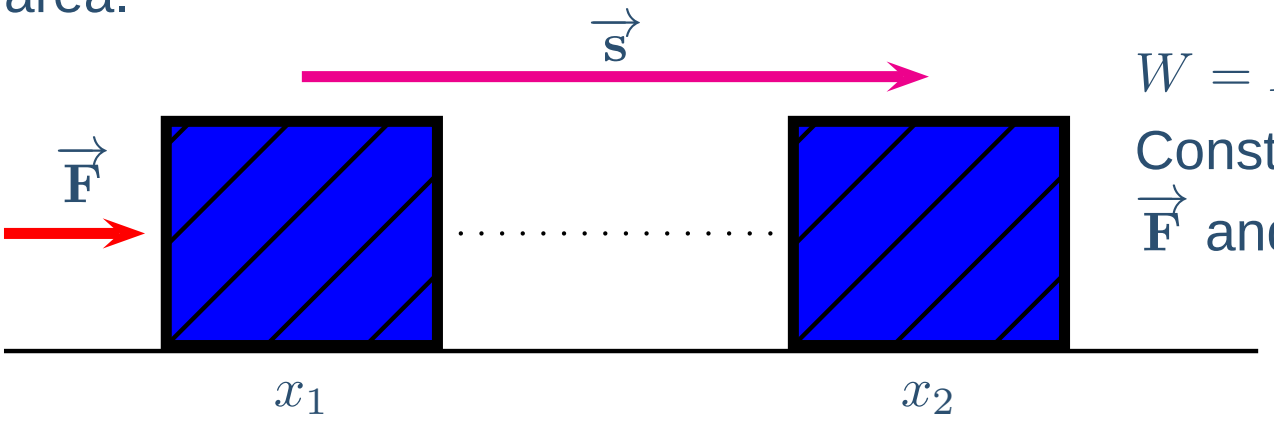

$W = Fs = F(x_2 - x_1)$

Constant F

$\vec{\mathbf{F}}$ and $\vec{\mathbf{s}}$ parallel

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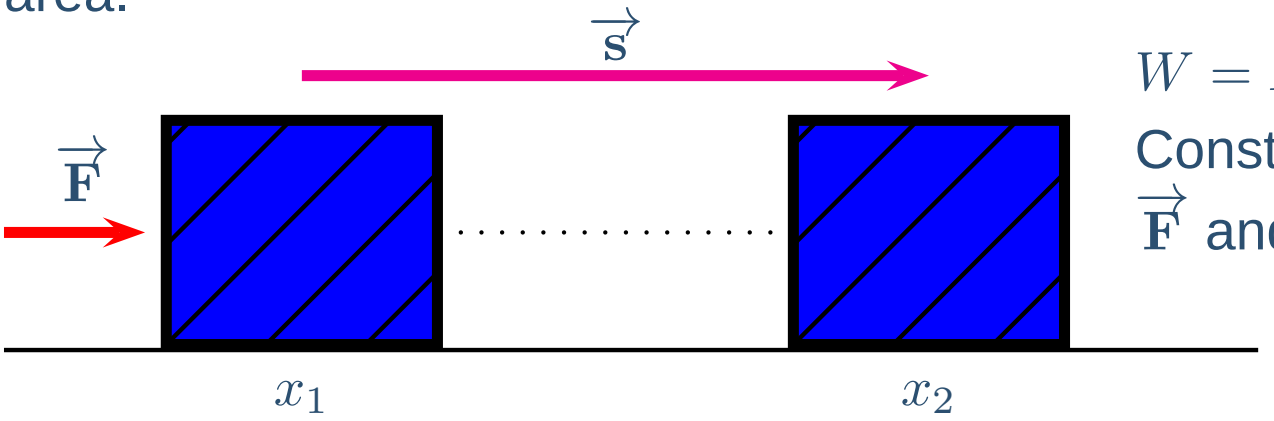

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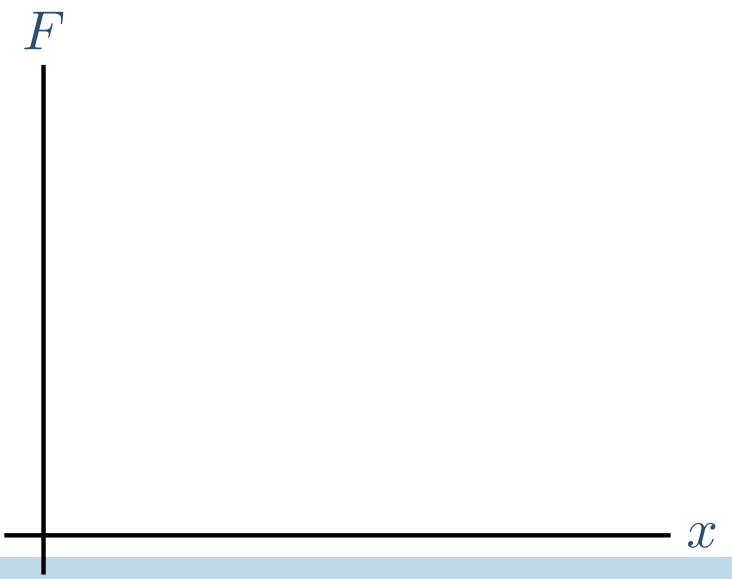

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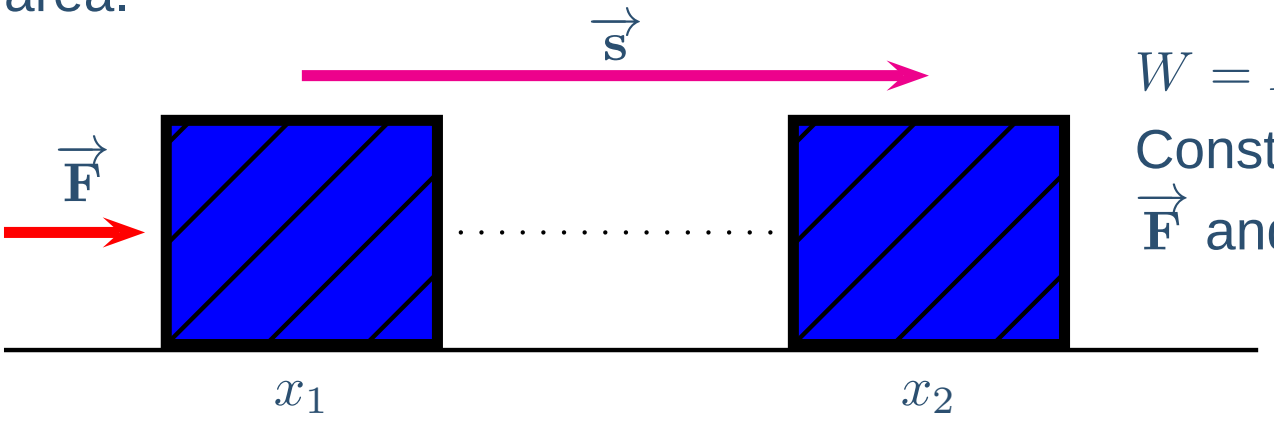

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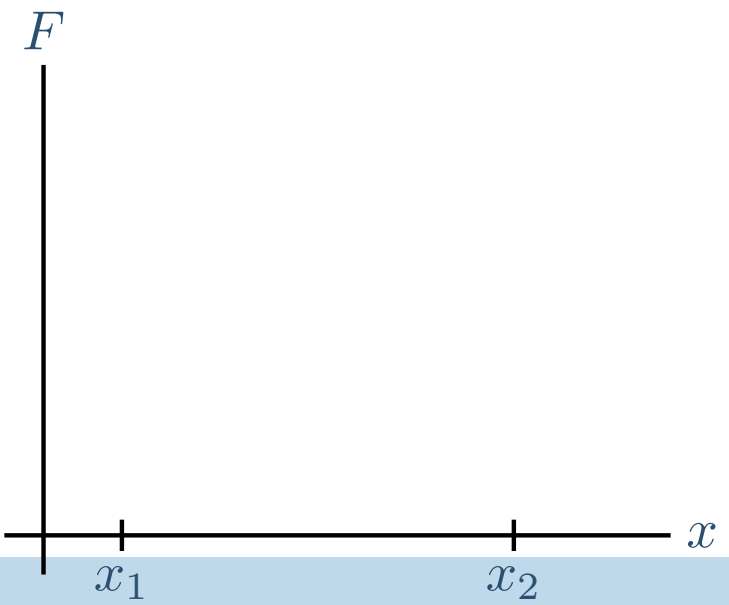

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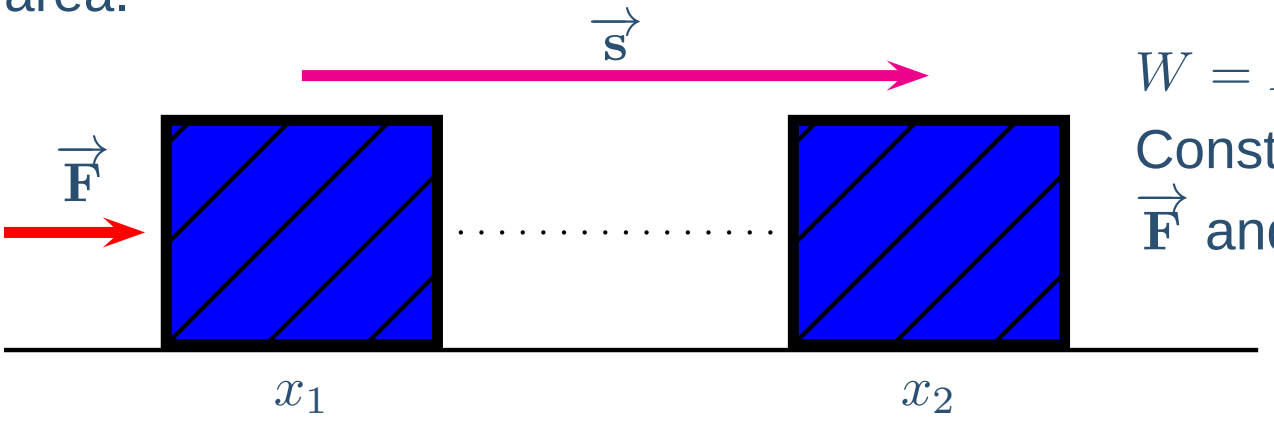

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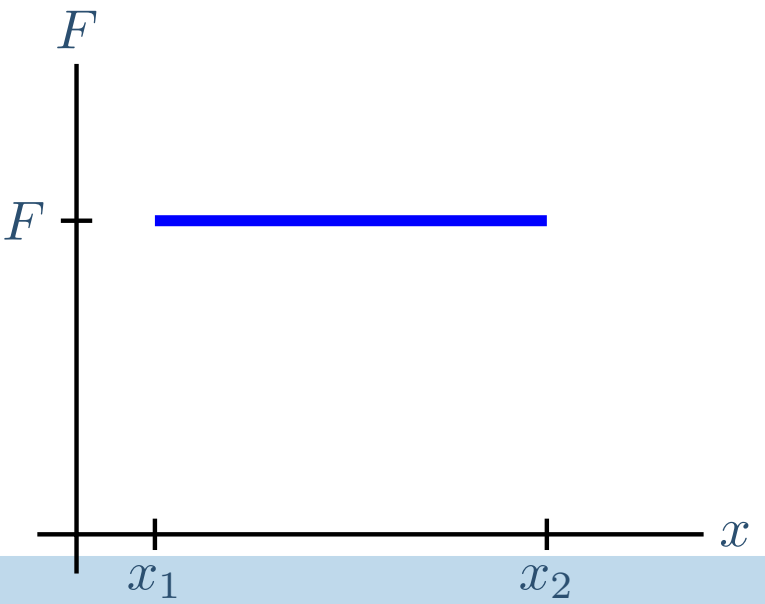

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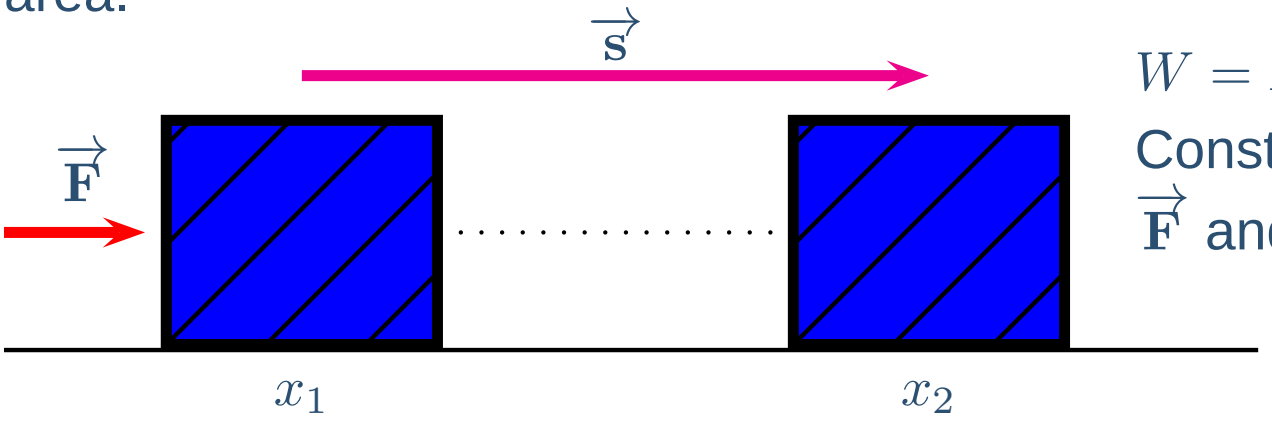

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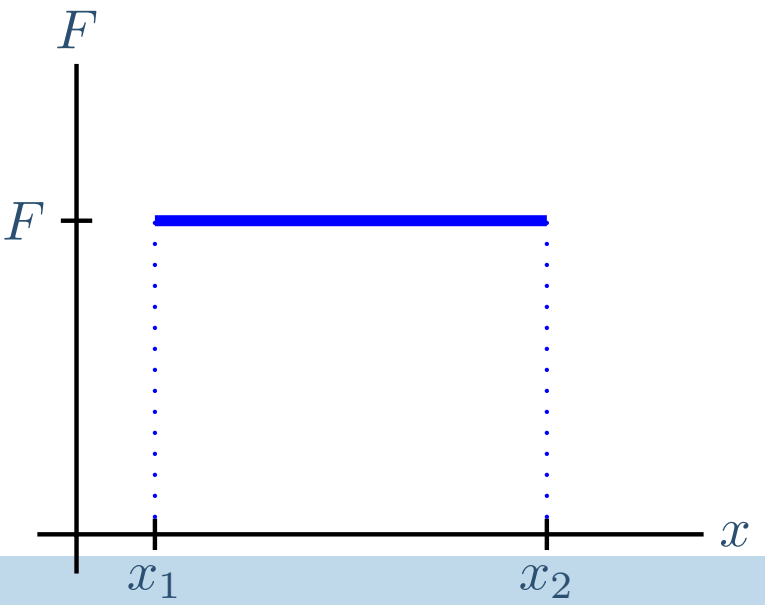

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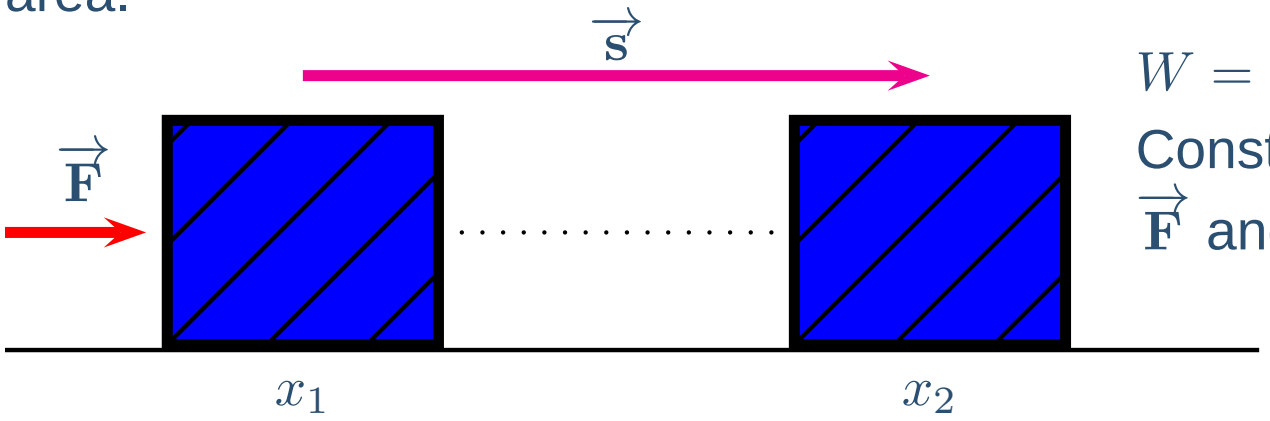

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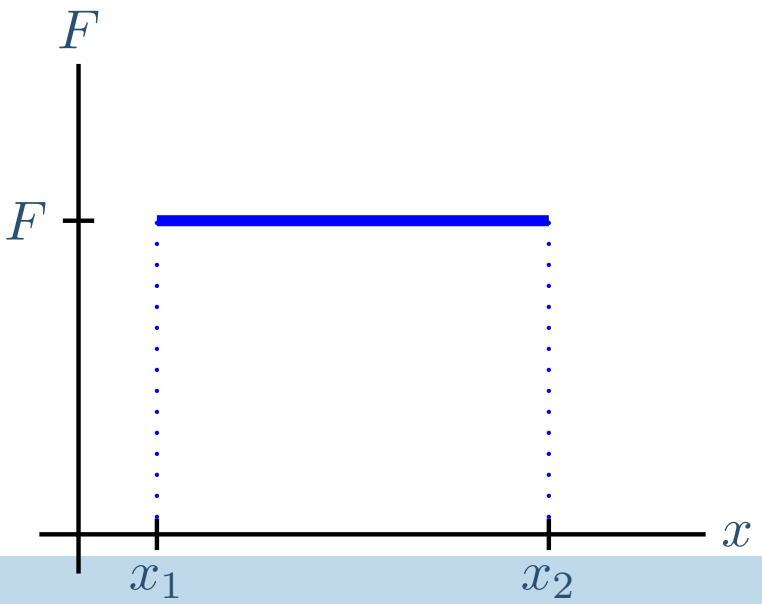

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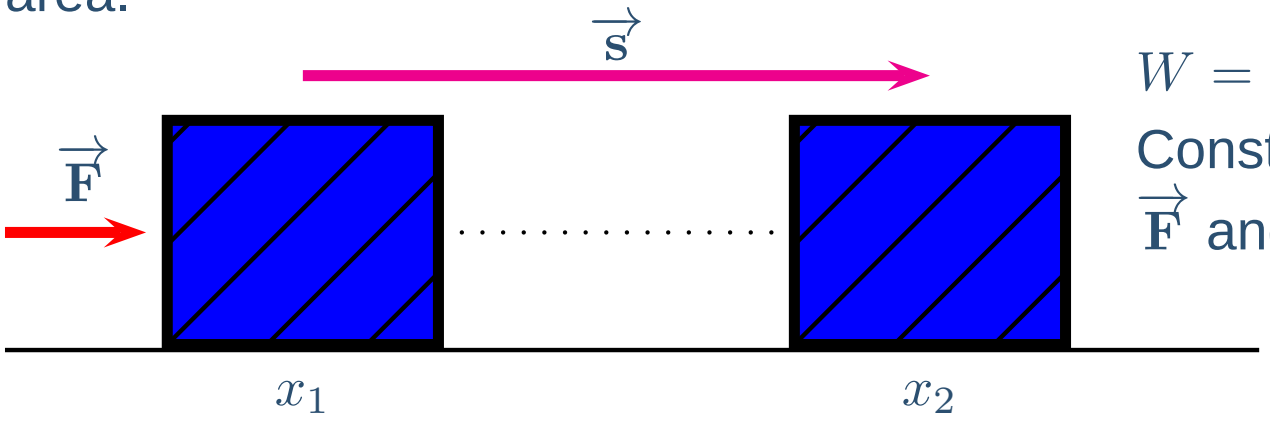

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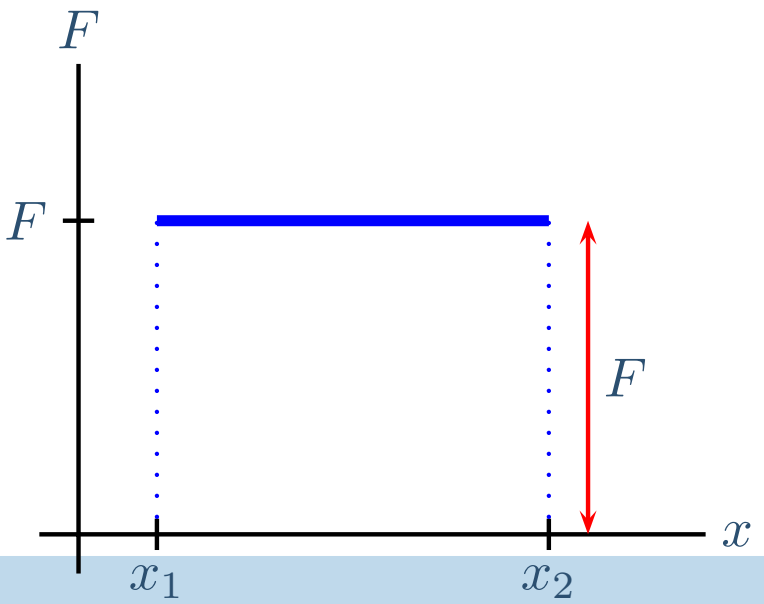

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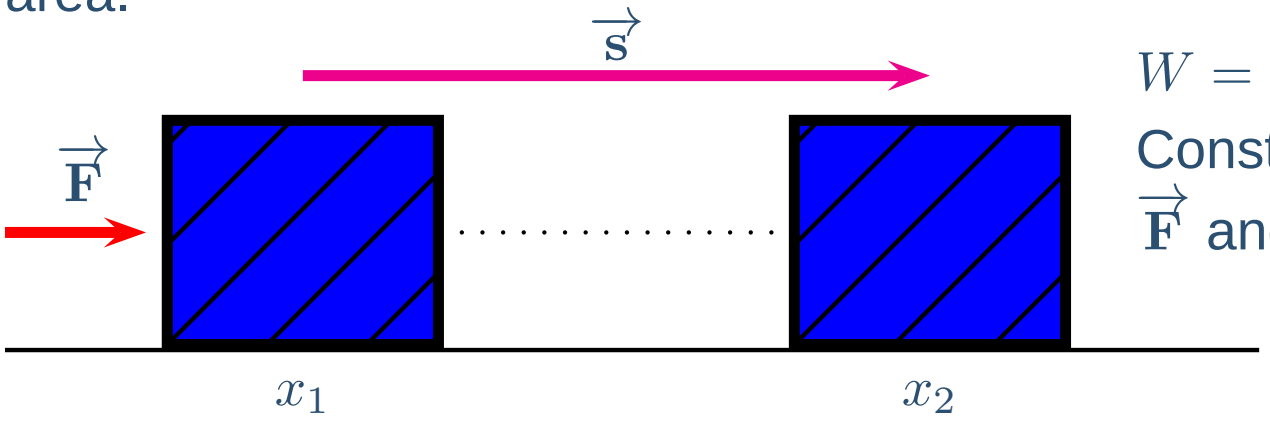

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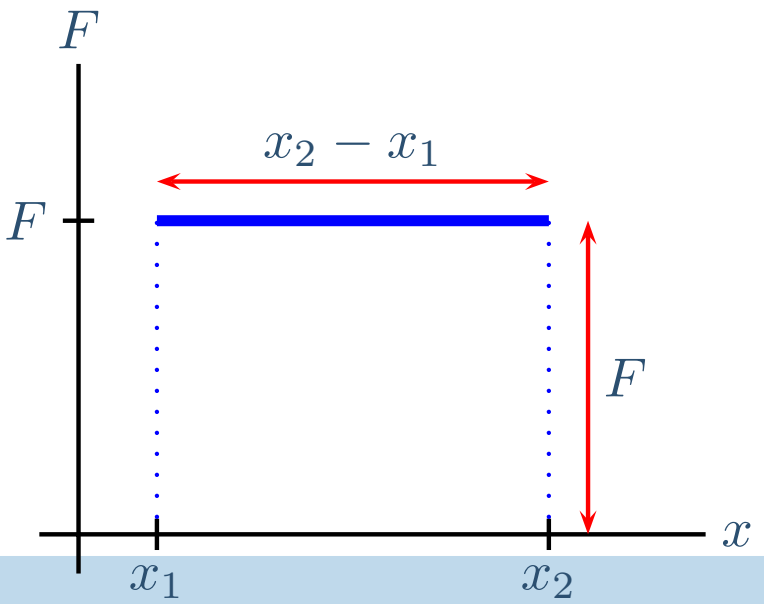

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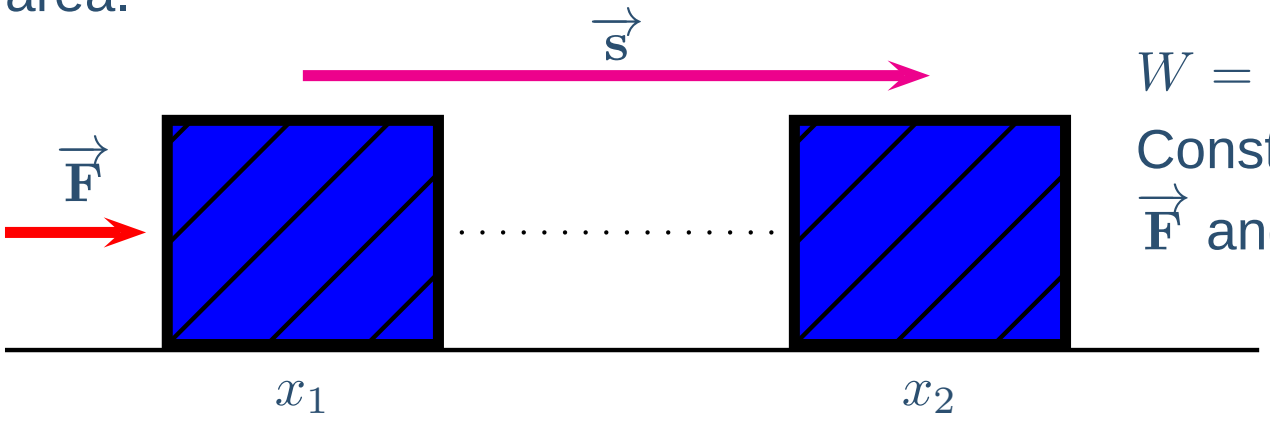

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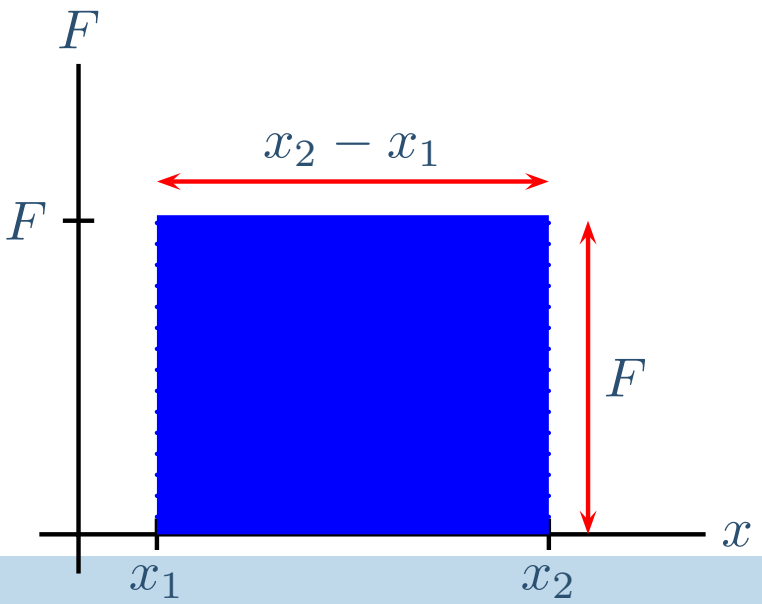

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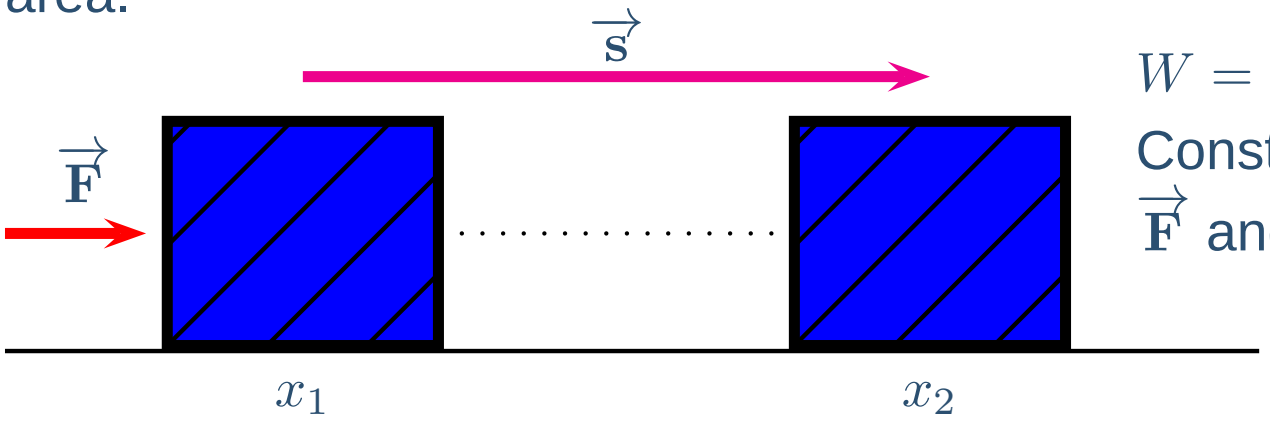

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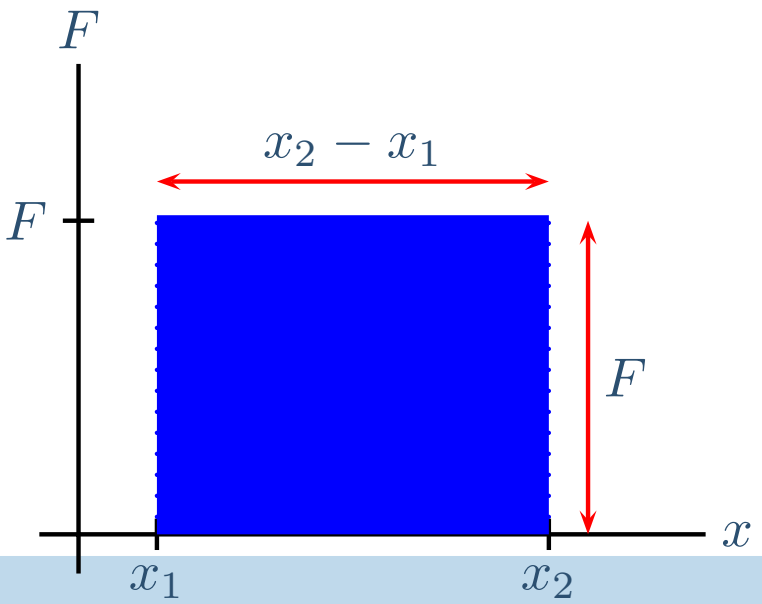
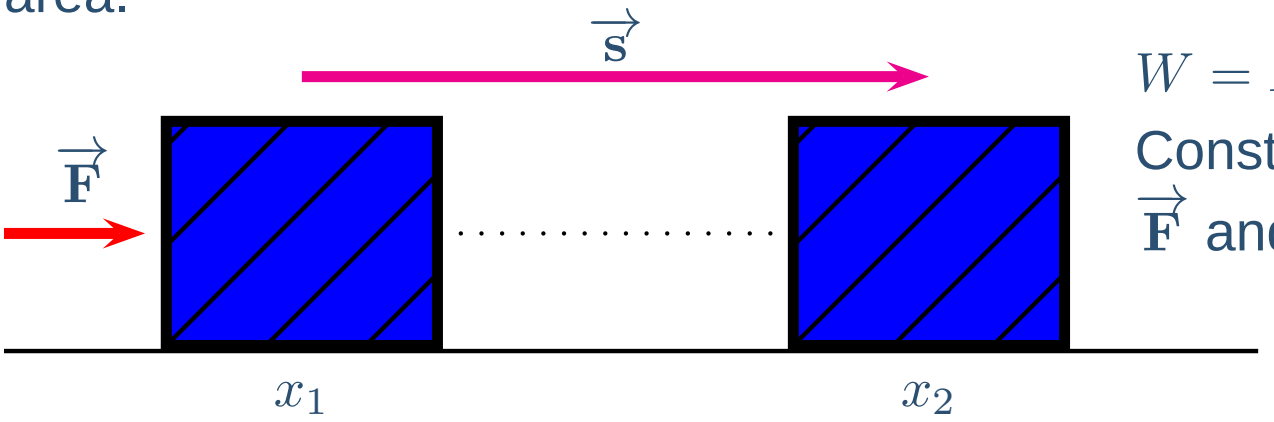


$W = F\,(x_2 - x_1)$

Work is the area under the curve

Variable Forces II

To find the work done by a changing force requires finding an area.



$W = Fs = F(x_2 - x_1)$

Constant F

$\vec{\mathbf{F}}$ and $\vec{\mathbf{s}}$ parallel

Variable Forces II

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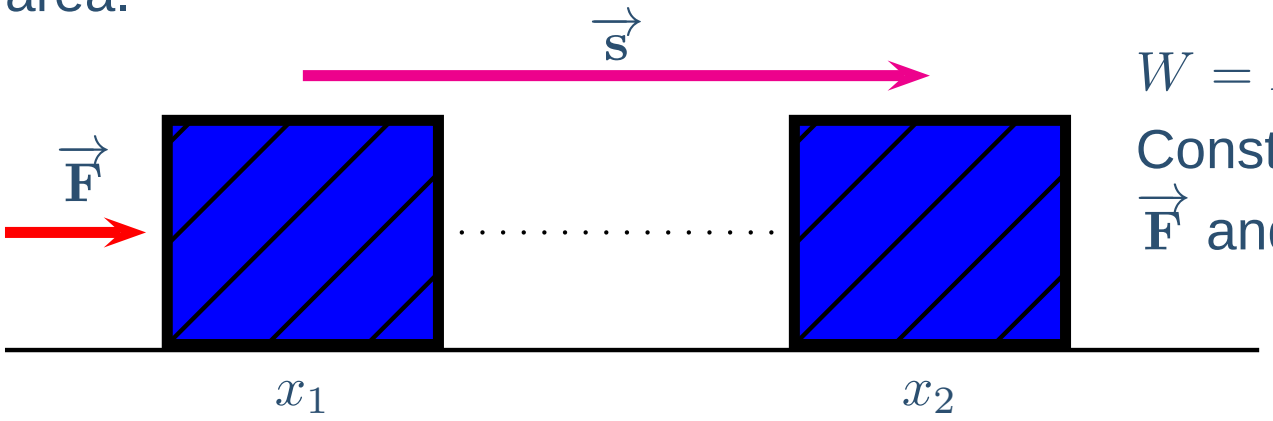

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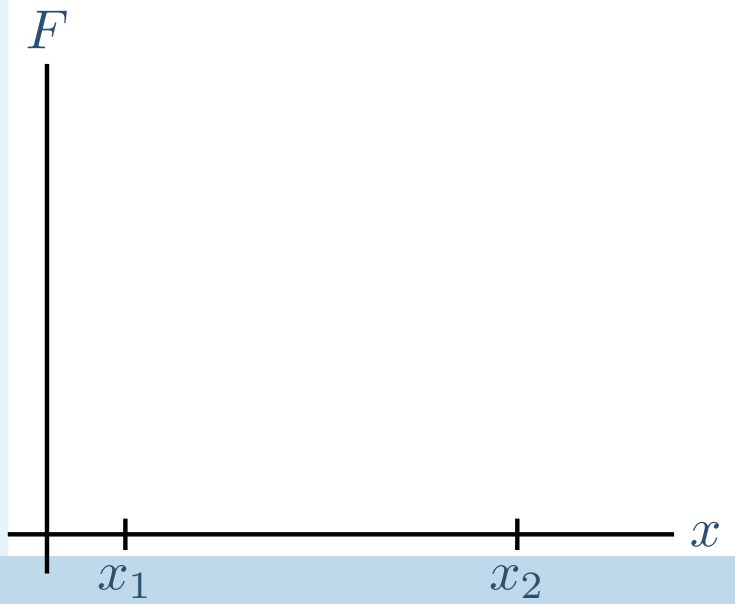

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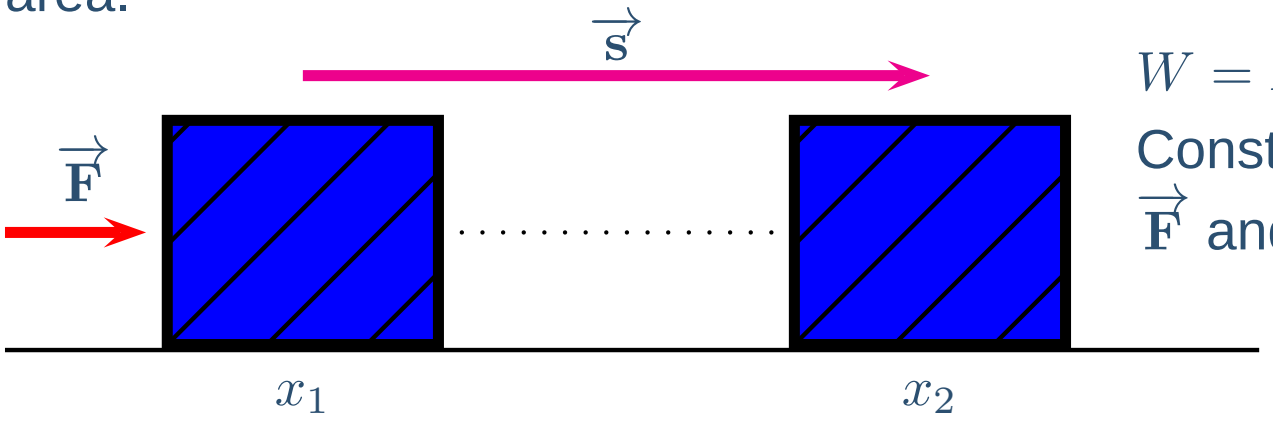

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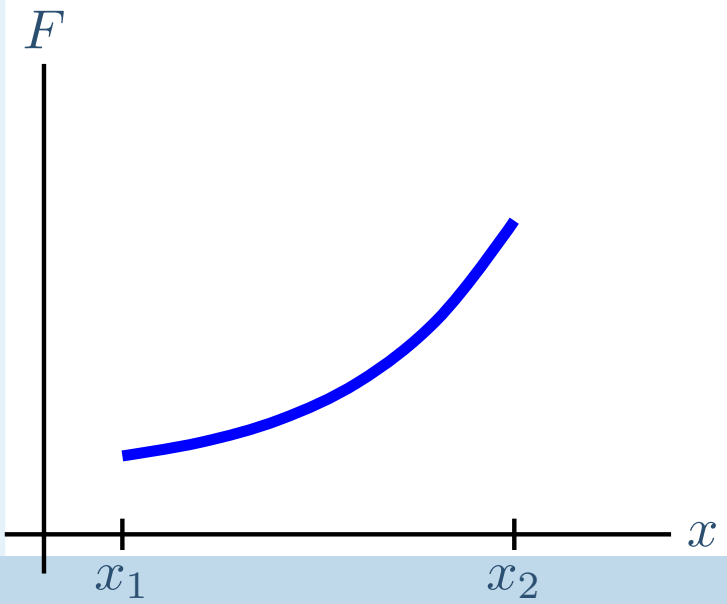

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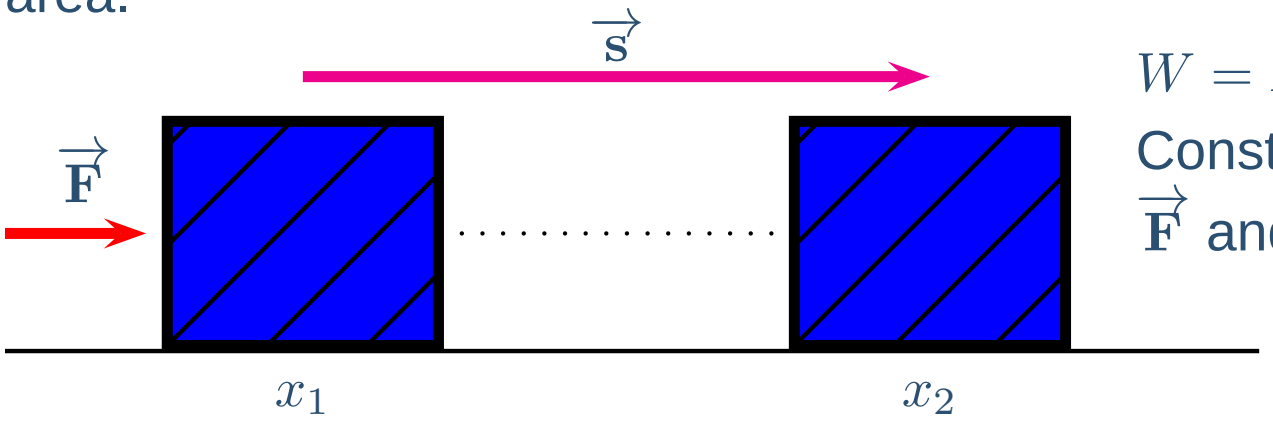

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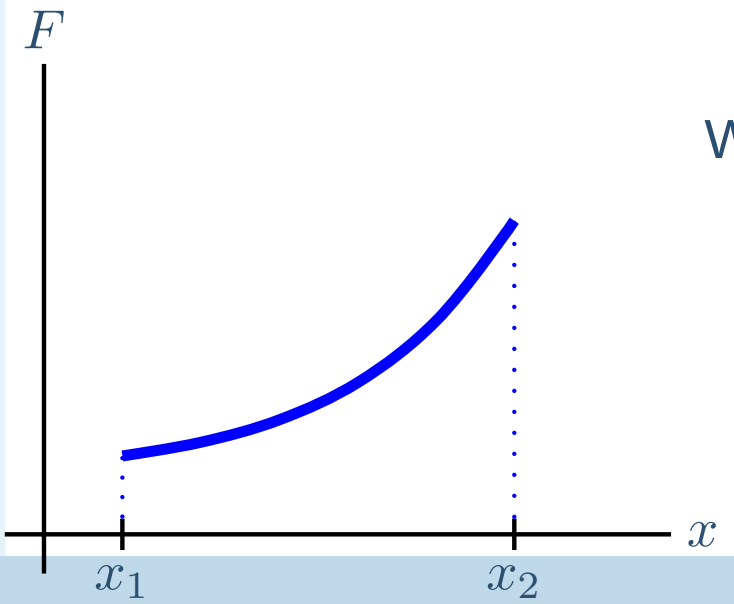
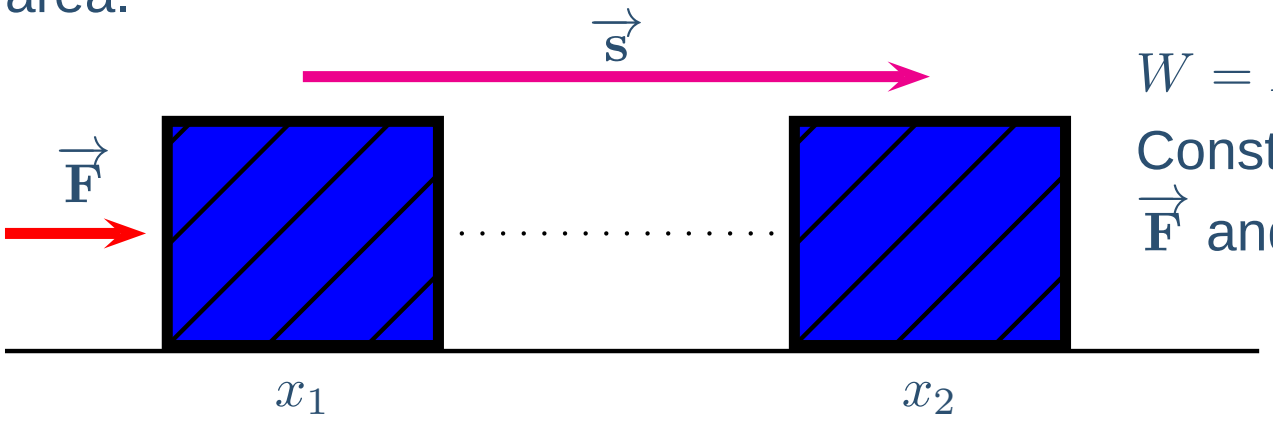


Work is the area under this curve

Variable Forces II

To find the work done by a changing force requires finding an area.



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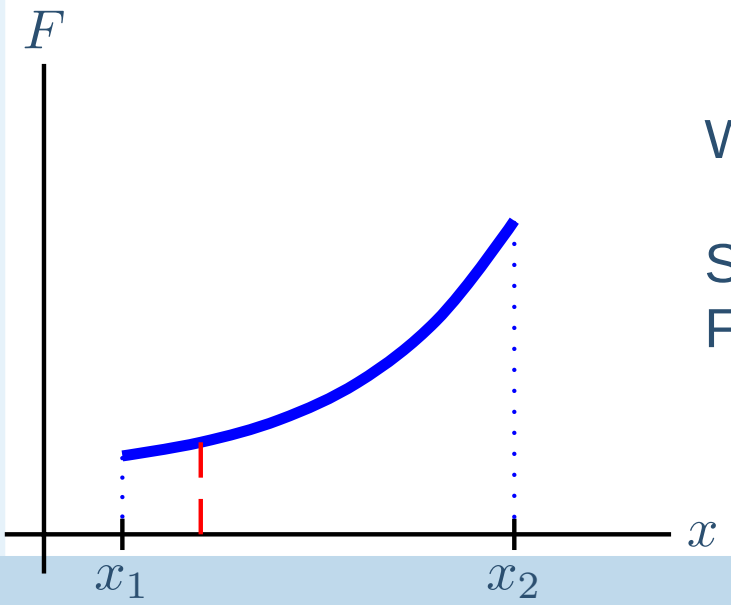
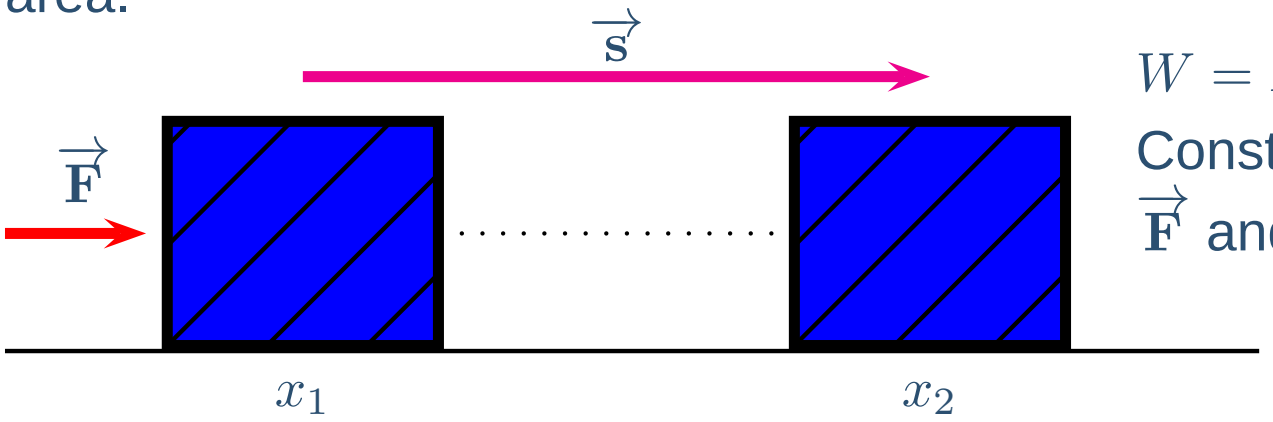


Work is the area under this curve

Split region into many small rectangles.
Find area of each rectangle and add.

Variable Forces II

To find the work done by a changing force requires finding an area.



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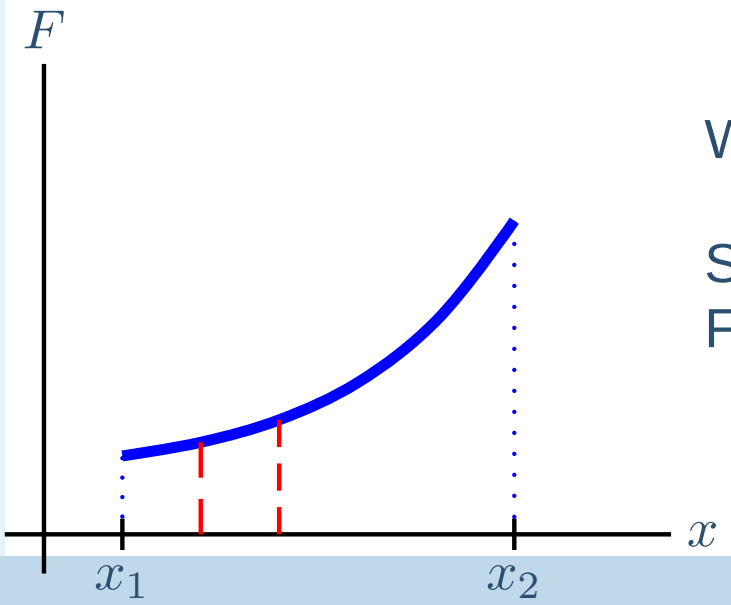

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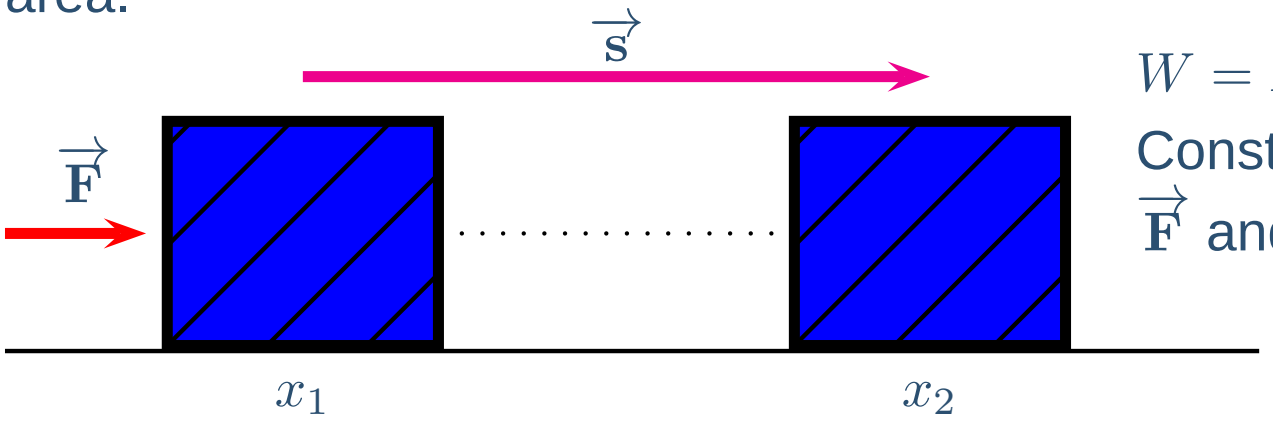

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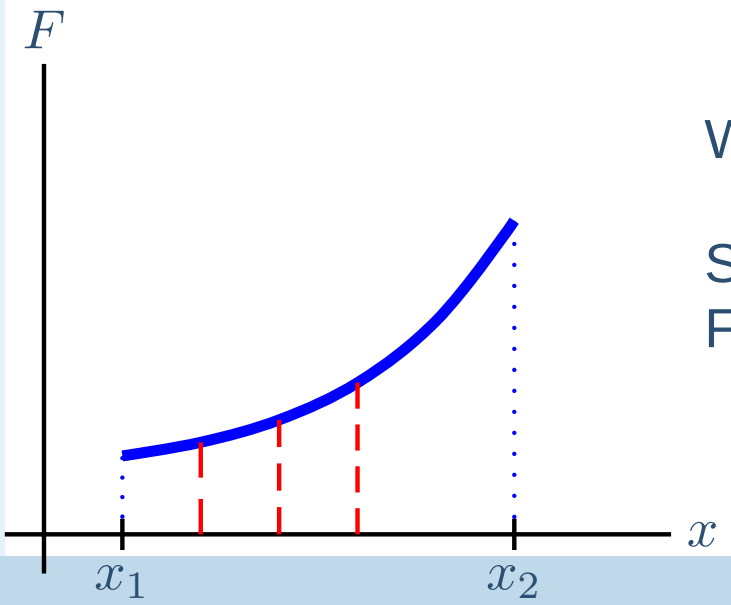

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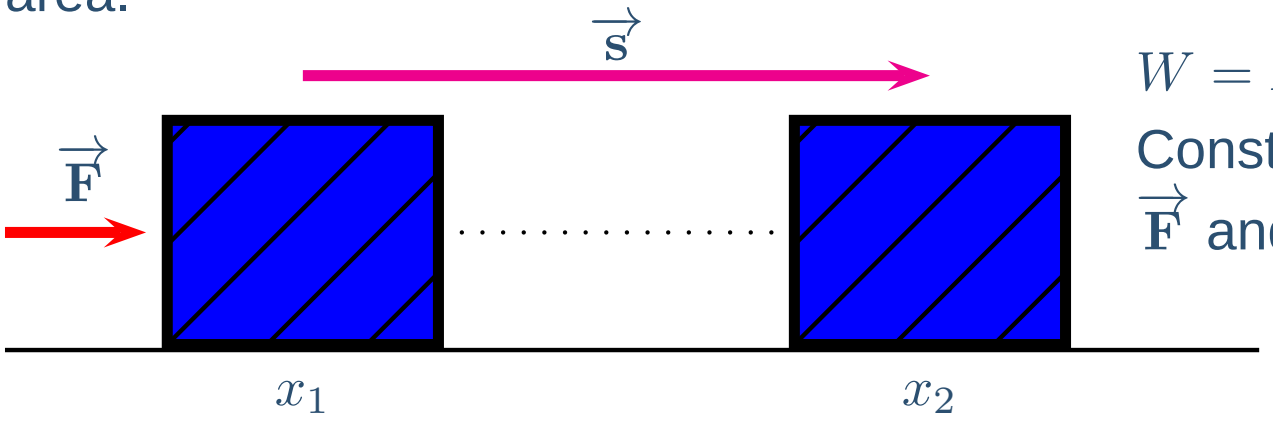

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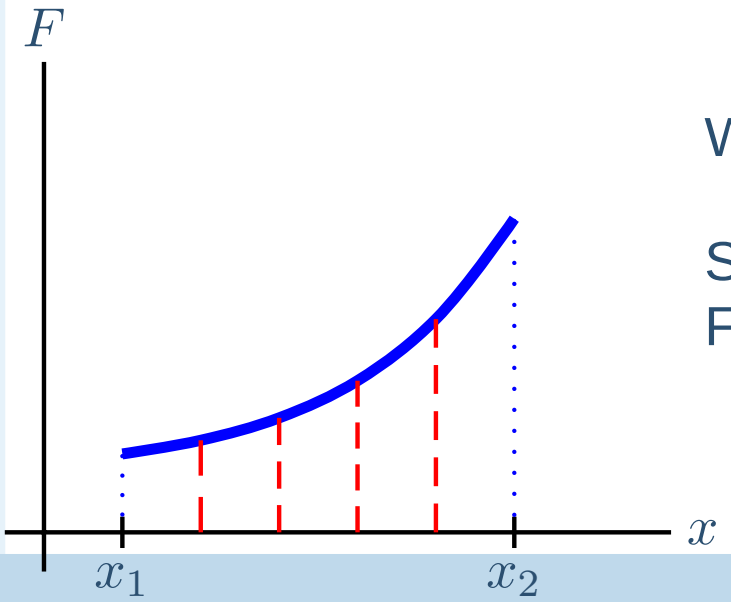

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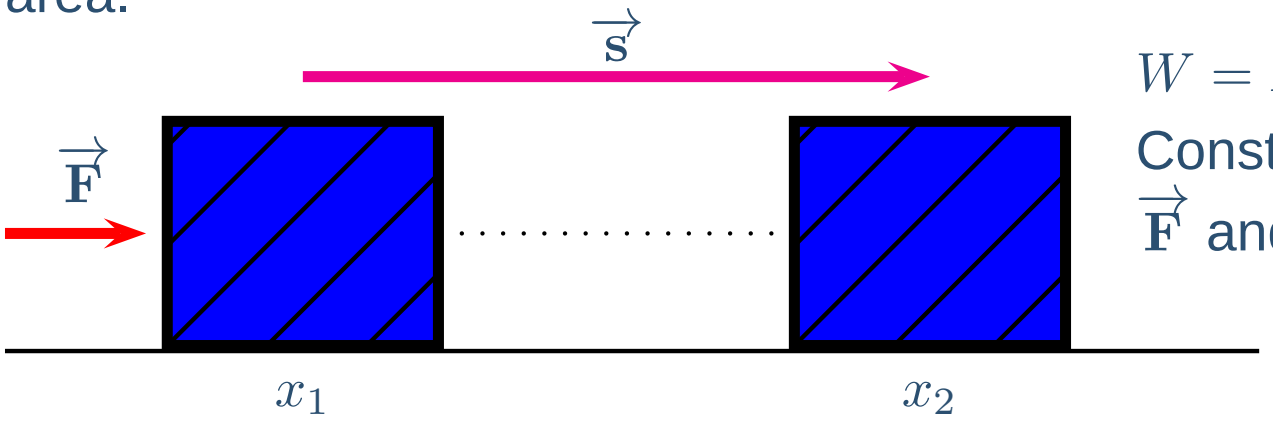

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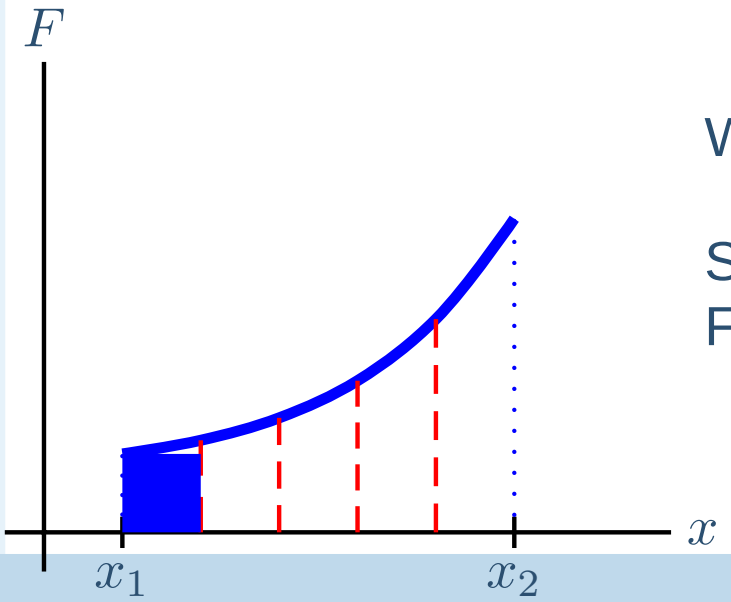

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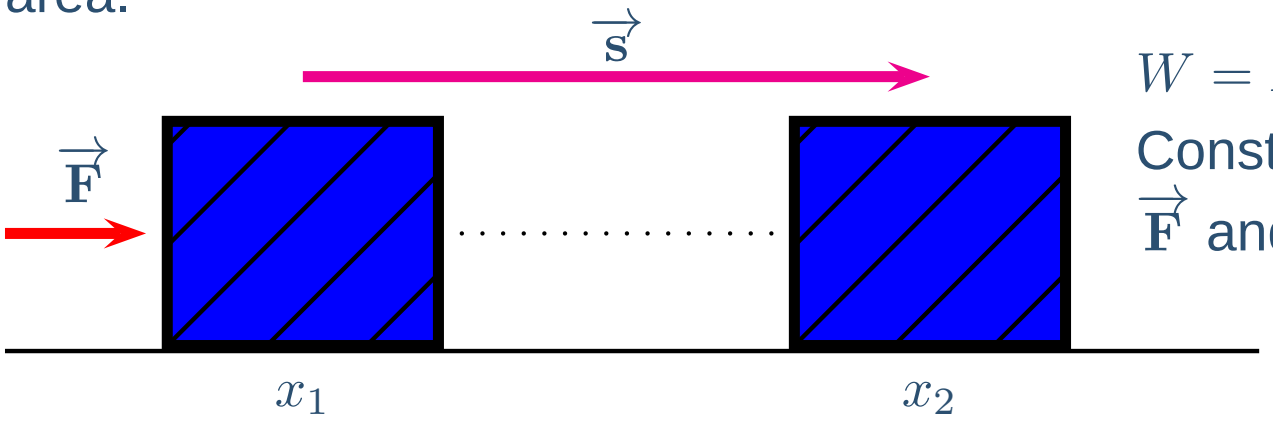

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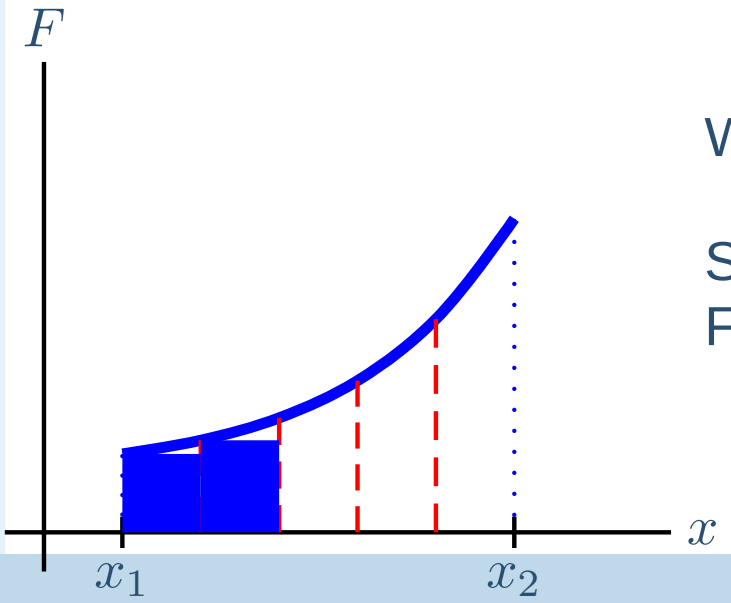

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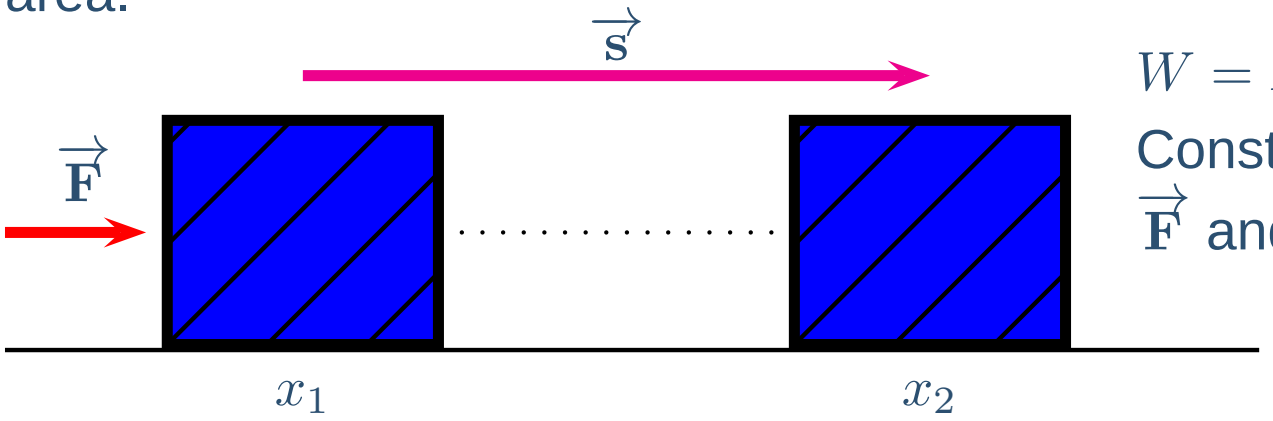

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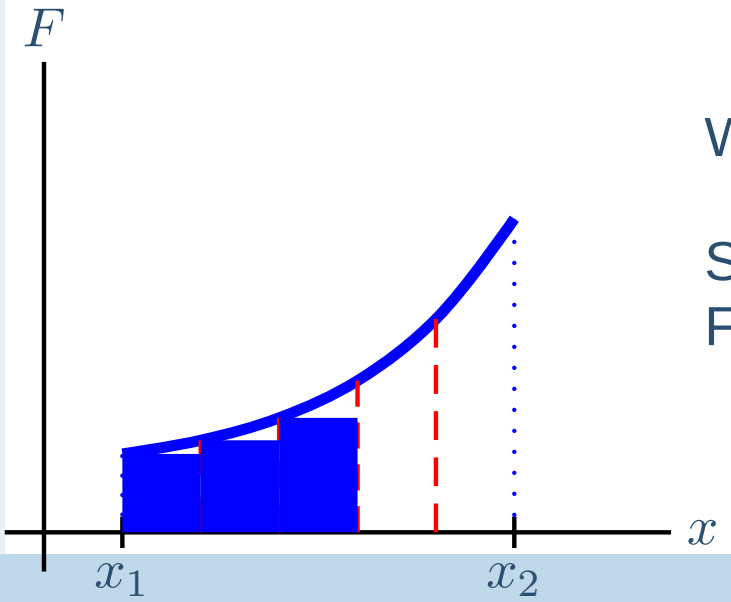

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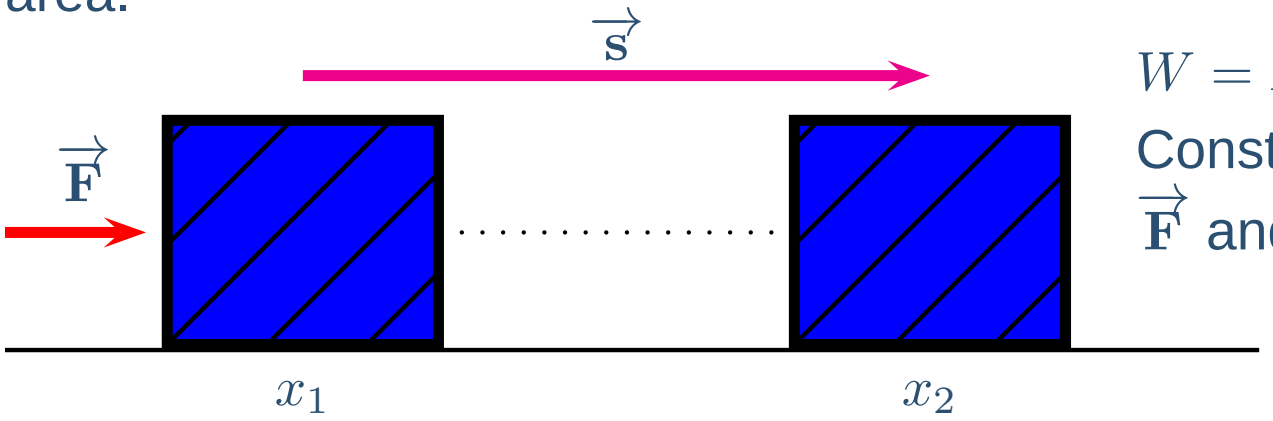

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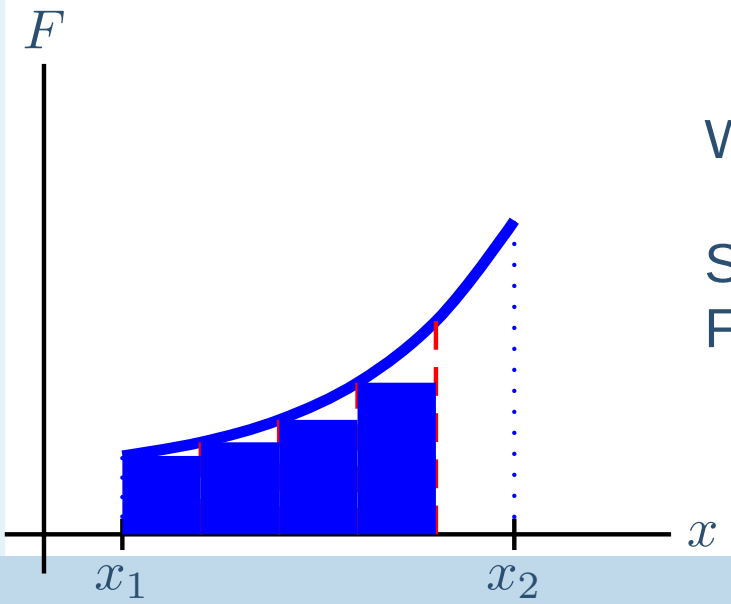

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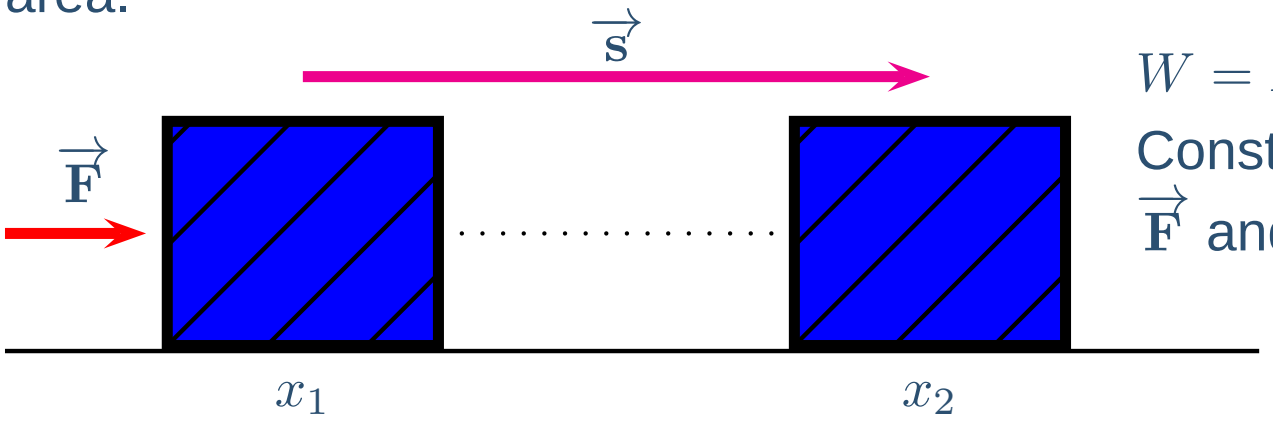

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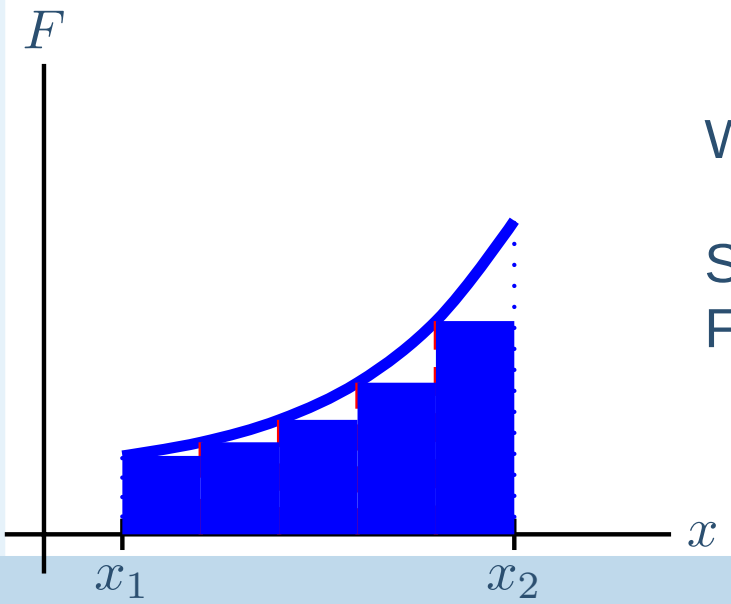

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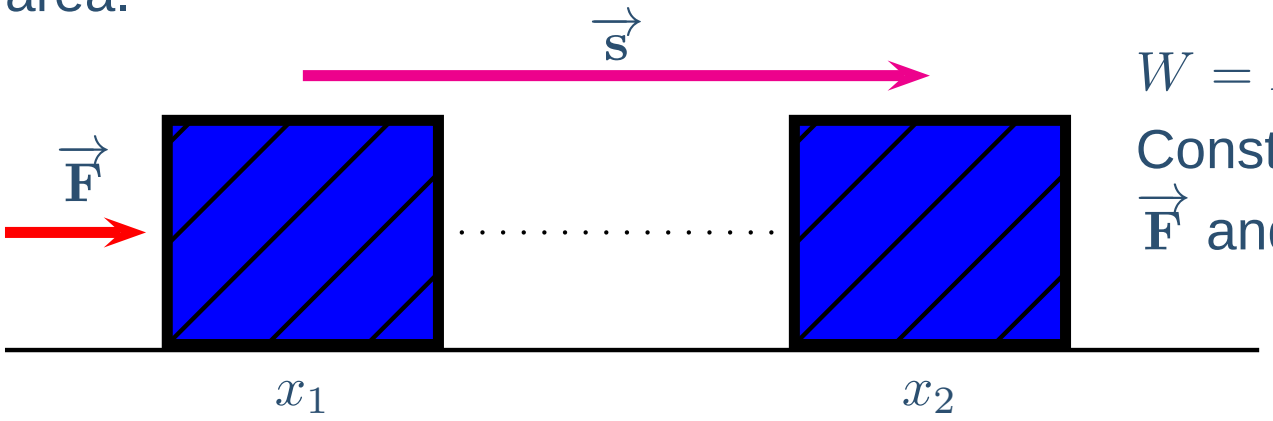

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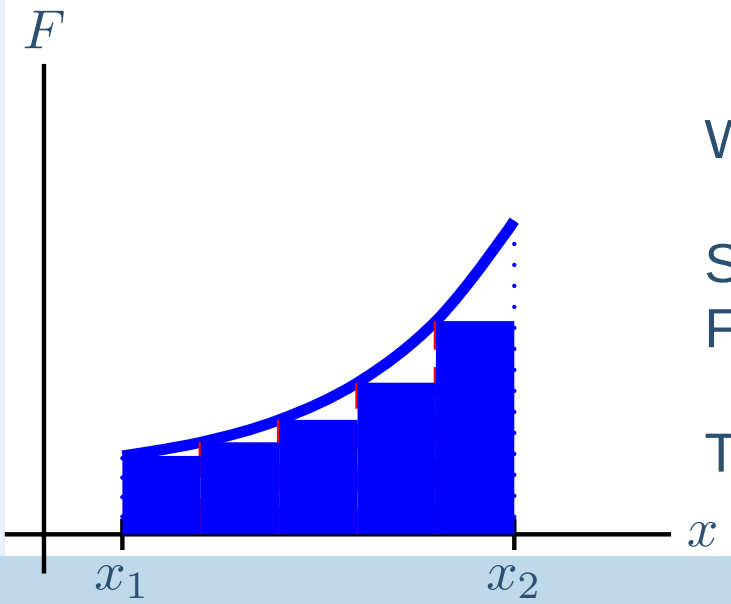


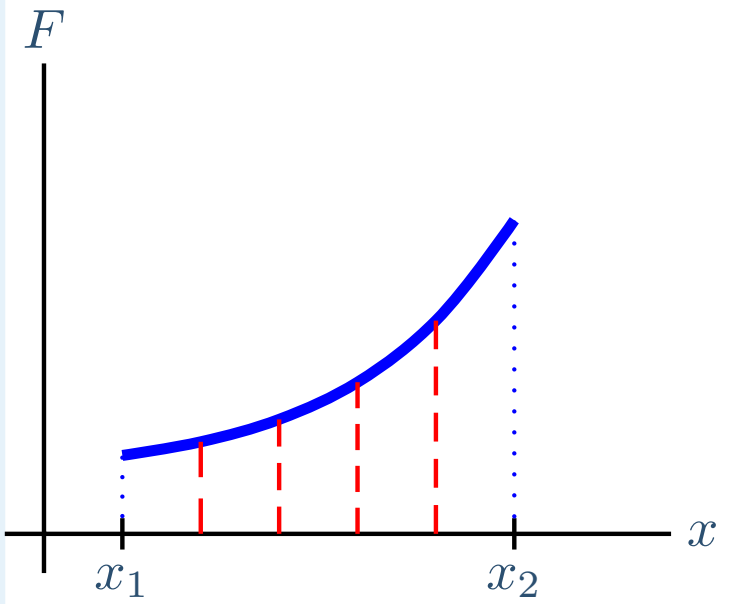
Work is the area under this curve

Split region into many small rectangles. Find area of each rectangle and add.

Take a limit to find the exact area.

Variable Forces III

To find the work done by a changing force requires finding an area.



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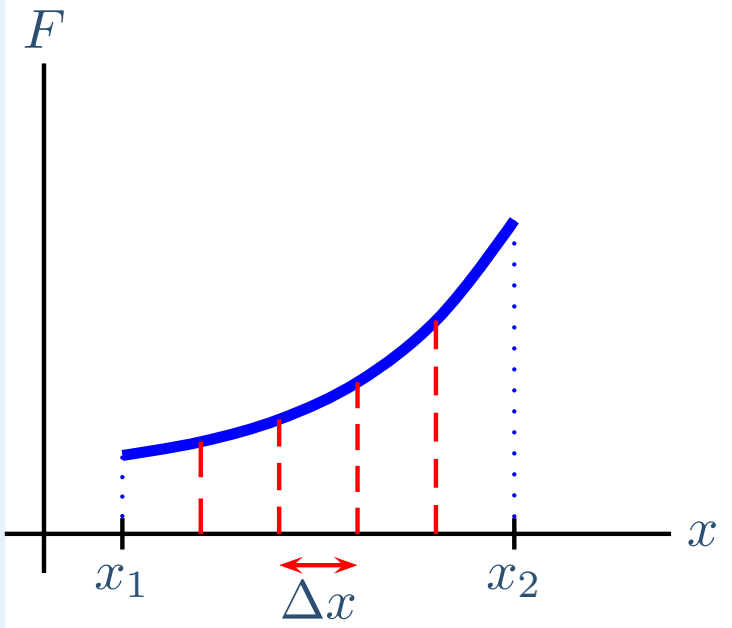

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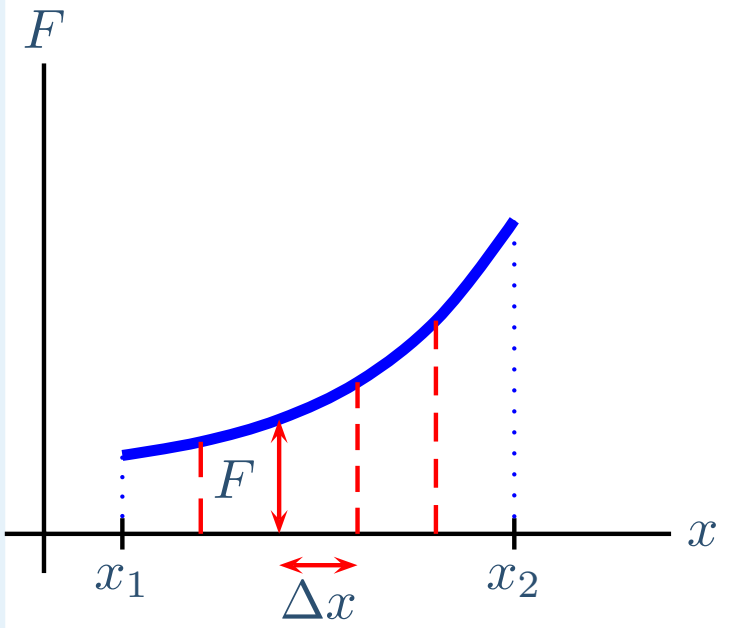

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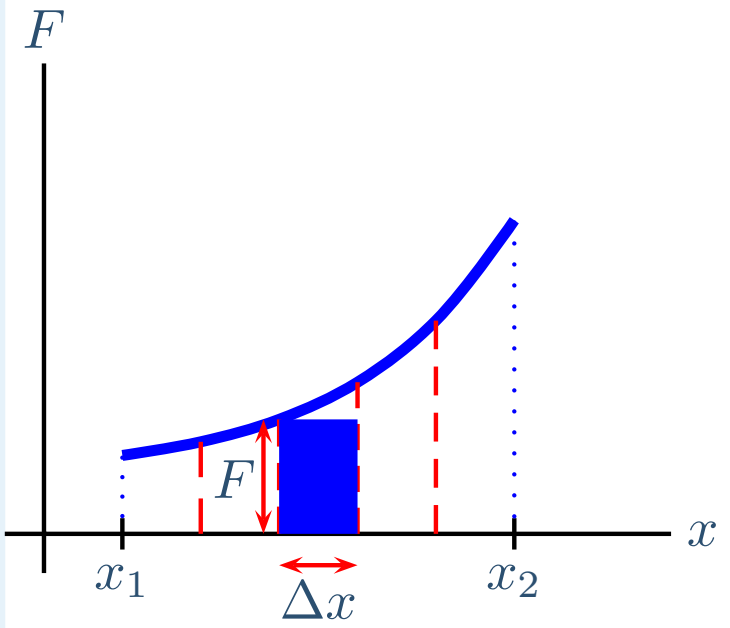

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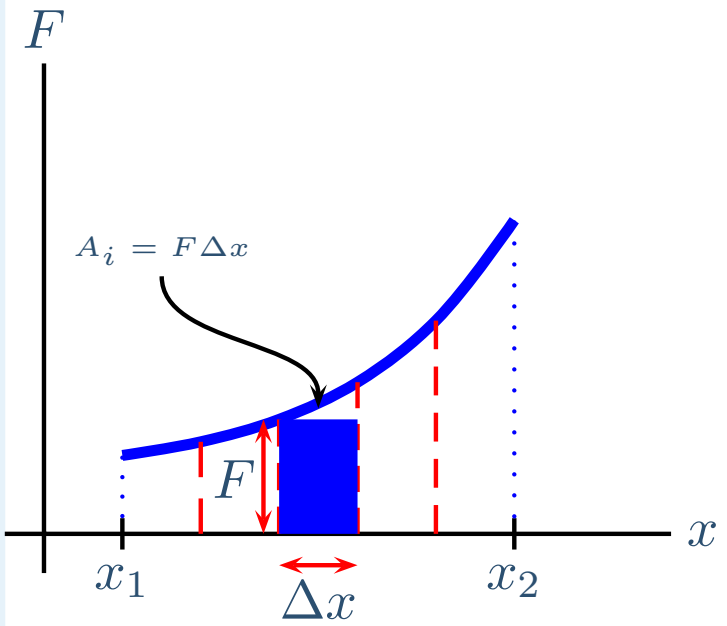

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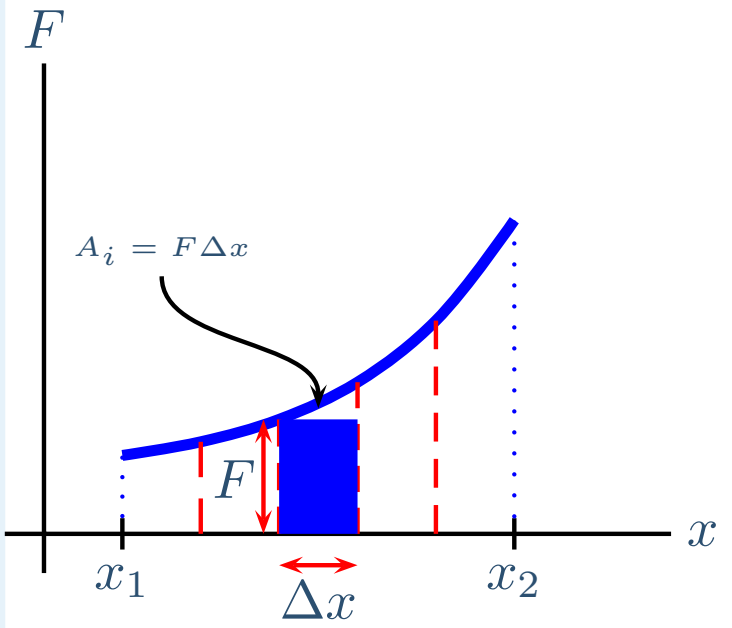

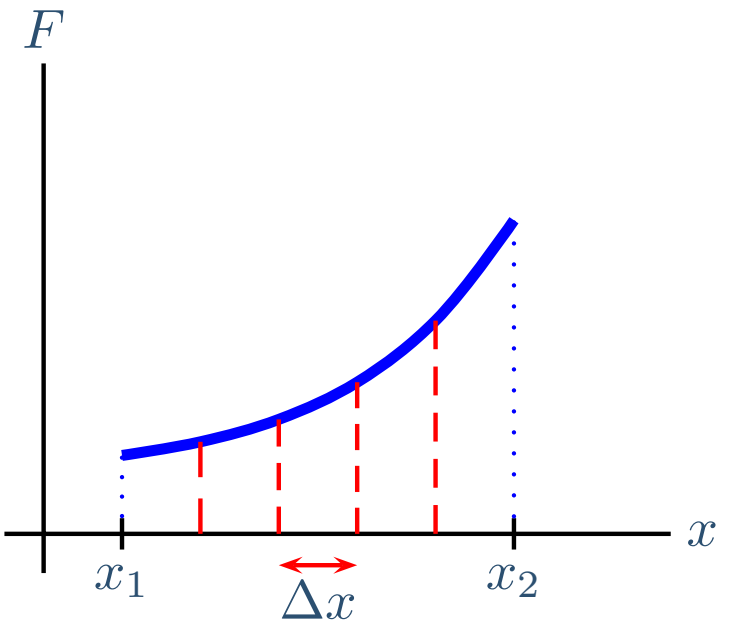

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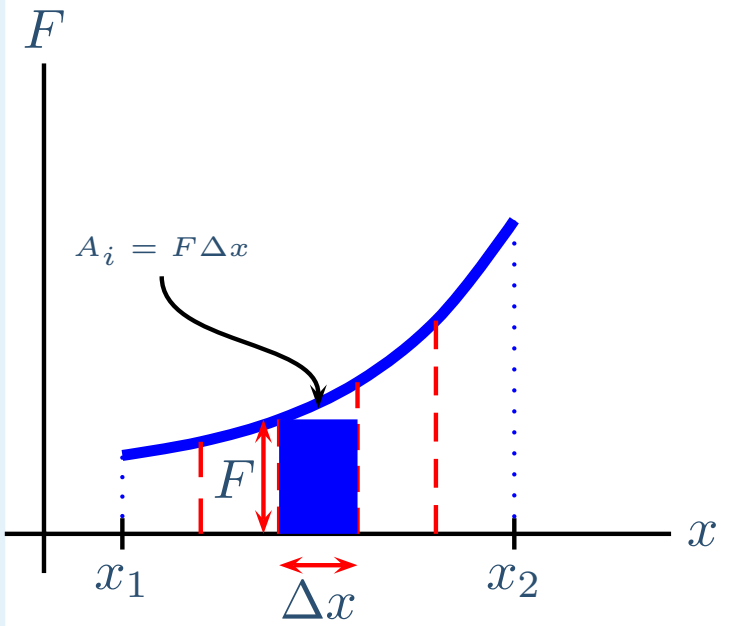

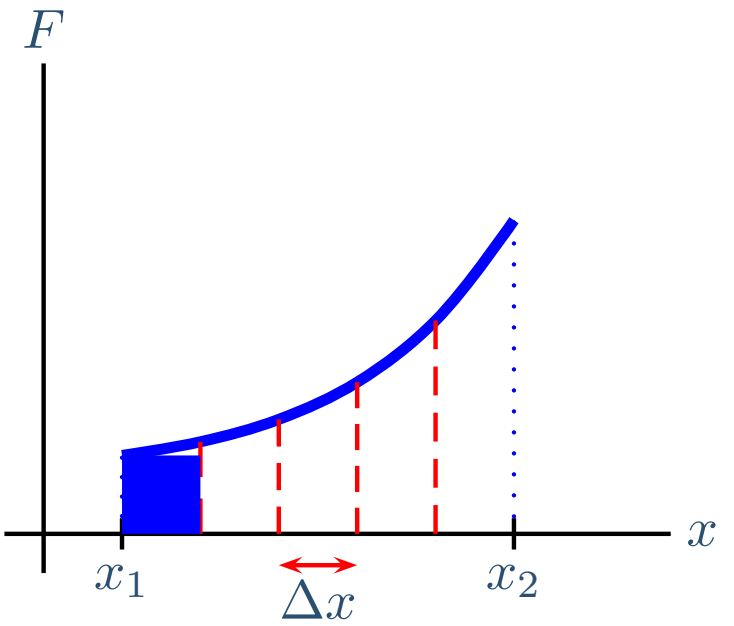

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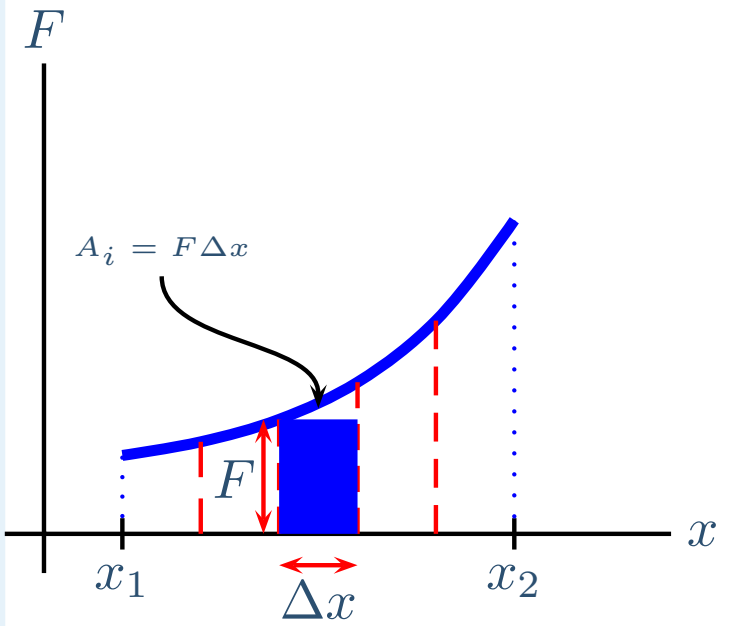

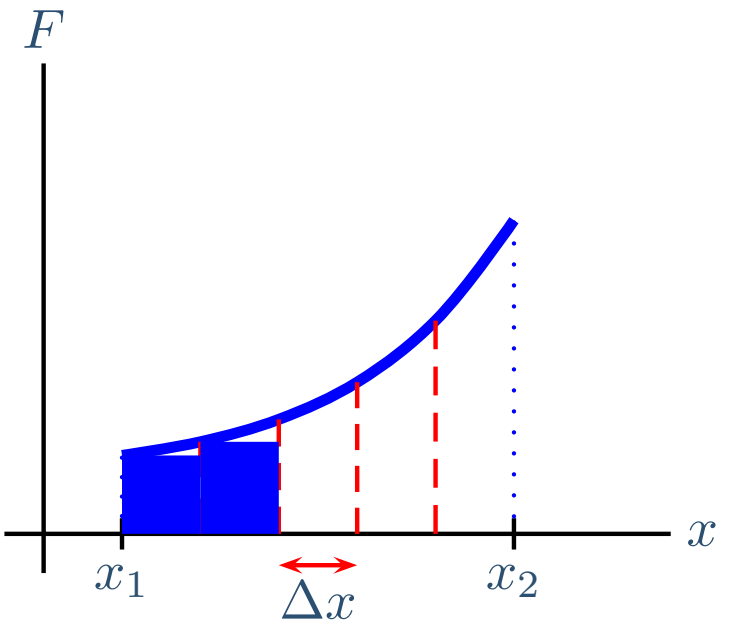

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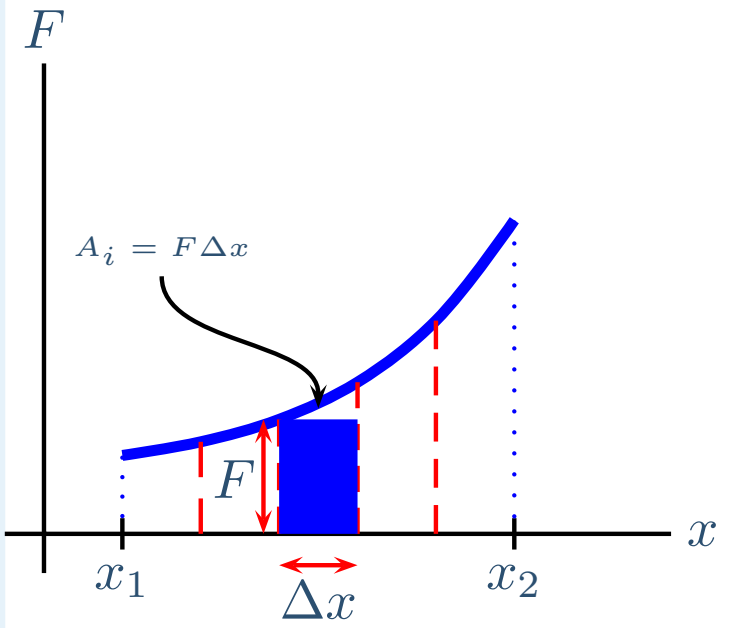

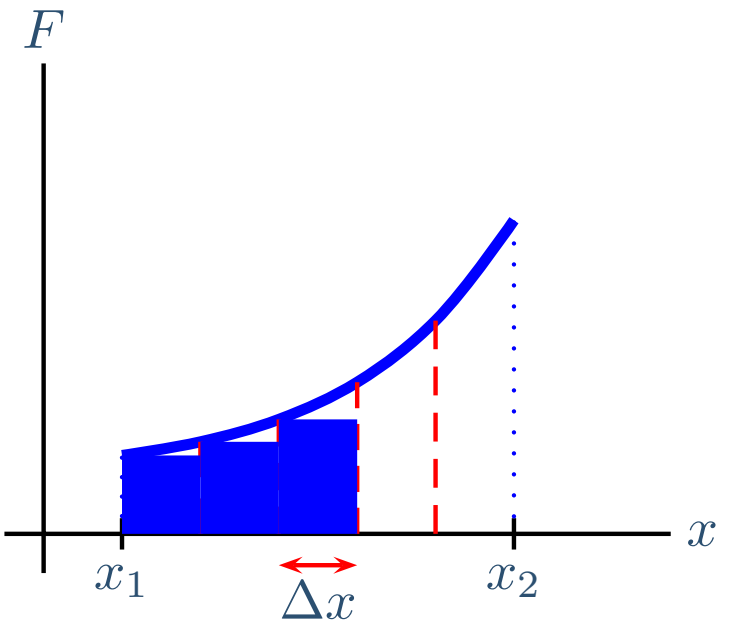

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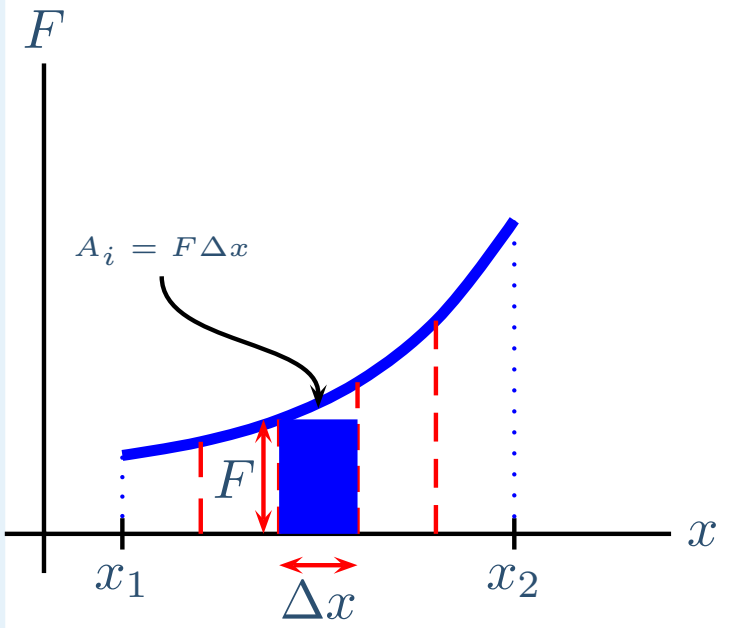

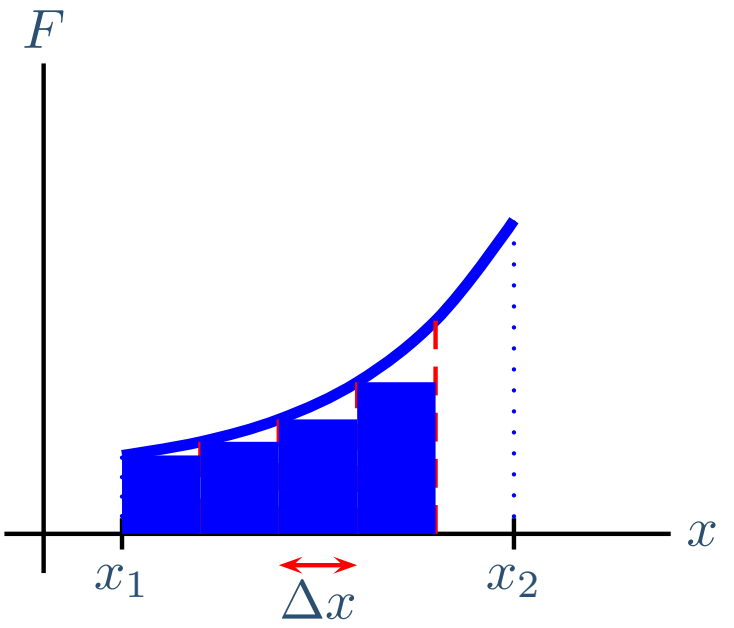

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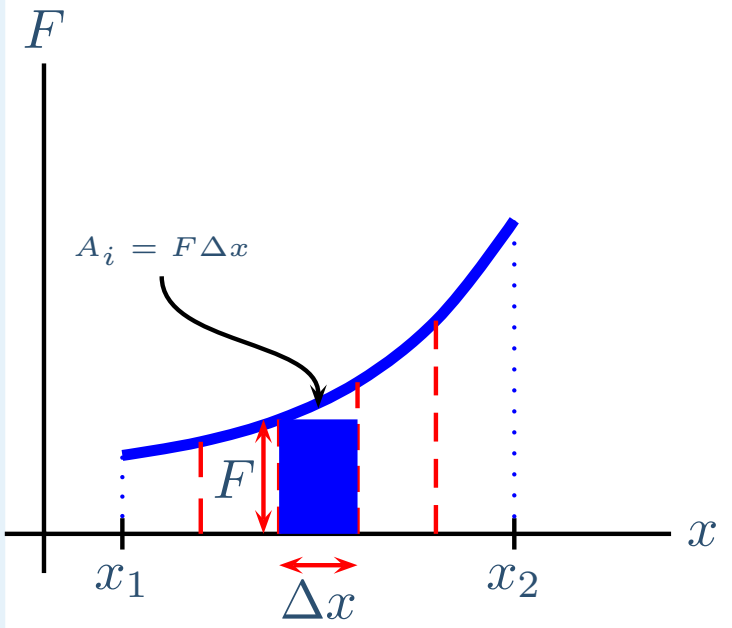
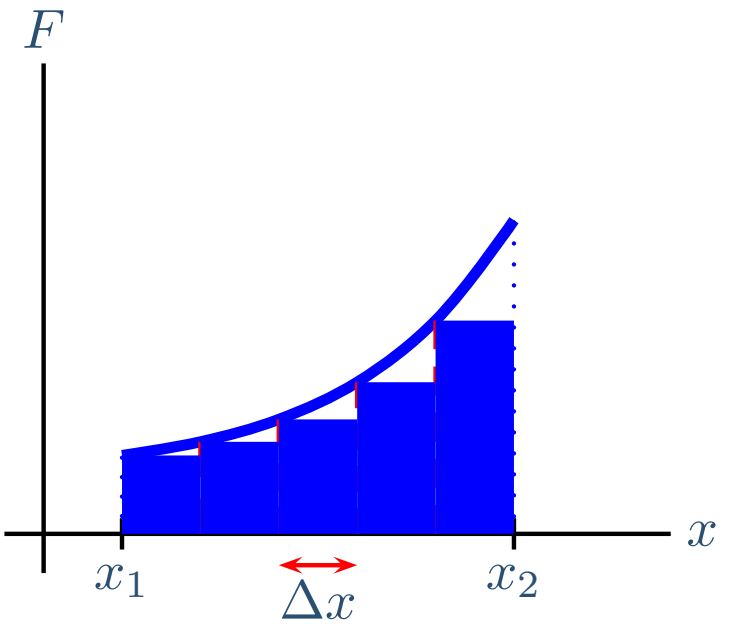
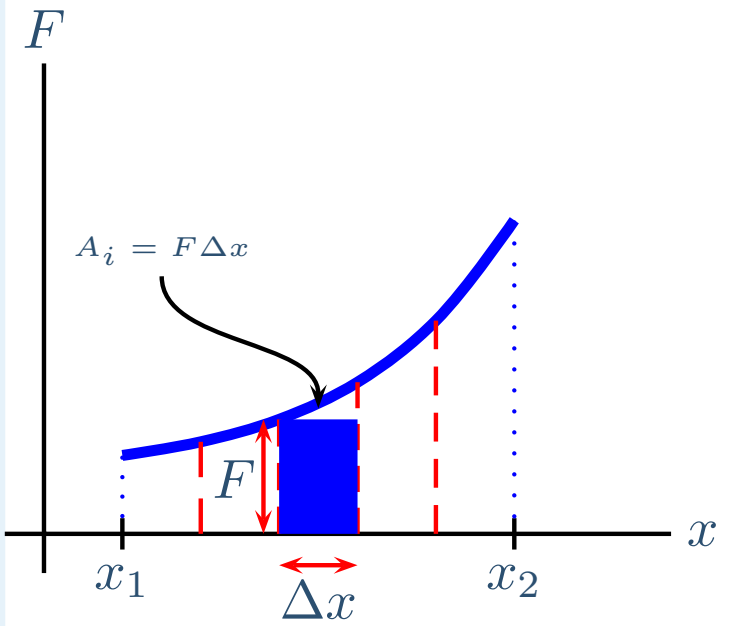


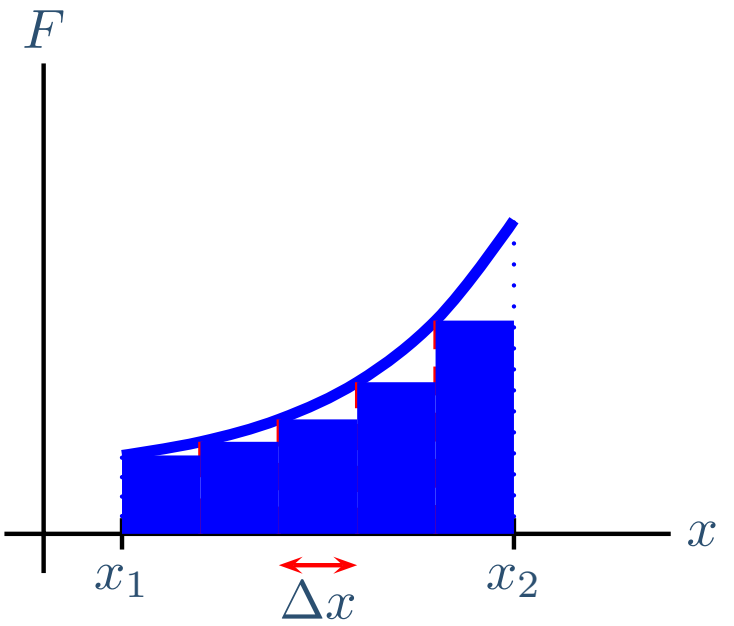


Variable Forces III

To find the work done by a changing force requires finding an area.

$$W \approx \sum_i A_i = \sum_i F\Delta x$$

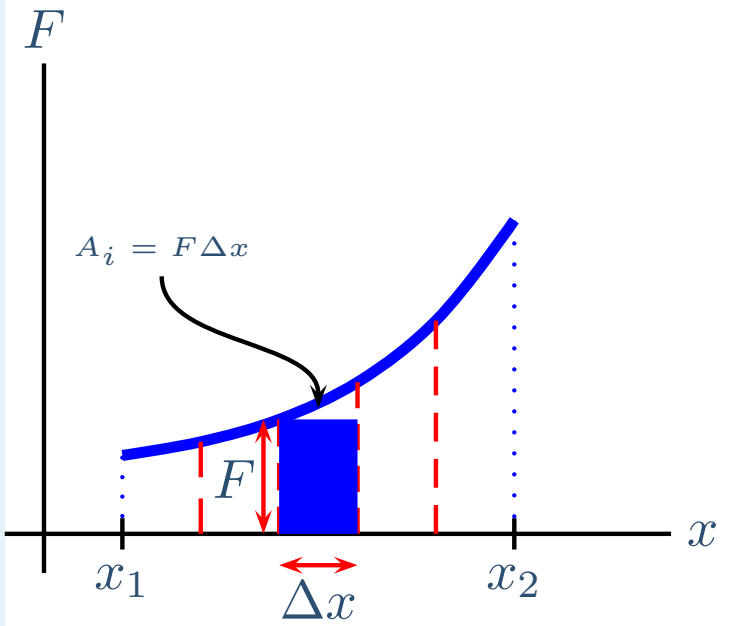


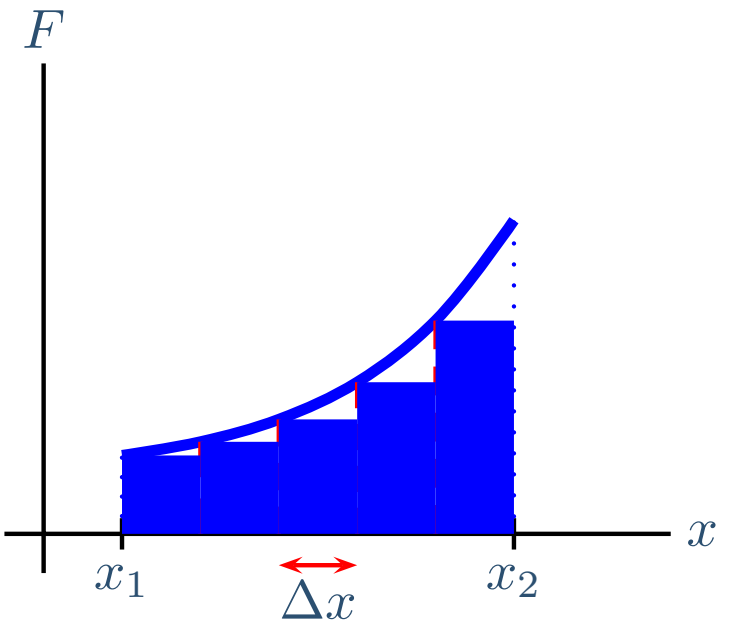


Variable Forces III

To find the work done by a changing force requires finding an area.

$$W \approx \sum_i A_i = \sum_i F\Delta x \qquad W = \lim_{\Delta x \to 0} \sum F\Delta x$$





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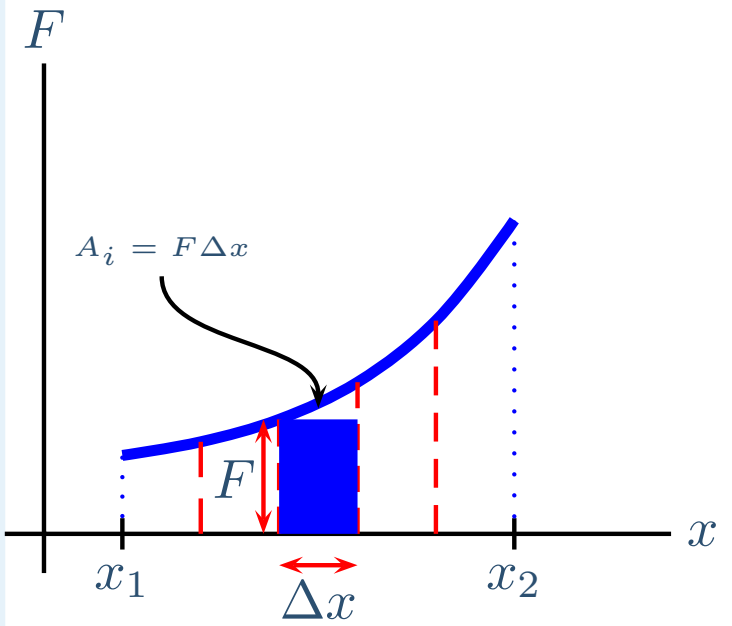

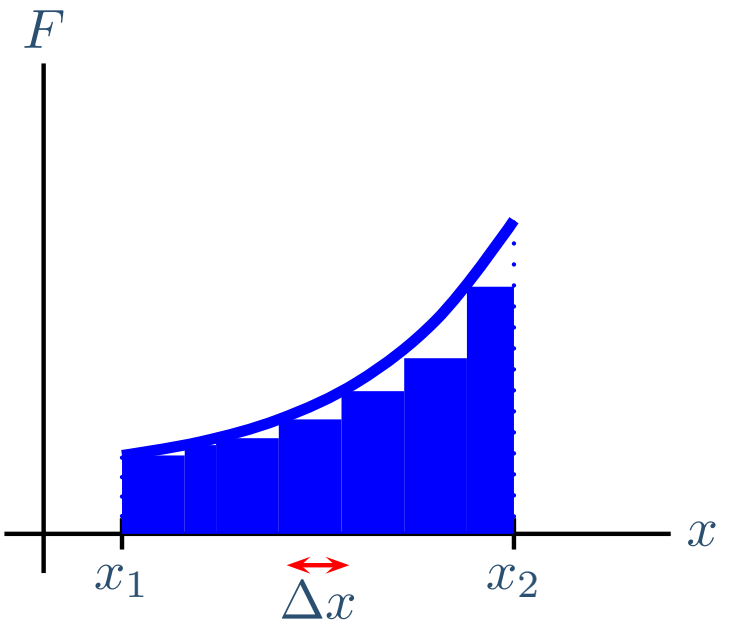

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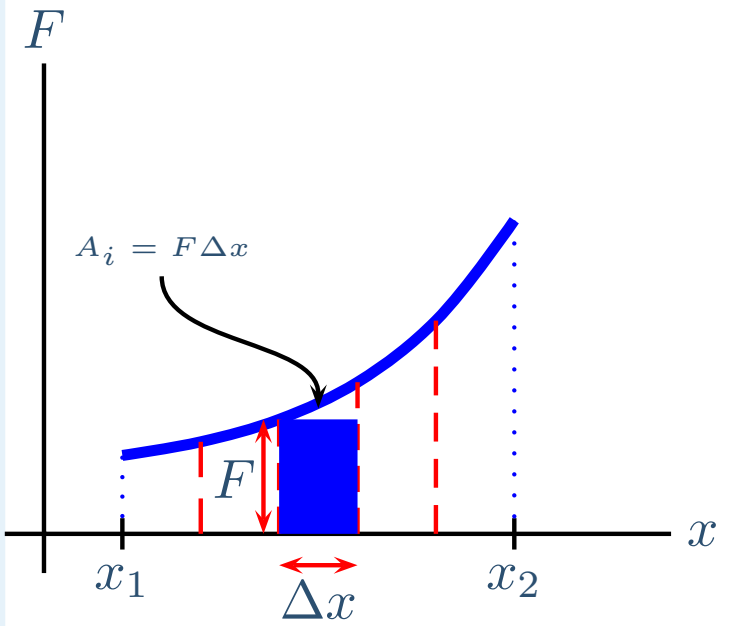

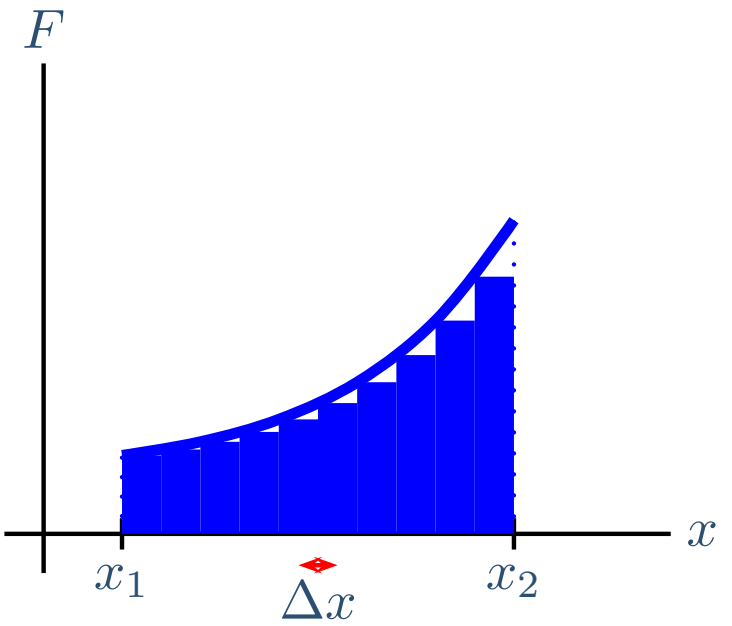

Variable Forces III

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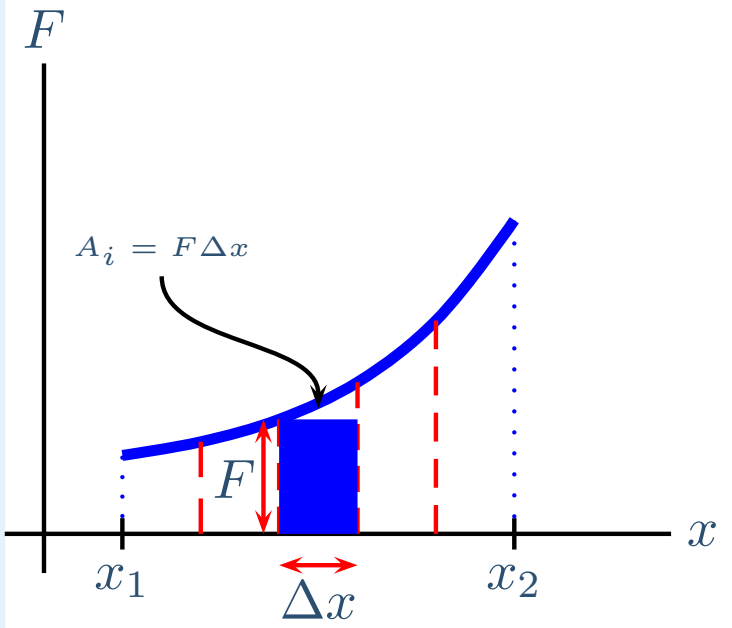

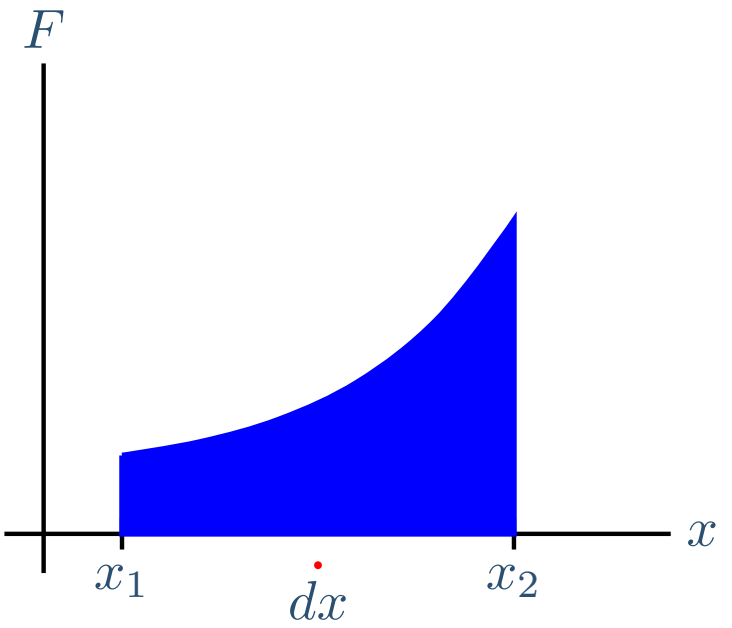

Variable Forces III

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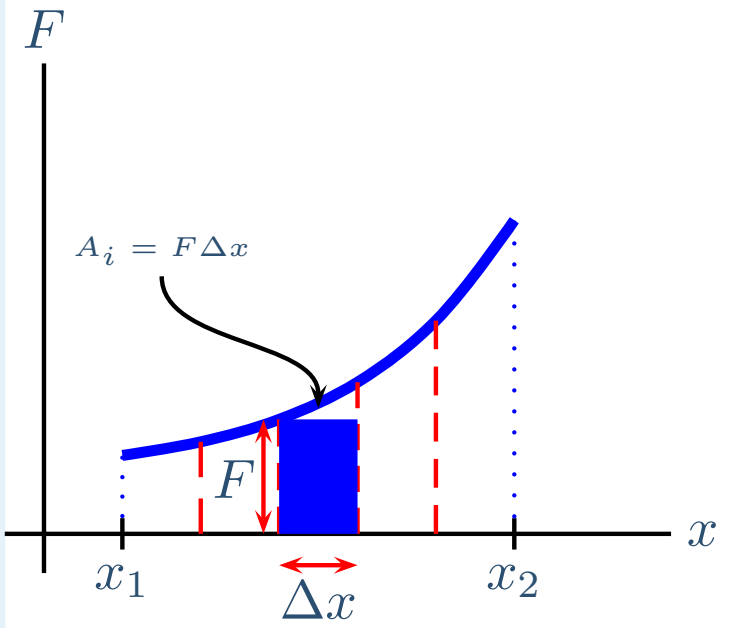
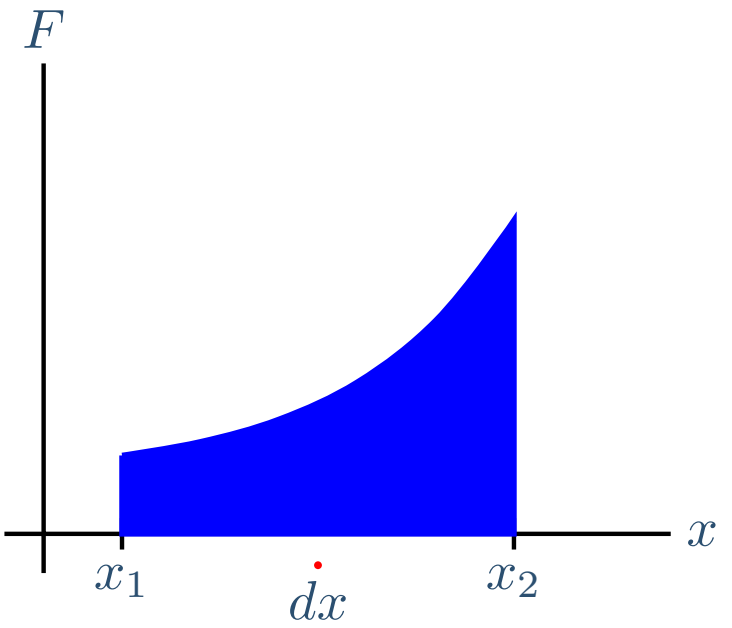
$$W \approx \sum_i A_i = \sum_i F\Delta x \qquad W = \lim_{\Delta x \to 0} \sum F\Delta x = \int_{x_1}^{x_2} F\,dx$$

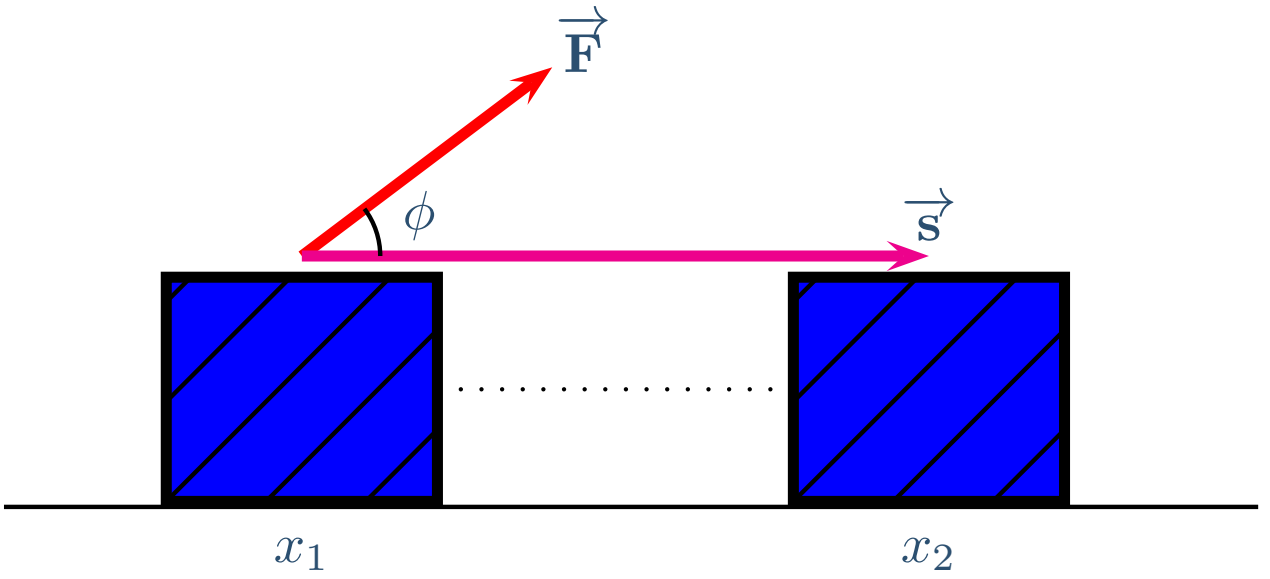




Variable Force Arbitrary Direction

Still only the component of the force parallel to the displacement does work.

$\phi =$ angle between $\vec{\mathbf{F}}$ and $\vec{\mathbf{s}}$



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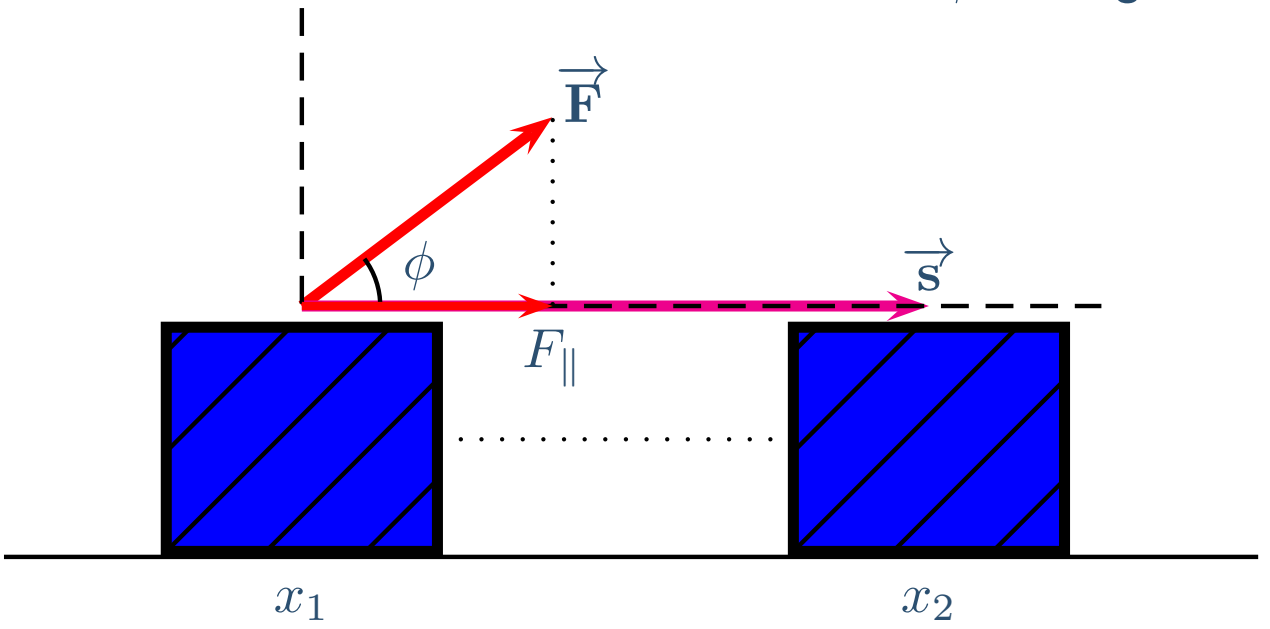

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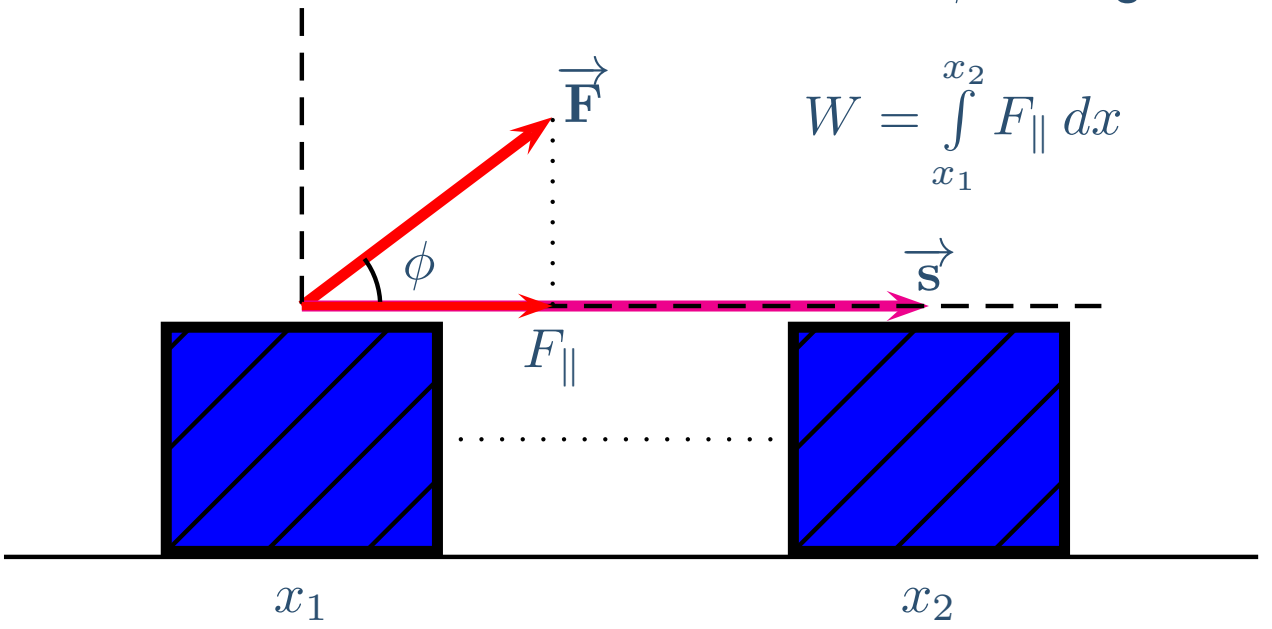

$$W = \int_{x_1}^{x_2} F_{\|}\, dx$$

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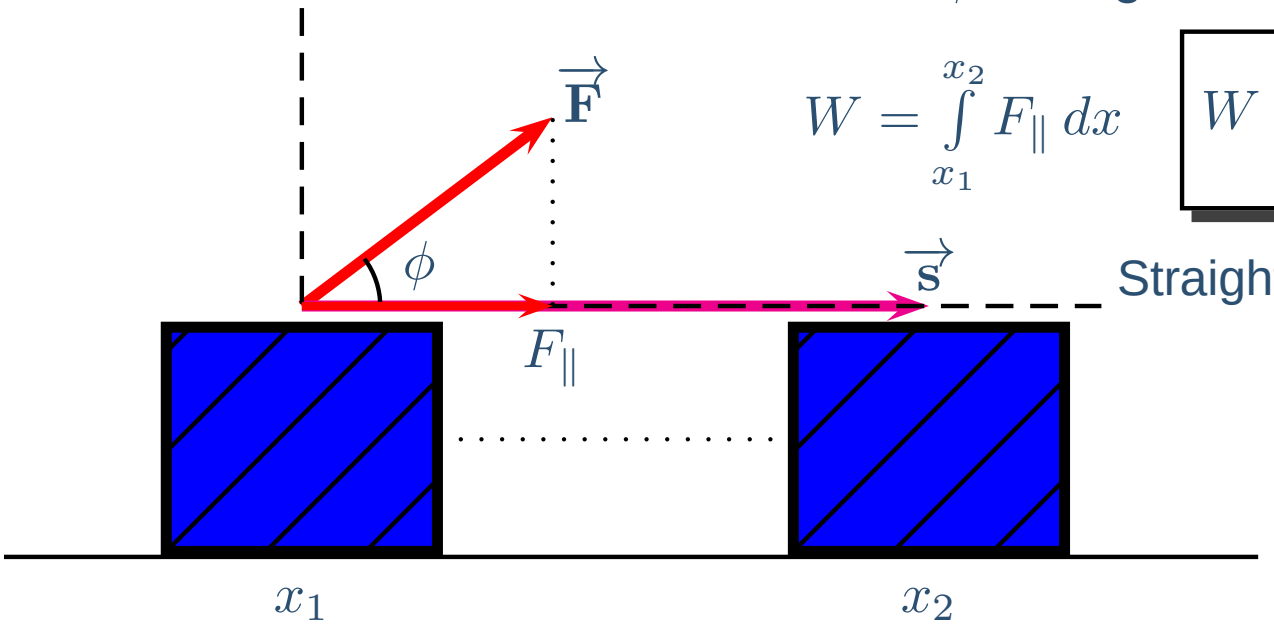

$$W = \int_{x_1}^{x_2} F_{\parallel}\, dx$$

$$W = \int_{x_1}^{x_2} F \cos\phi\, dx$$

Straight-line Displacement

Variable Force Arbitrary Direction

Still only the component of the force parallel to the displacement does work.

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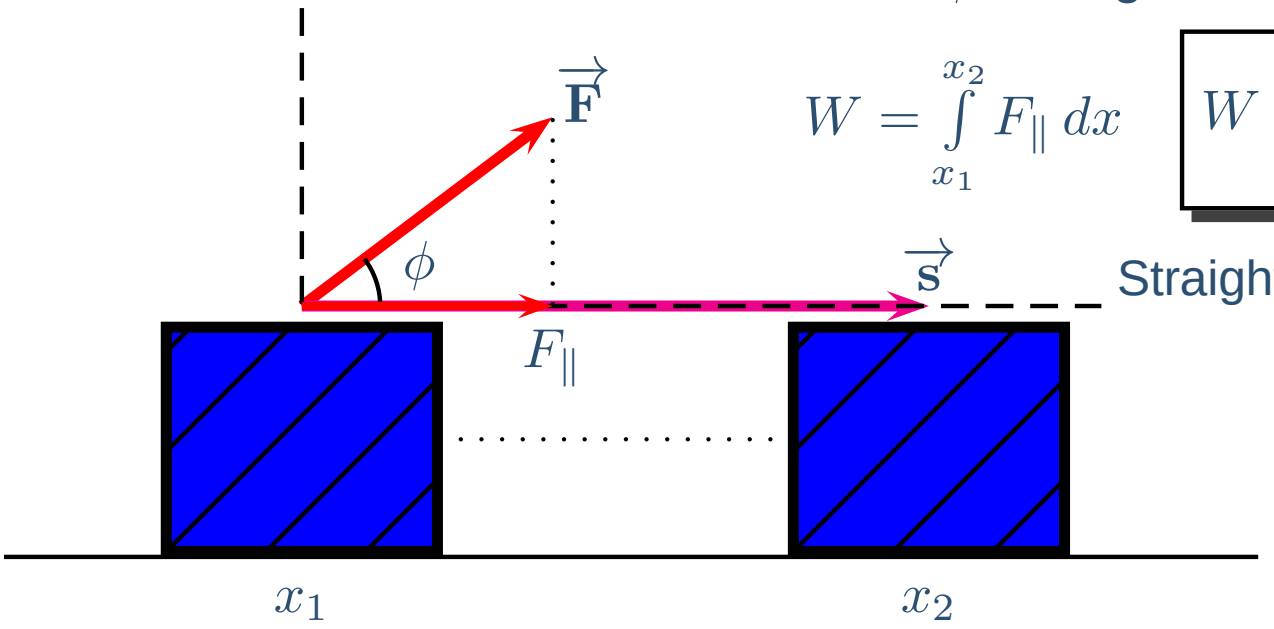

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$$W = \int_{x_1}^{x_2} F \cos\phi\, dx$$

Straight-line Displacement

For variable forces, it can be shown that the work-energy theorem holds! $W_{total} = \frac{1}{2}mv_2^2 - \frac{1}{2}mv_1^2$