

July 7, Week 6

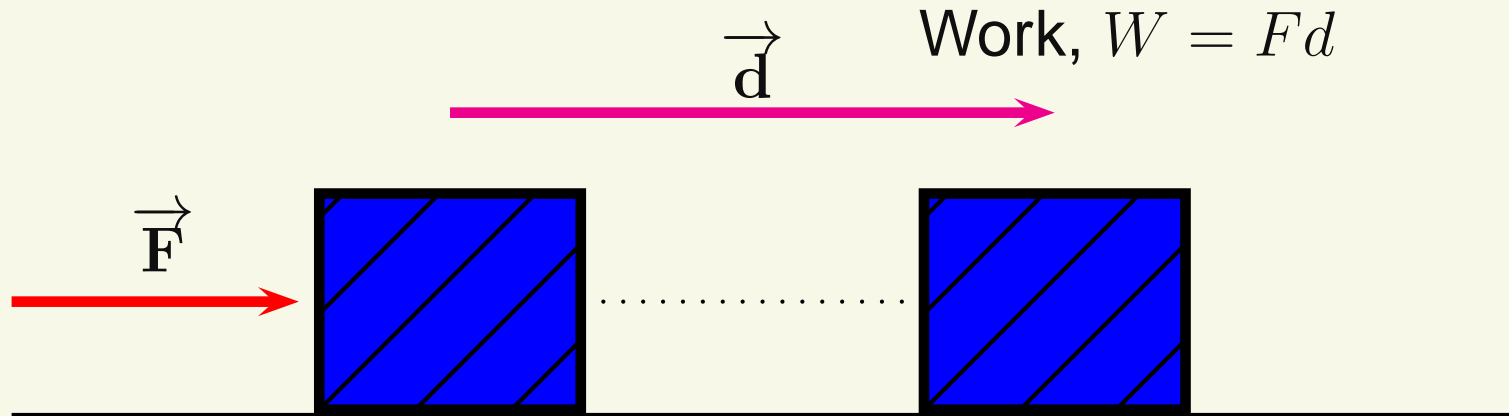
Today: Chapter 10, Gravitational Potential Energy

Homework #5 due today at 5:00PM

Office hours today: 1:00-5:00

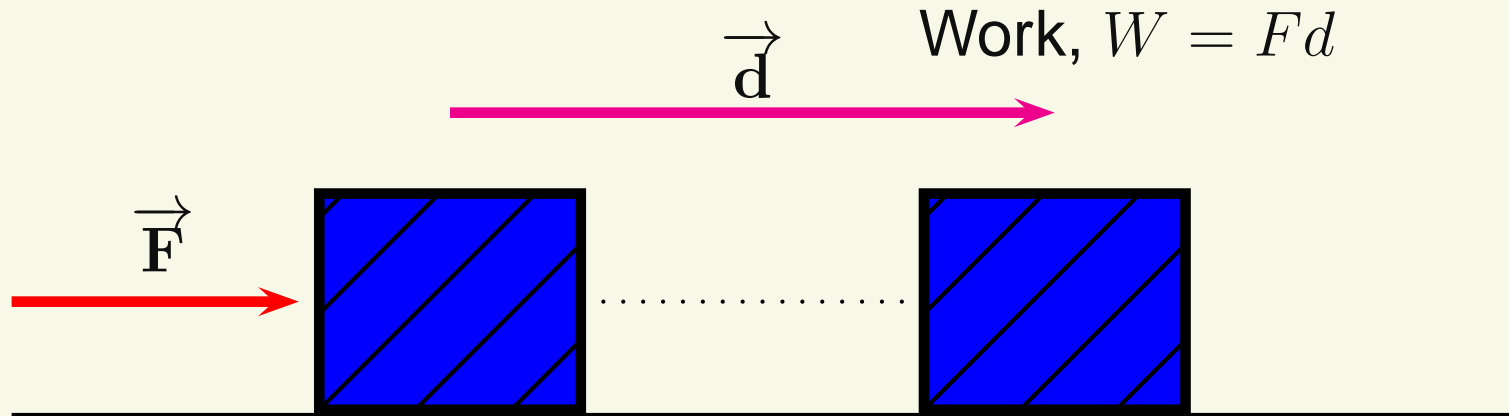
Test #5, tomorrow.

Restrictions



This equation is correct only in the situation that:

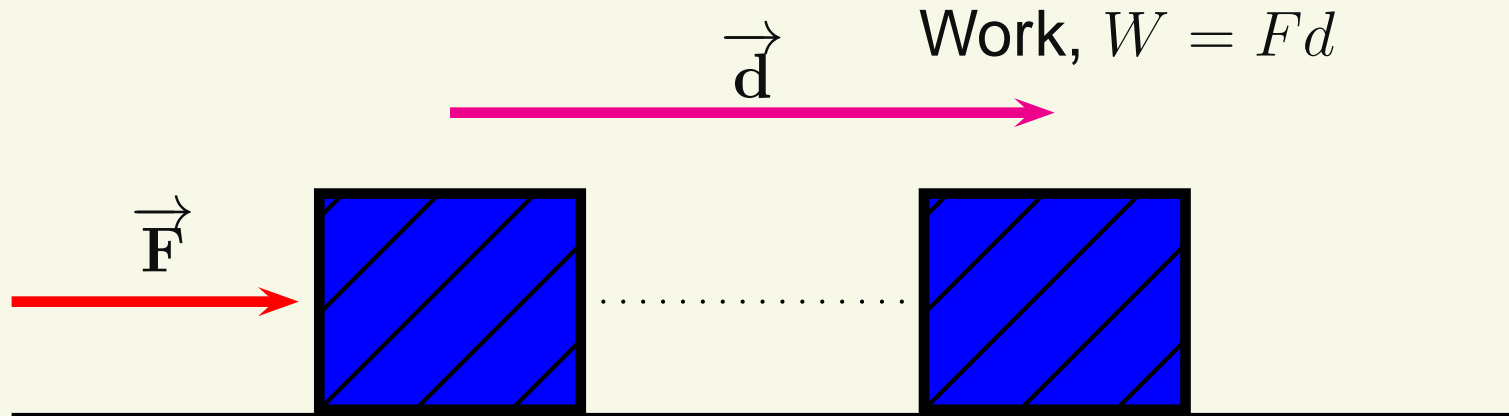
Restrictions



This equation is correct only in the situation that:

\vec{F} is constant

Restrictions

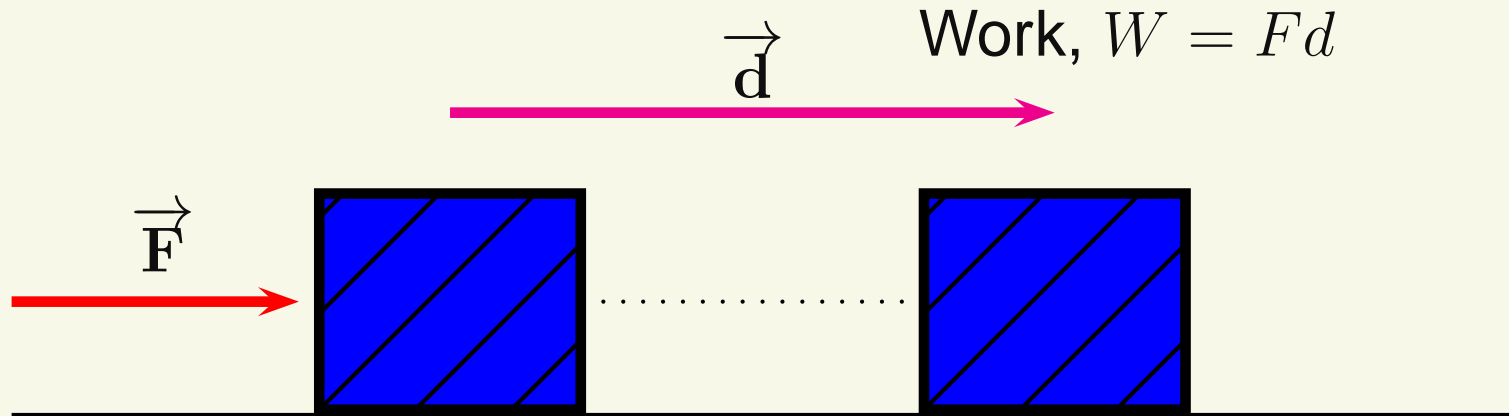


This equation is correct only in the situation that:

\vec{F} is constant

\vec{d} is a straight line

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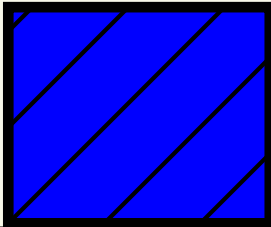
\vec{F} and \vec{d} are in the same direction.

Arbitrary Direction

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

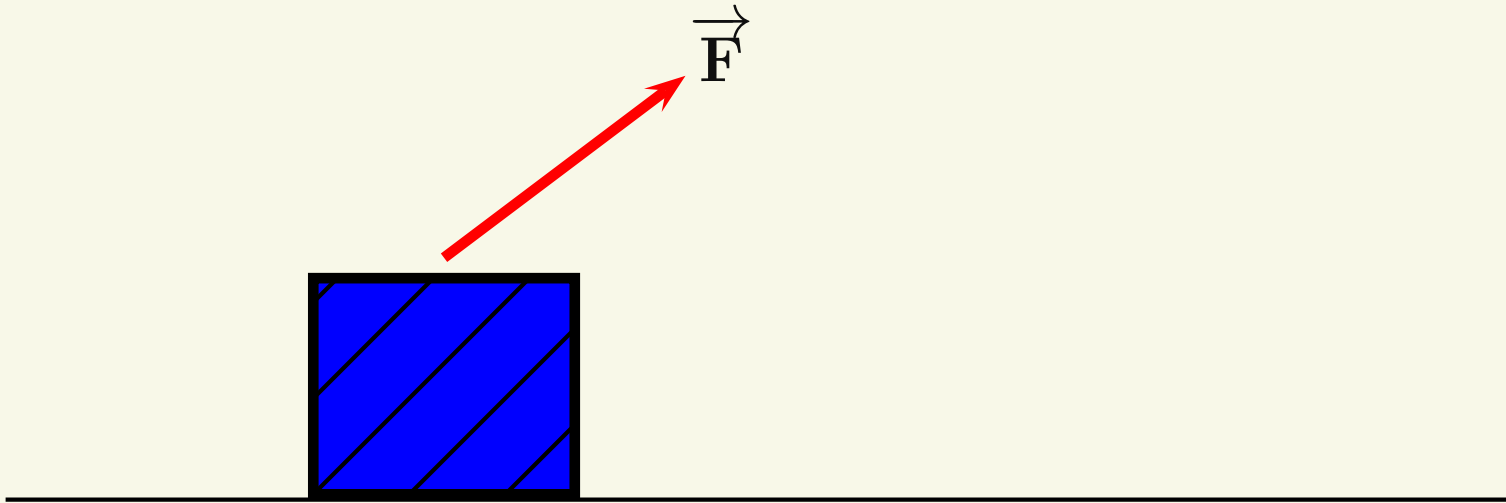
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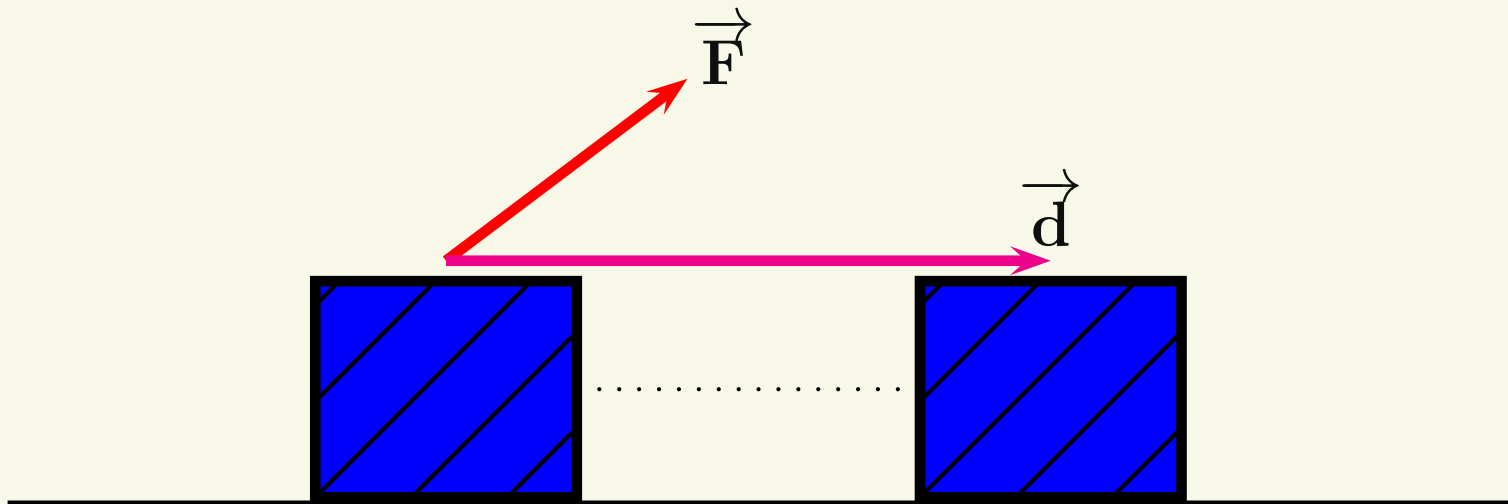
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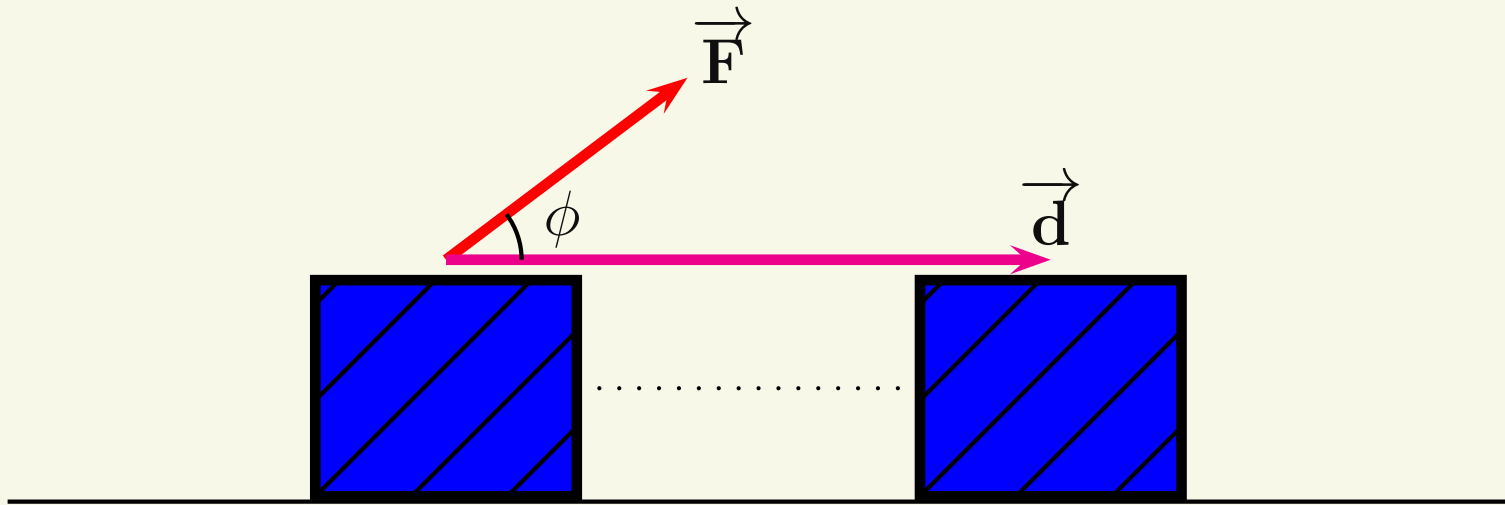
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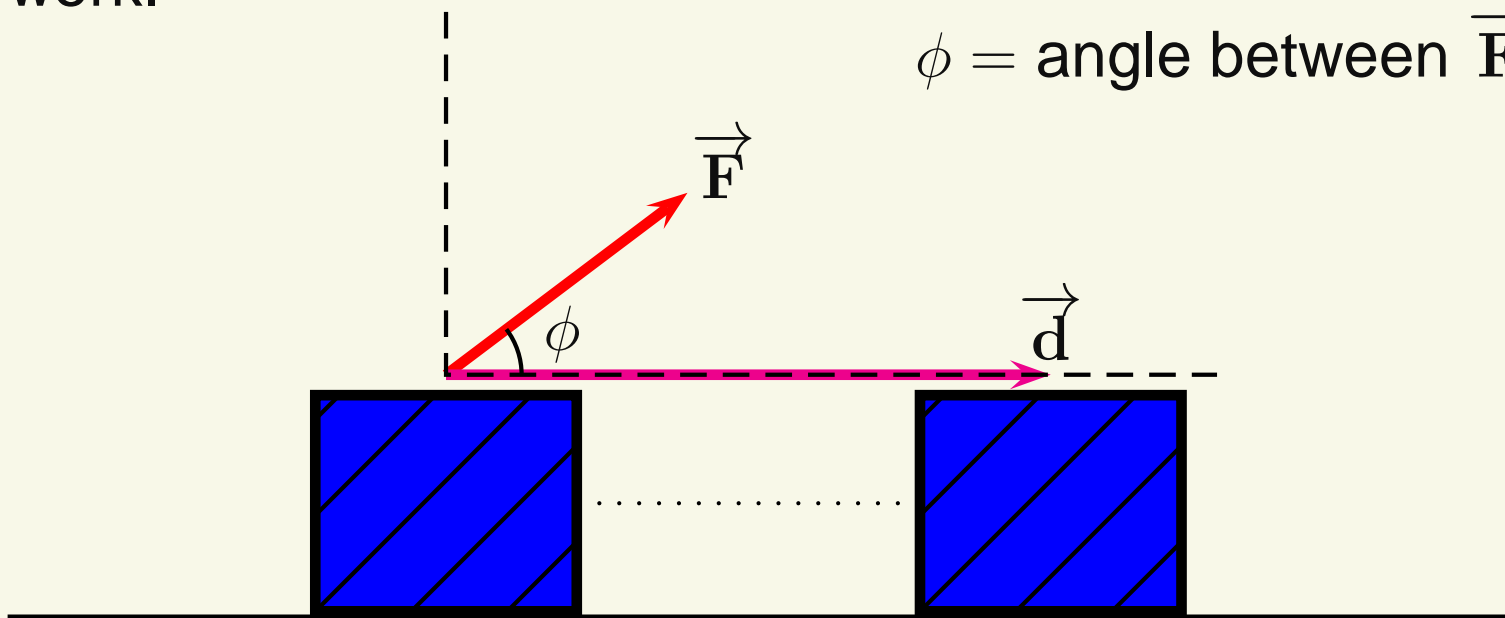
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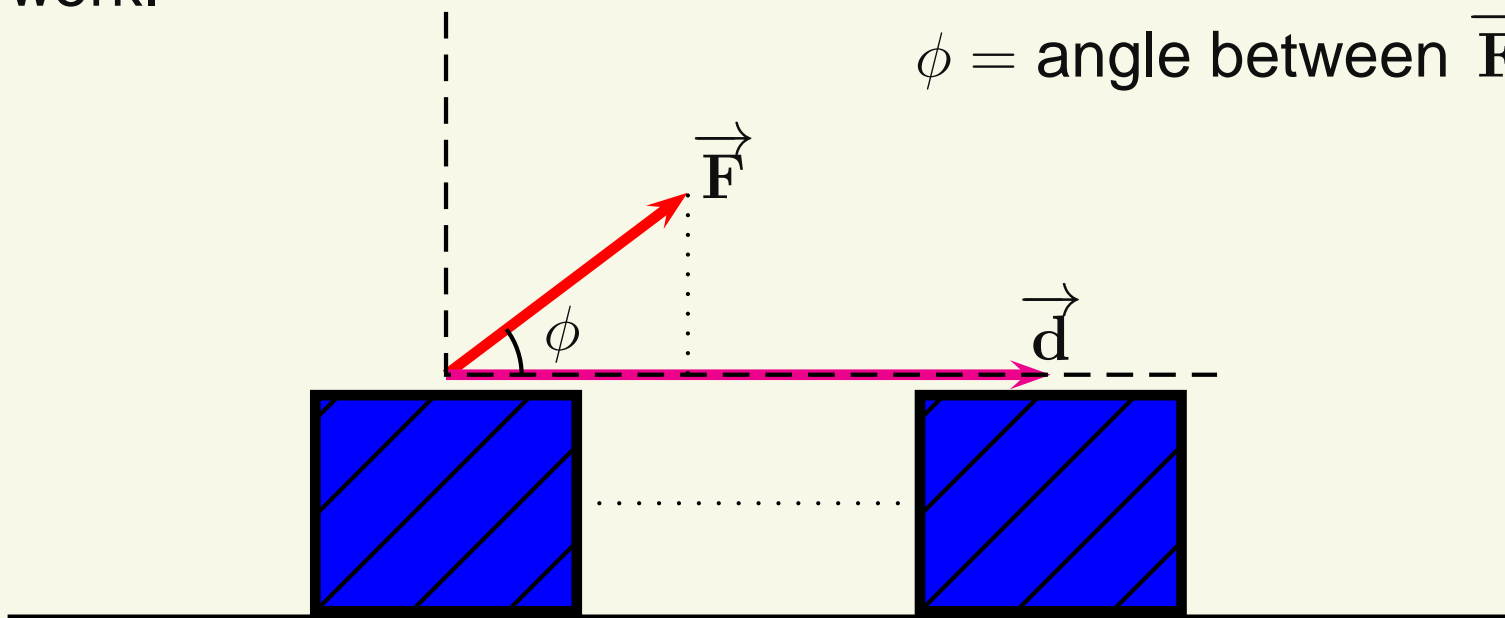
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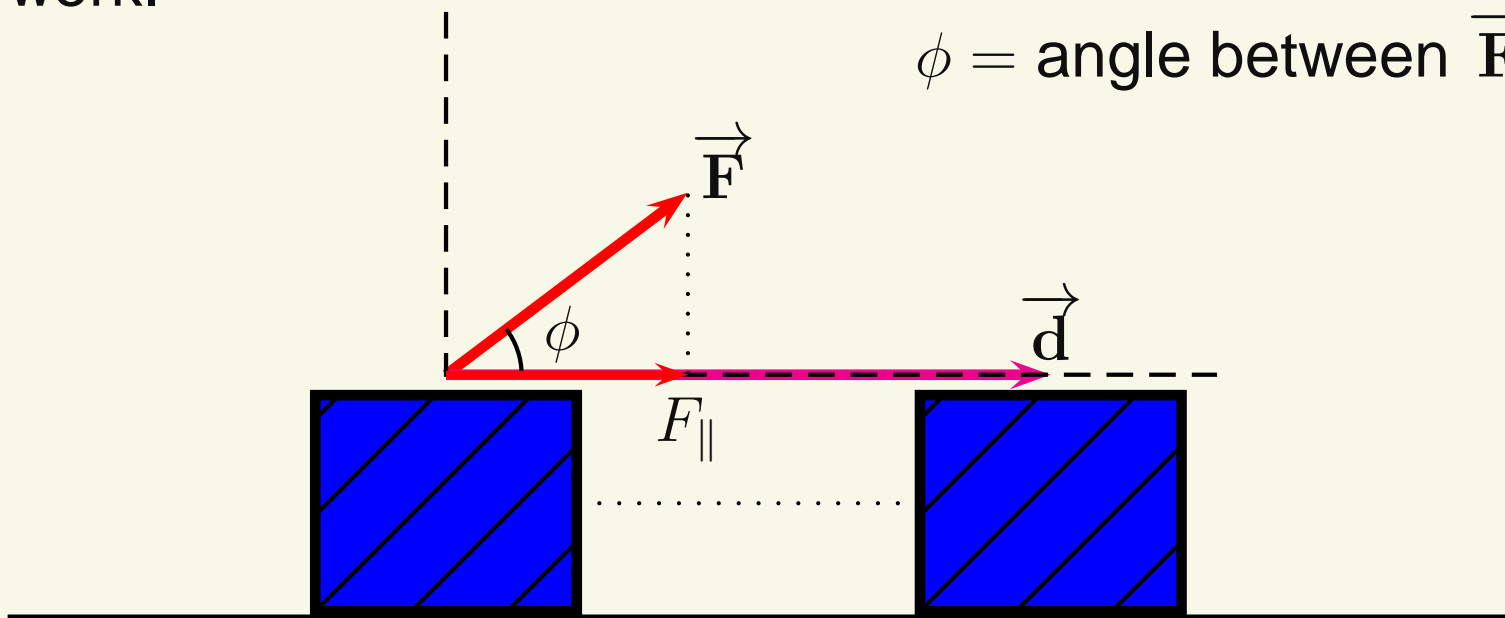
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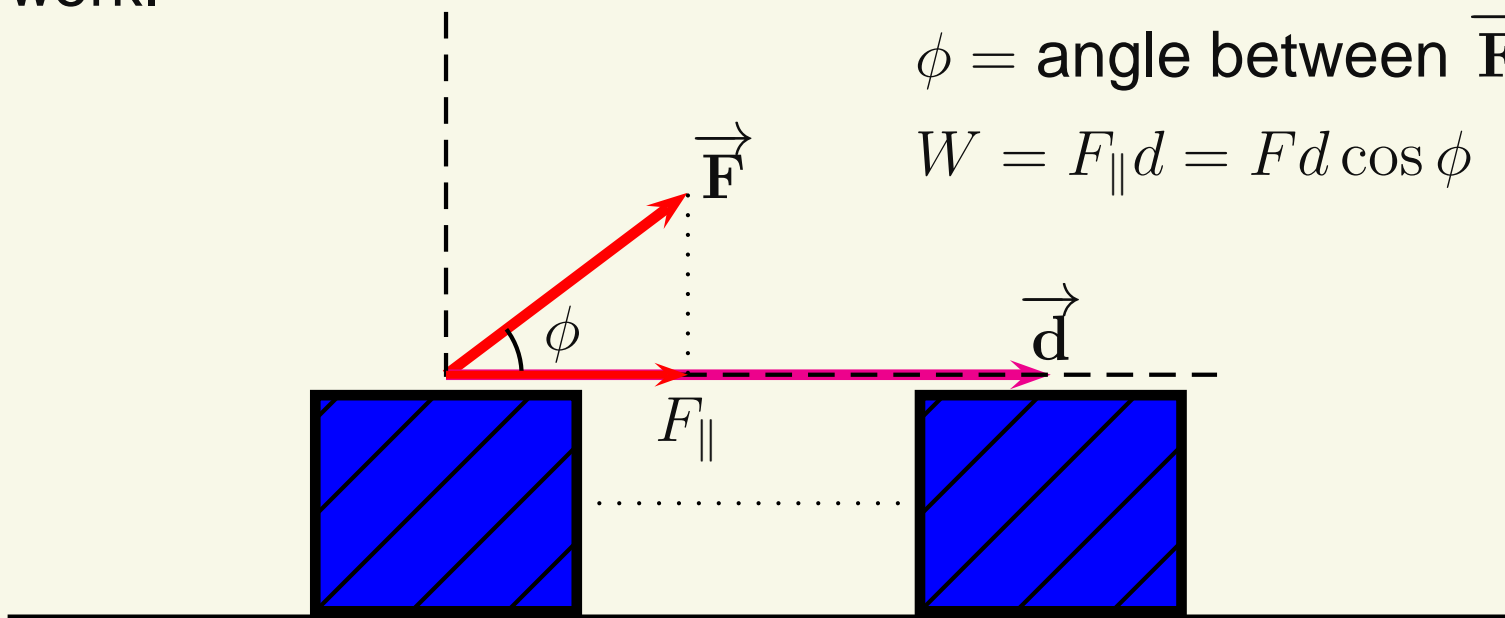


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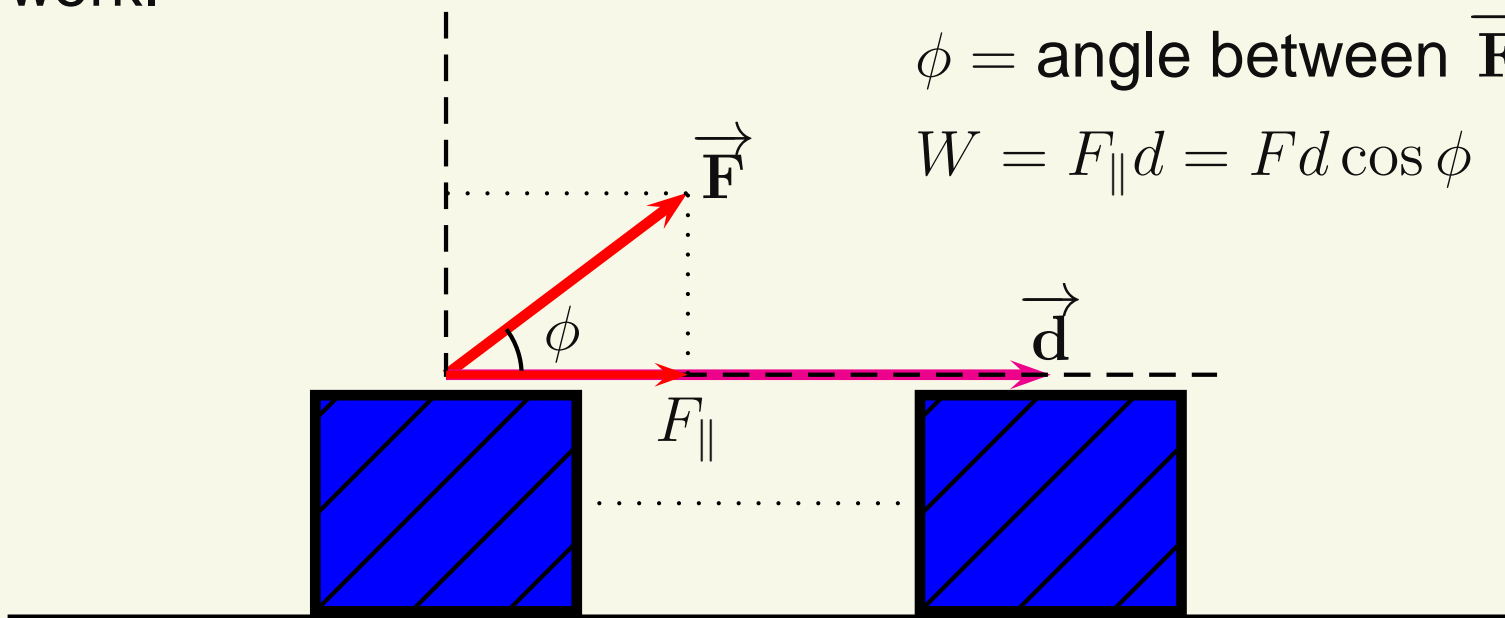


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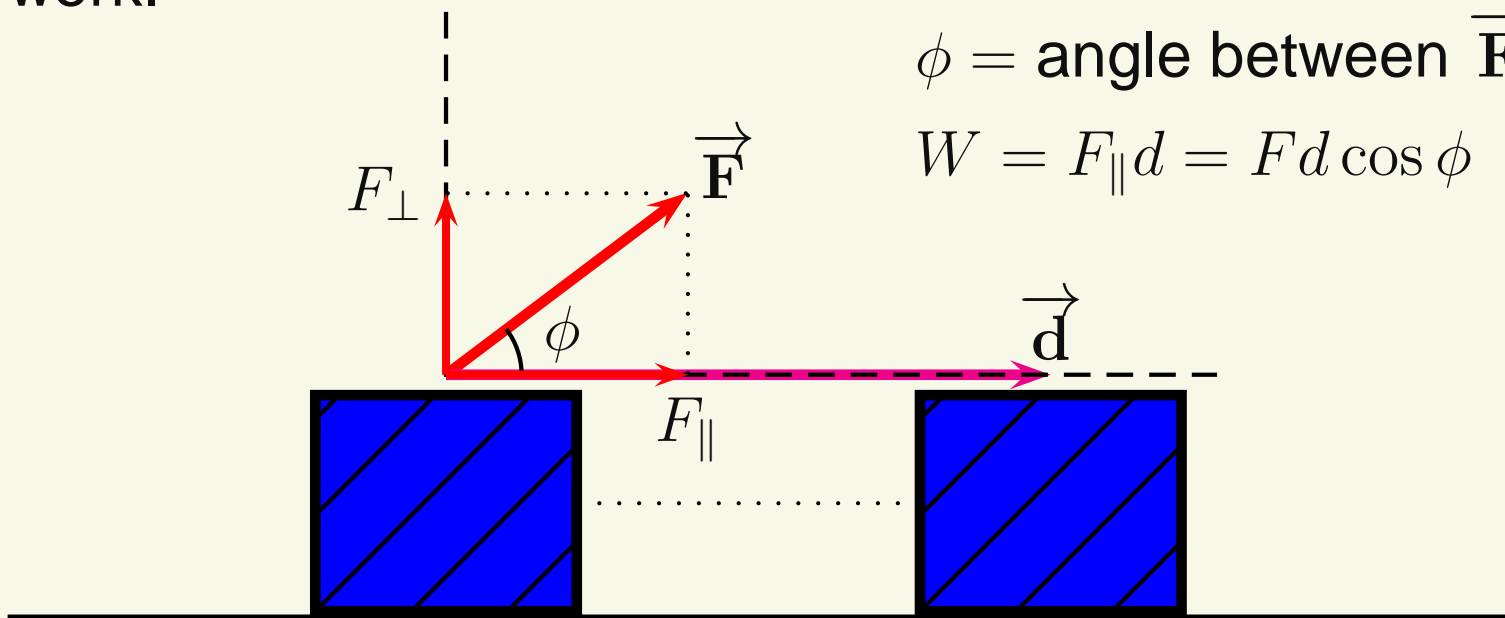


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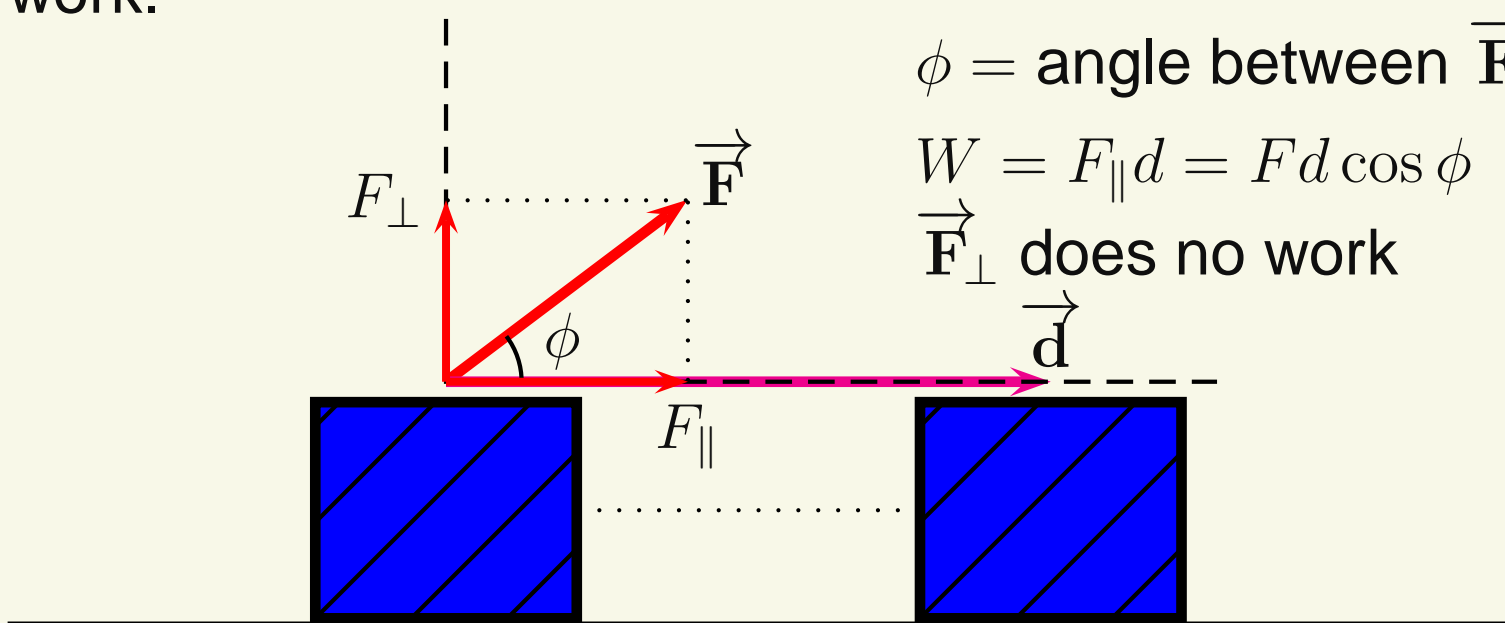
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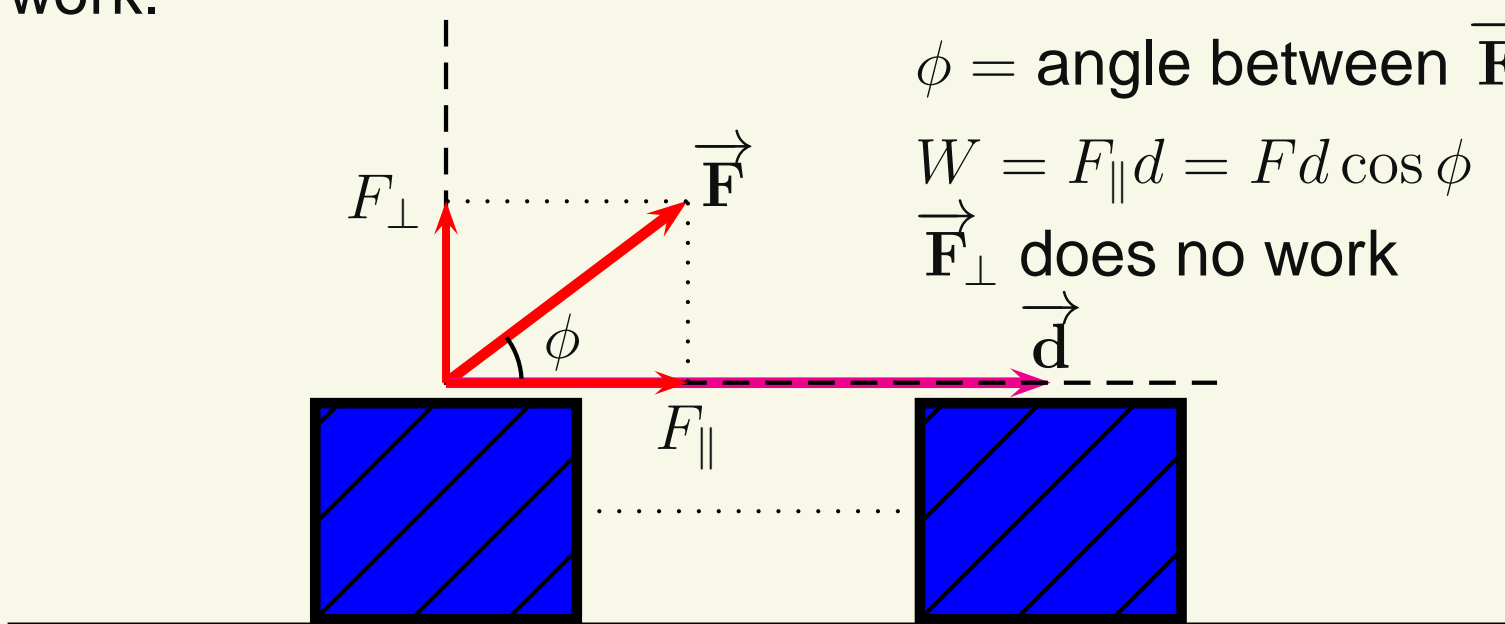
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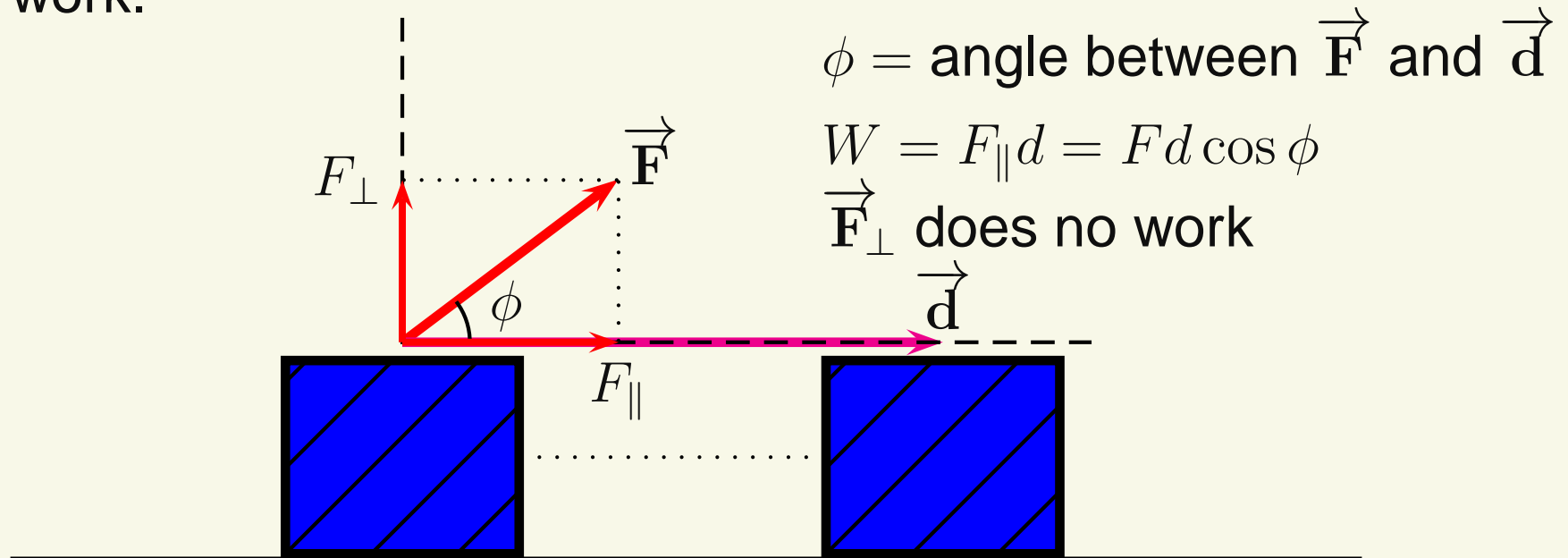
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Only correct for Constant force & Straight-line displacement

Total Work

Work is a scalar quantity.

Total Work

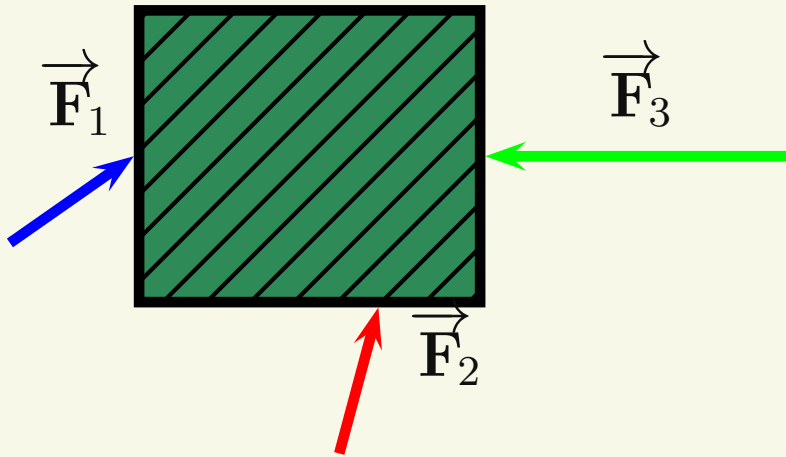
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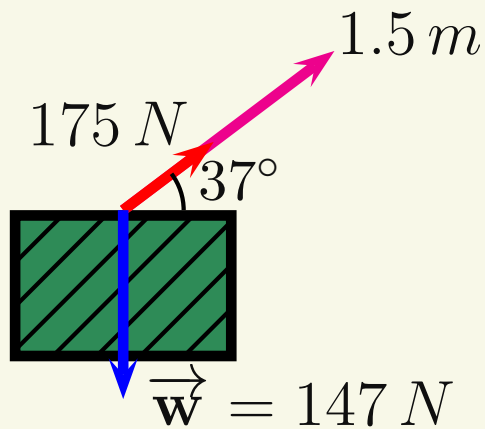
So total work done by a collection of forces is given by the sum of the individual works.



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

Total Work Exercise

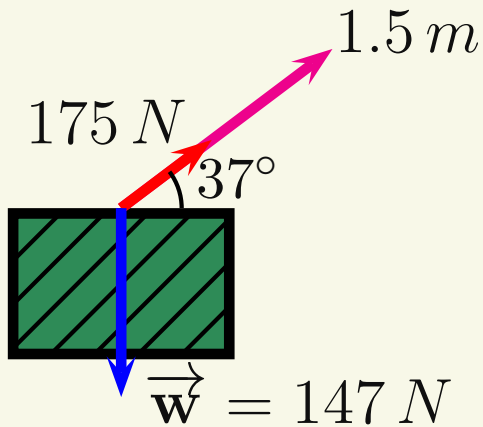
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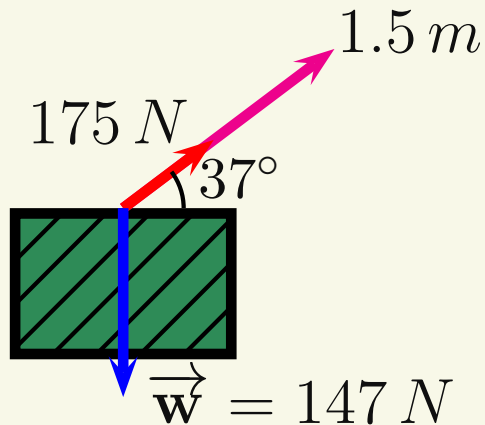


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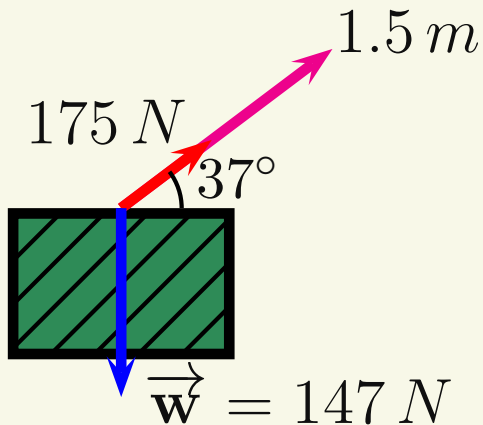
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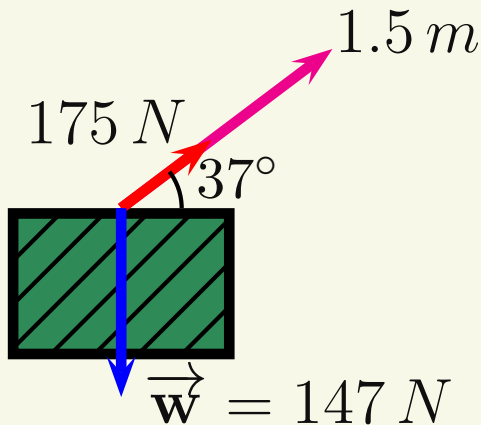
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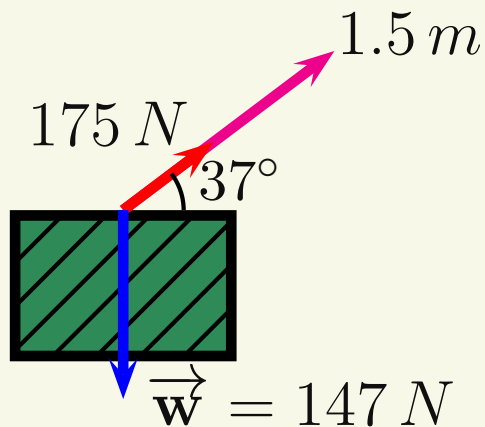
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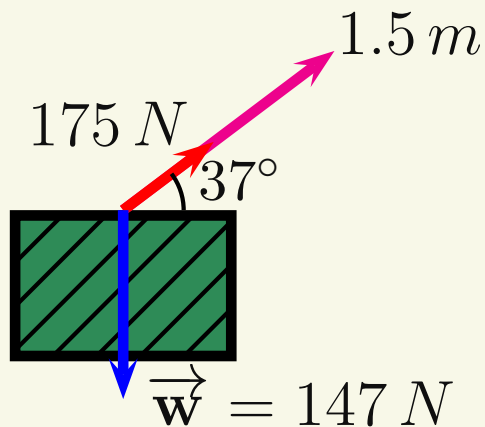
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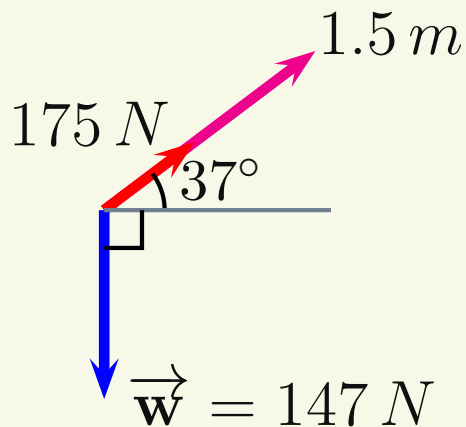
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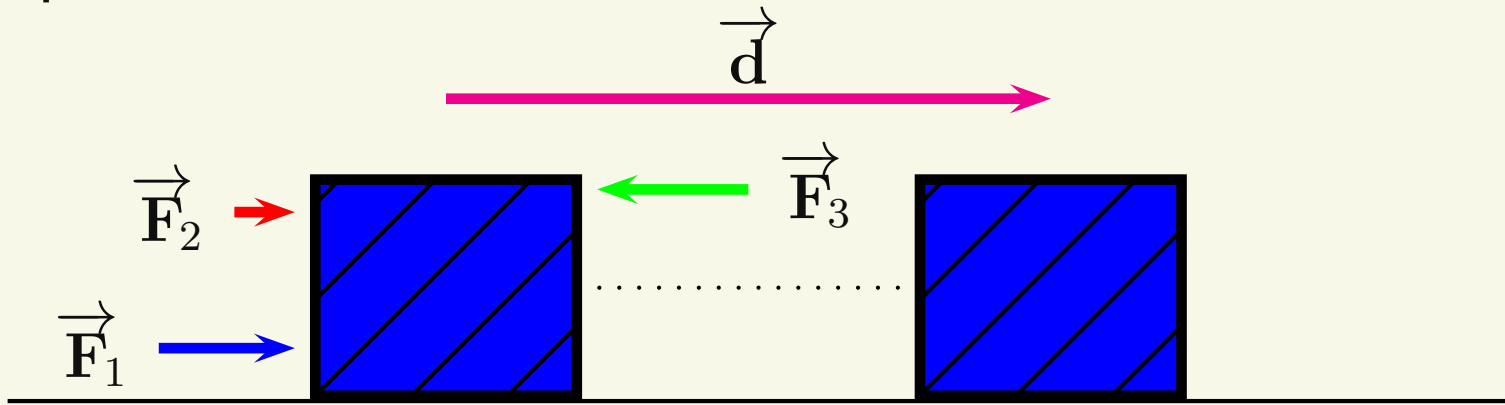
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Work-Energy Theorem

Work-Energy Theorem - Allows us to calculate the physical effect that work has on an object. It says that work causes a change in speed.

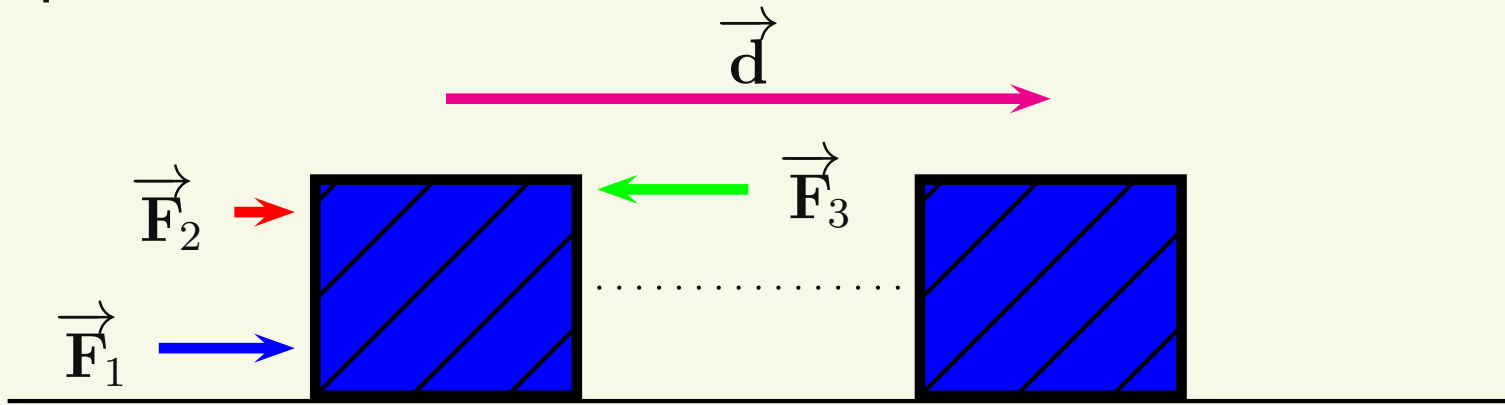
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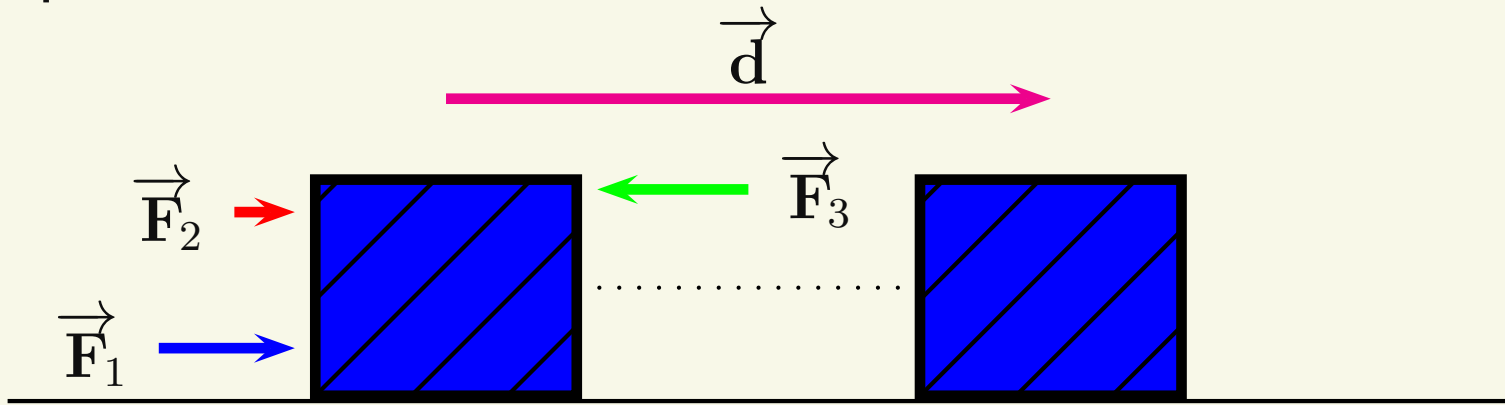
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Forces all in a line

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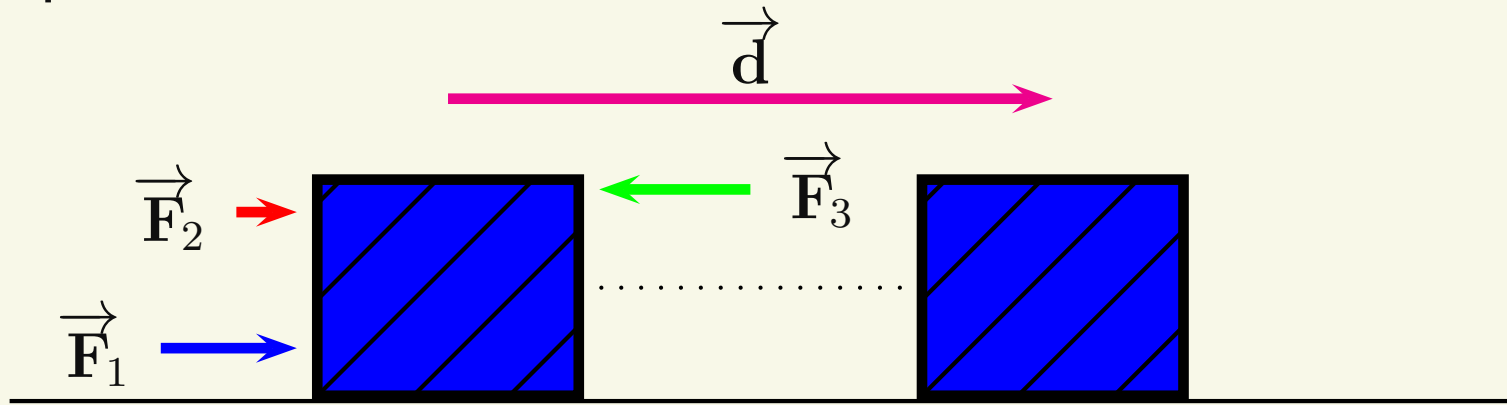
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Forces all in a line $\Rightarrow W_{total} = \sum (F d) = (\sum F) d$

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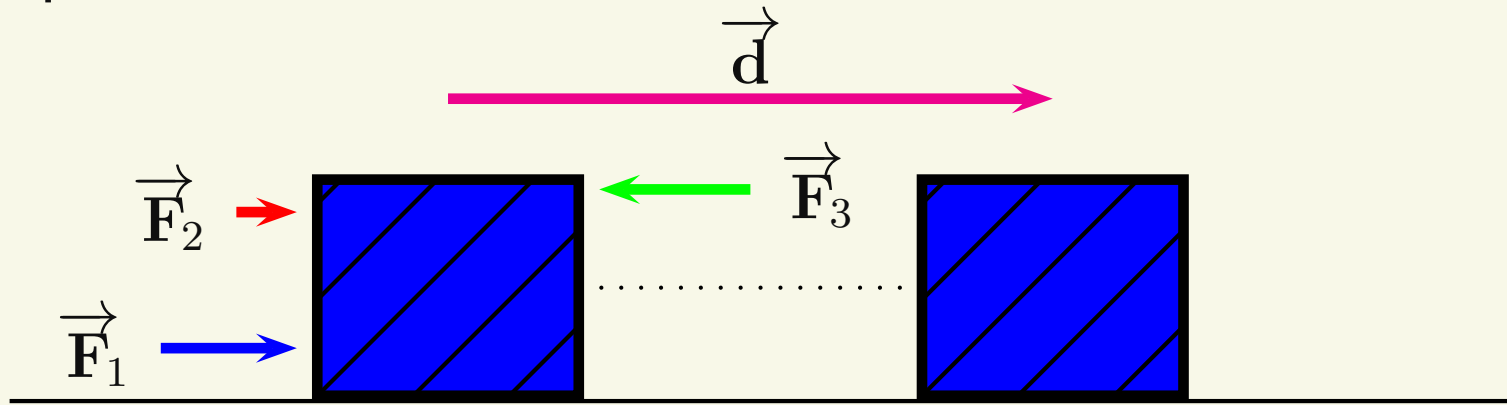


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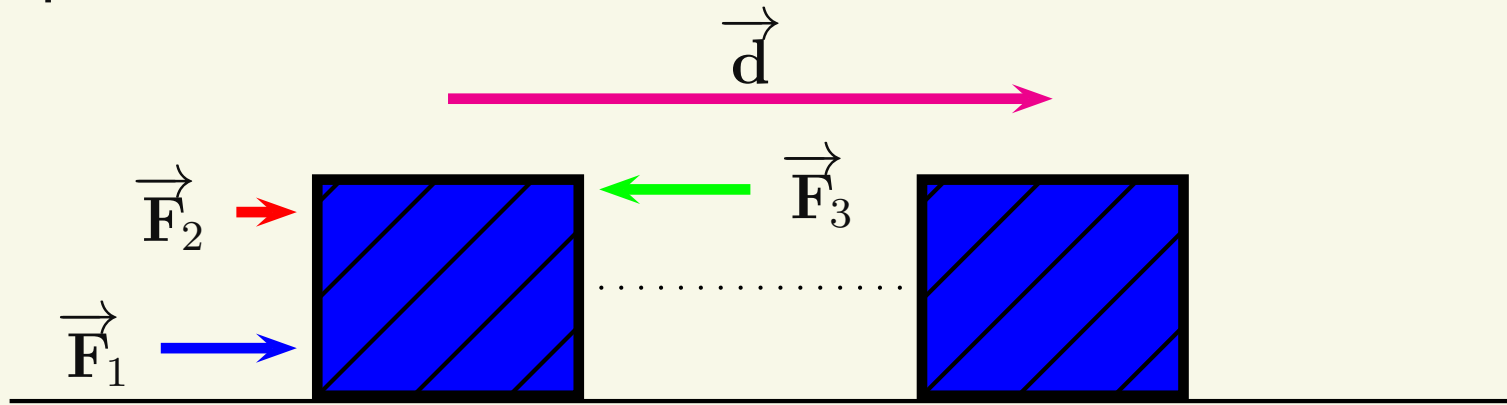


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Using $v_f^2 = v_i^2 + 2ad \Rightarrow$ $W_{total} = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$

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 ? (Remember that the total work done was 129.8 J .)

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A 15 kg box has a total of 129.8 J of work done to it (by different forces than before). How fast and in what direction is it going?

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Scalars cannot determine direction

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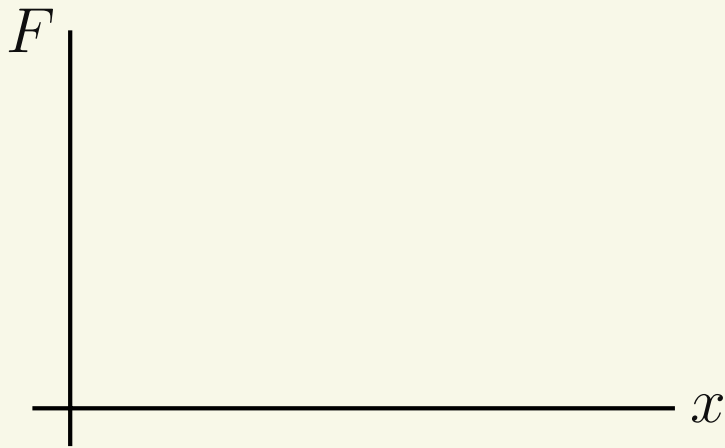
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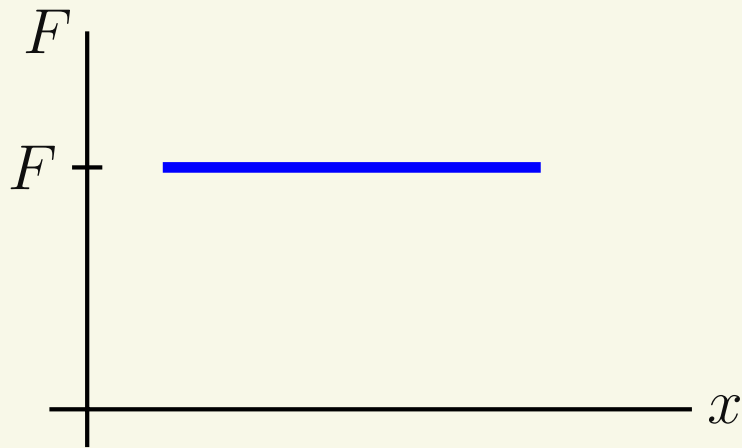
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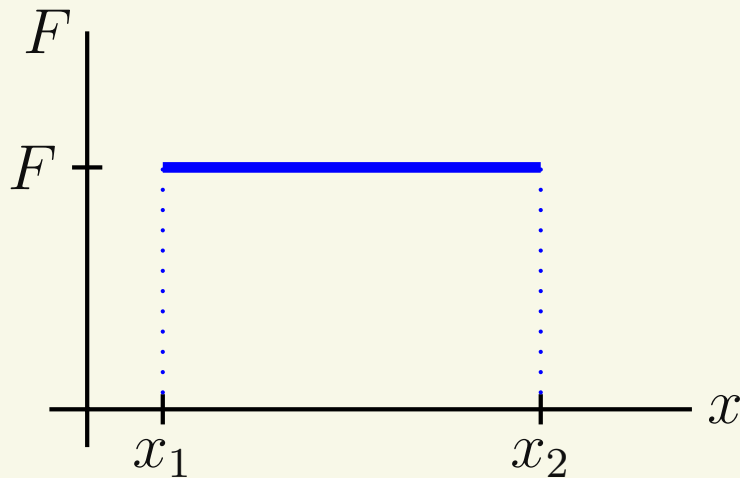
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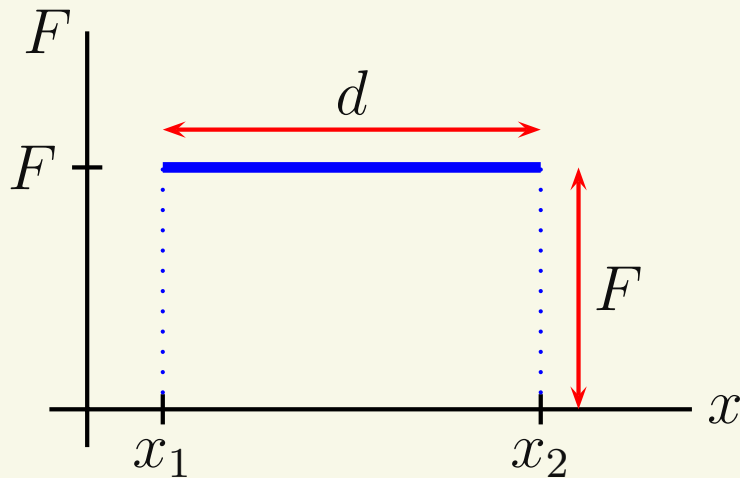
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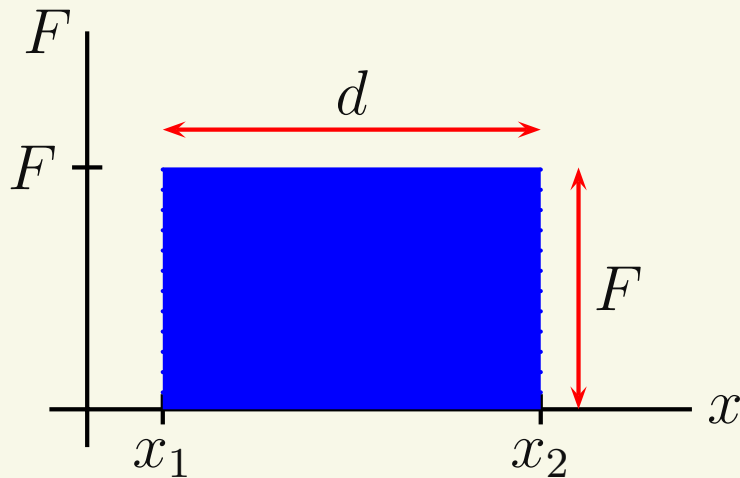
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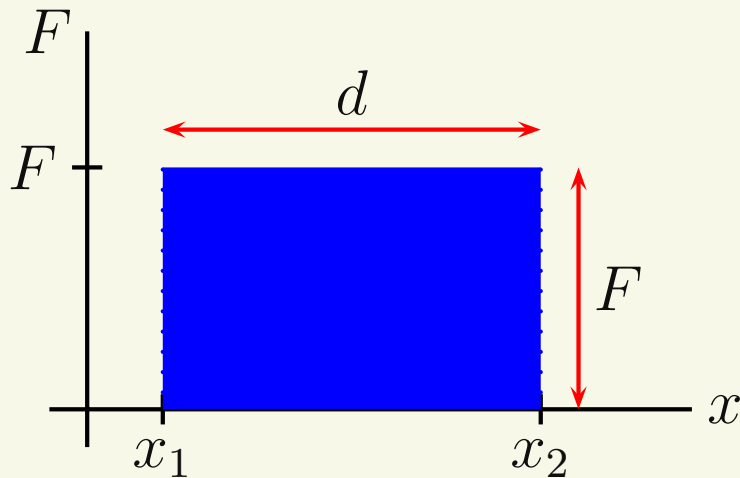
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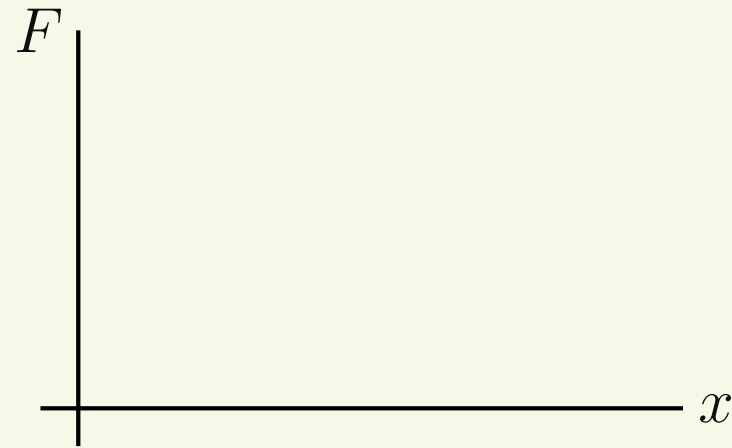
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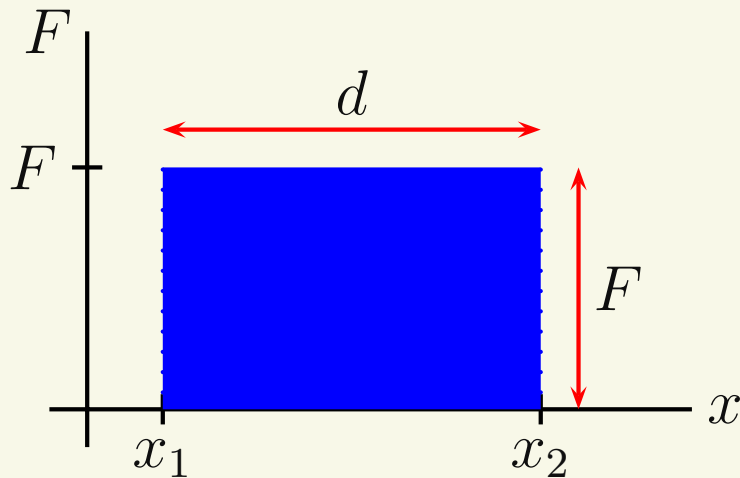
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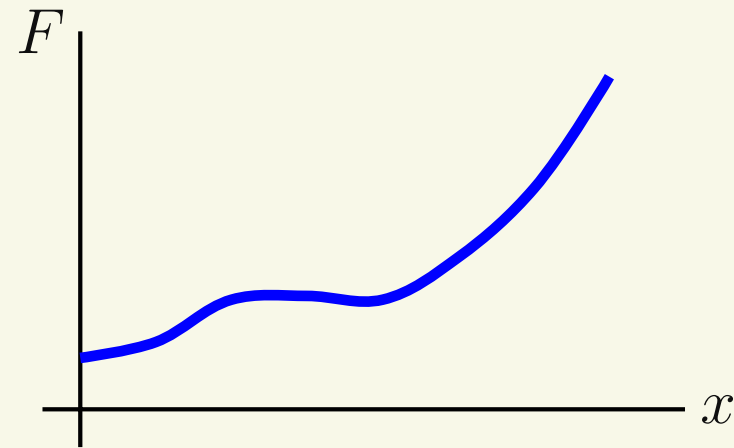
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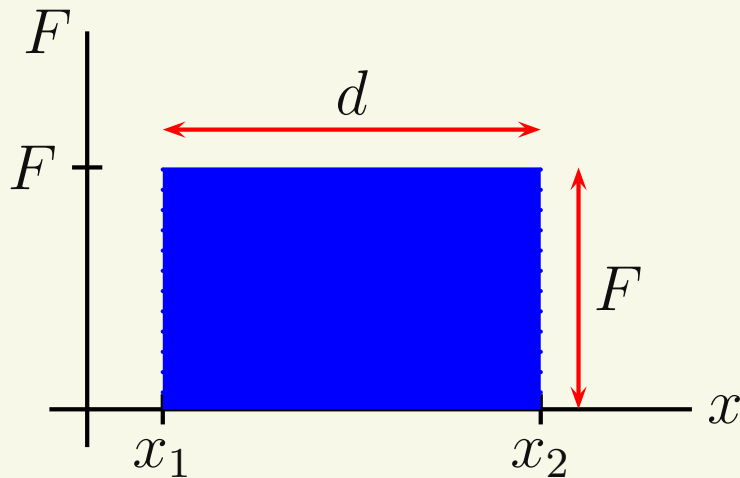
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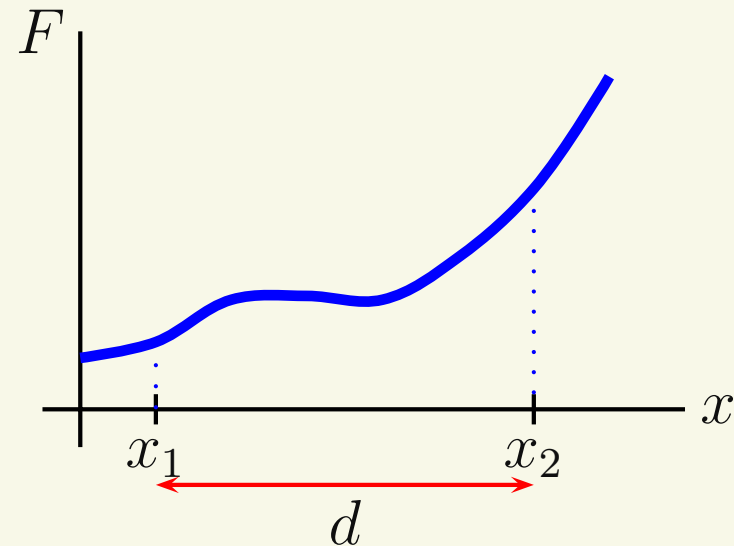
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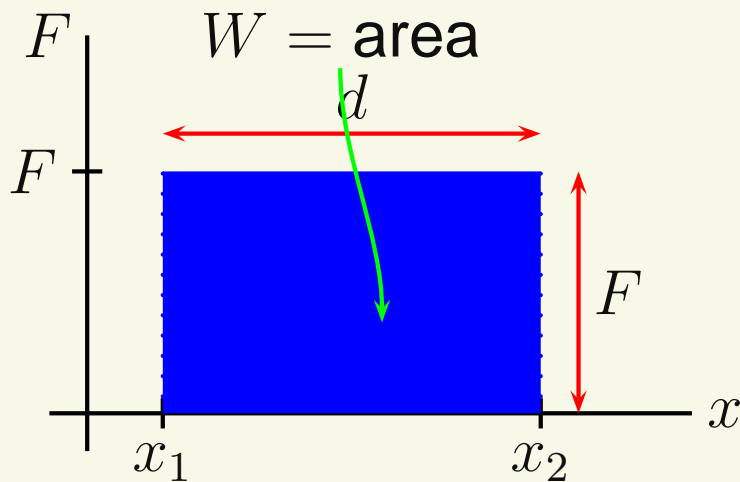
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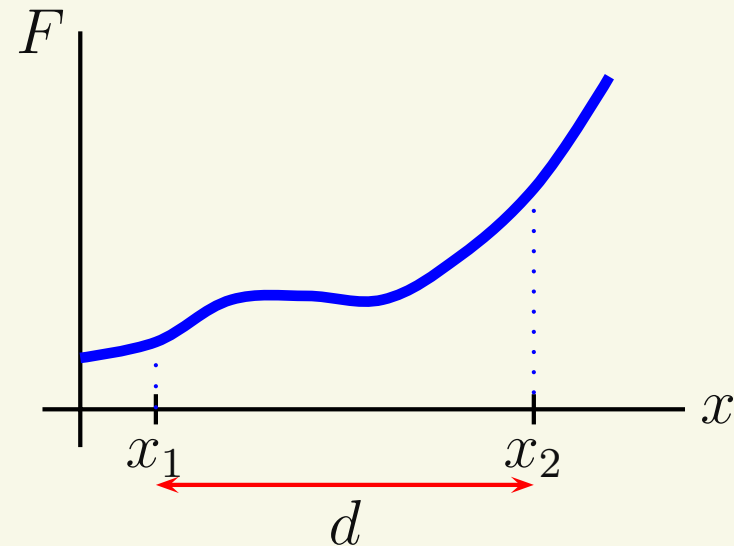
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To find the work done by a changing force, we have to find the area under a curve.

Constant Force, $W = Fd$



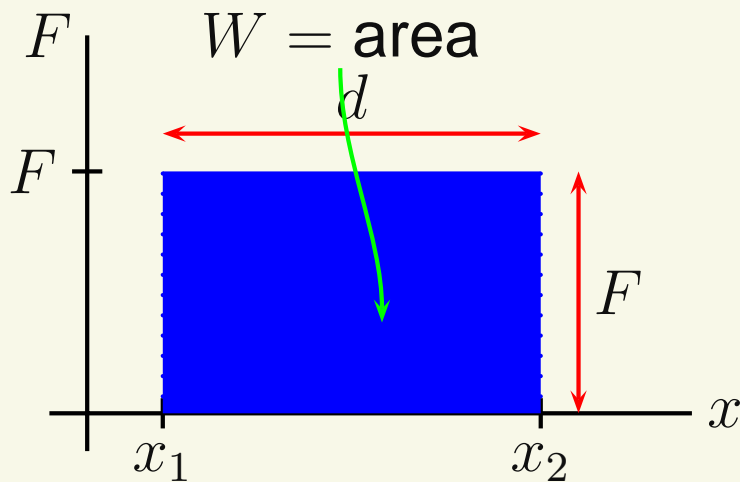
Variable Force



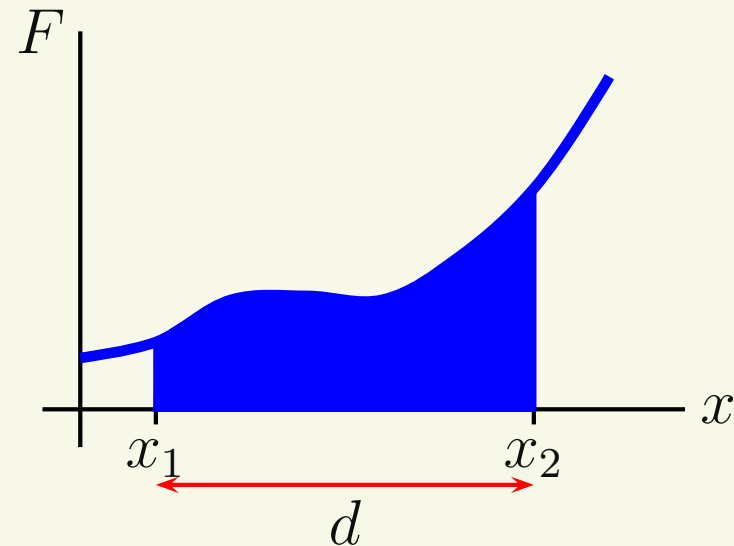
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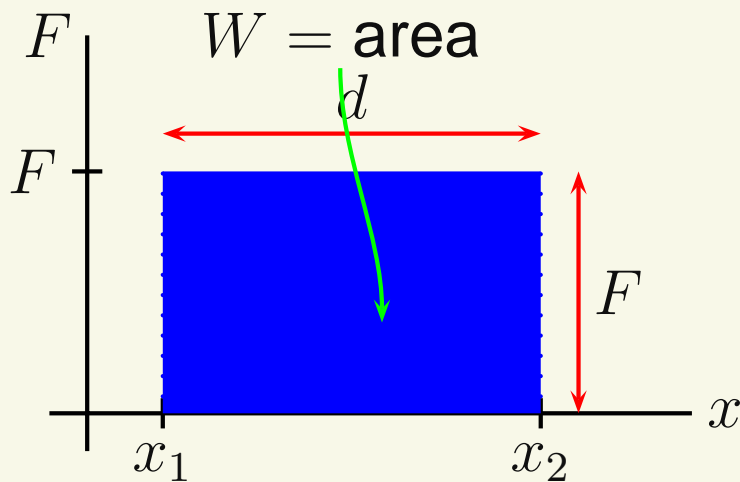
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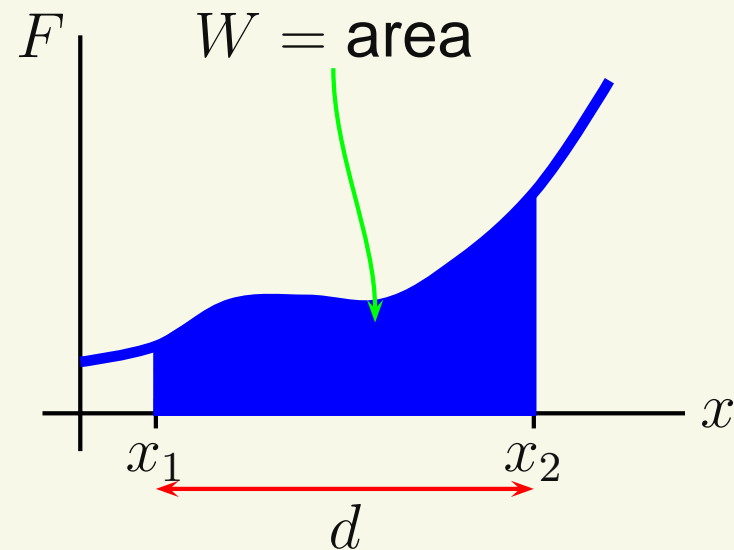
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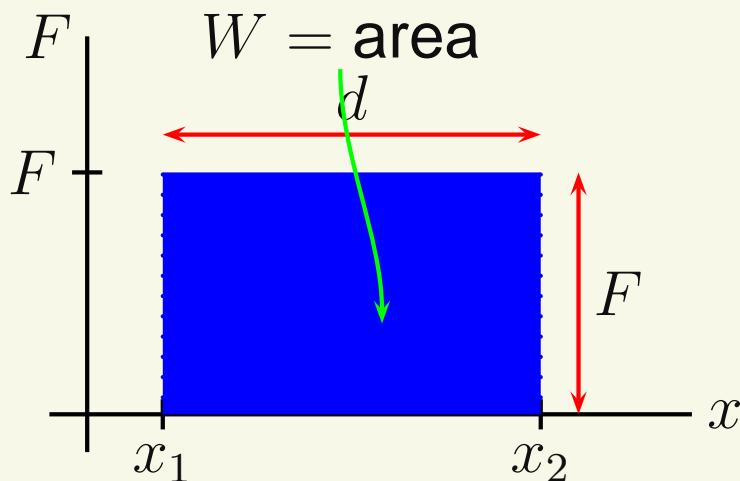
Variable Force



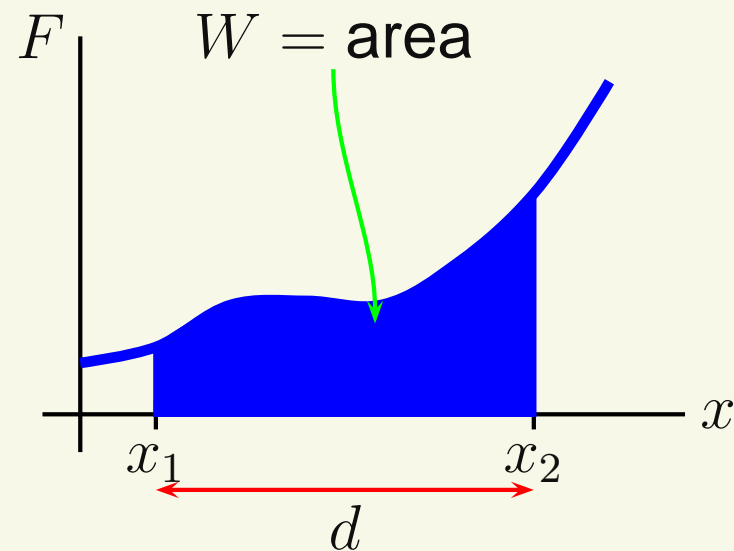
Variable Forces

To find the work done by a changing force, we have to find the area under a curve.

Constant Force, $W = Fd$



Variable Force



For variable forces, it can be shown that the work-energy theorem still holds!

$$W_{total} = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$$

Potential Energy

Some forces do work that can be saved or stored.

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Conservative Forces - Forces that create potential energy.

Conservative forces are rare. Only gravity and the spring force are conservative. (You'll learn two more next term - the electric and magnetic force.) For a force to be conservative, the work it does must be independent of path.

Conservation of Energy

For a conservative force,

$$W = -\Delta U$$

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Conservation of Energy - If only conservative forces do work on an object, its total energy cannot change.

Total Energy, E = the sum of kinetic and potential energy.

$$E = K + U$$

Conservation of Energy II

Proof: If a conservative force is the only force doing work on an object then:

$$W_{total} = W$$

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Conservation of Energy II

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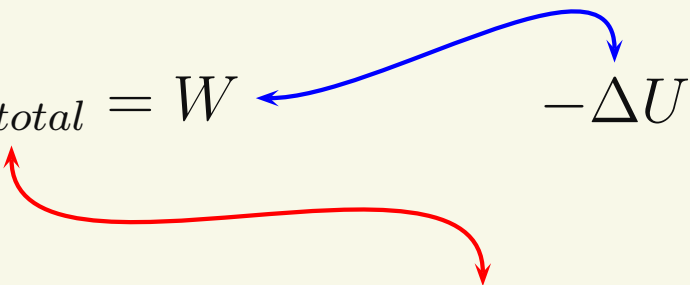
$$W_{total} = W$$

The diagram illustrates the conservation of energy. It shows the equation $W_{total} = W$ in the center. A blue arrow points from $-\Delta U$ to W , and a red arrow points from ΔK to W . This indicates that the total work done on an object is equal to the negative change in potential energy and the change in kinetic energy.

The work-energy Theorem $\Rightarrow W_{total} = \Delta K$

Conservation of Energy II

Proof: If a conservative force is the only force doing work on an object then:

$$W_{total} = W$$


The work-energy Theorem $\Rightarrow W_{total} = \Delta K$

$$\Rightarrow \Delta K = -\Delta U$$

Conservation of Energy II

Proof: If a conservative force is the only force doing work on an object then:

$$W_{total} = W$$

A diagram illustrating the relationship between work and potential energy change. A blue arrow points from $-\Delta U$ to W , and a red arrow points from W to ΔK .

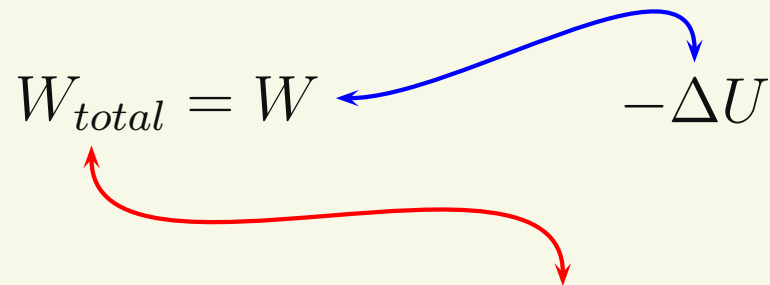
The work-energy Theorem $\Rightarrow W_{total} = \Delta K$

$$\Rightarrow \Delta K = -\Delta U$$

$$\Rightarrow K_f - K_i = -(U_f - U_i) \Rightarrow \boxed{K_i + U_i = K_f + U_f}$$

Conservation of Energy II

Proof: If a conservative force is the only force doing work on an object then:

$$W_{total} = W$$


The diagram shows the equation $W_{total} = W$. A blue curved arrow points from $-\Delta U$ to W . A red curved arrow points from W to ΔK in the subsequent equation.

The work-energy Theorem $\Rightarrow W_{total} = \Delta K$

$$\Rightarrow \Delta K = -\Delta U$$

$$\Rightarrow K_f - K_i = -(U_f - U_i) \Rightarrow \boxed{K_i + U_i = K_f + U_f}$$

$$\Rightarrow E_i = E_f$$

Energy-Conservation Exercise


A block having 15 J of gravitational potential energy is dropped from rest. When the block hits the ground, it has 15 J of kinetic energy. If gravity is the only force acting on the block, how much potential energy does the block have when it hits the ground?



● $U_g = 15\text{ J}$



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 $K = 15\text{ J}$


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A block having 15 J of gravitational potential energy is dropped from rest. When the block hits the ground, it has 15 J of kinetic energy. If gravity is the only force acting on the block, how much potential energy does the block have when it hits the ground?


(a) 0 J

 $U_g = 15\text{ J}$

 $K = 15\text{ J}$




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 $U_g = 15\text{ J}$


(a) 0 J

(b) 7.5 J

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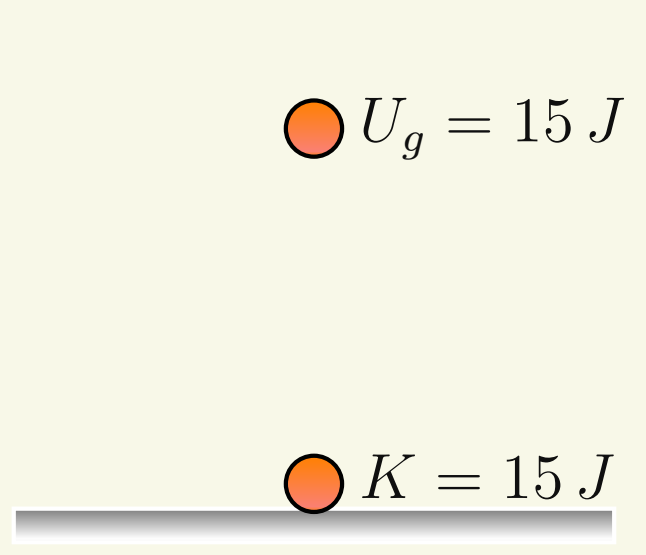
(c) 15 J

 $K = 15\text{ J}$



Energy-Conservation Exercise

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The diagram illustrates a physics problem. At the top, an orange circle represents a block with the text $U_g = 15\text{ J}$ next to it. A vertical dashed line indicates the path of the block as it falls. At the bottom, a horizontal grey bar represents the ground. An orange circle on the ground represents the block after impact, with the text $K = 15\text{ J}$ next to it.

$$\text{● } U_g = 15\text{ J}$$

(a) 0 J

(b) 7.5 J

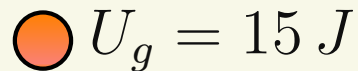
(c) 15 J

$$\text{● } K = 15\text{ J}$$

(d) 30 J

Energy-Conservation Exercise

A block having 15 J of gravitational potential energy is dropped from rest. When the block hits the ground, it has 15 J of kinetic energy. If gravity is the only force acting on the block, how much potential energy does the block have when it hits the ground?

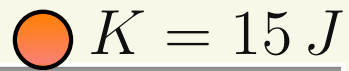
A diagram showing a block in free fall. An orange circle with a black outline represents the block. To its right is the text $U_g = 15\text{ J}$.

$\bigcirc U_g = 15\text{ J}$

(a) 0 J

(b) 7.5 J

(c) 15 J

A diagram showing a block on the ground. An orange circle with a black outline represents the block. To its right is the text $K = 15\text{ J}$. Below the block is a thick grey horizontal bar representing the ground.

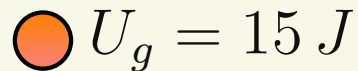
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(d) 30 J

(e) Cannot be determined

Energy-Conservation Exercise

A block having 15 J of gravitational potential energy is dropped from rest. When the block hits the ground, it has 15 J of kinetic energy. If gravity is the only force acting on the block, how much potential energy does the block have when it hits the ground?

A diagram showing a block in the air. It consists of an orange circle with a black outline, representing the block, and the text $U_g = 15\text{ J}$ to its right.

$U_g = 15\text{ J}$

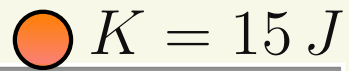
(a) 0 J

(b) 7.5 J

(c) 15 J

(d) 30 J


(e) Cannot be determined

A diagram showing a block on the ground. It consists of an orange circle with a black outline, representing the block, and the text $K = 15\text{ J}$ to its right. Below the block is a horizontal grey bar representing the ground.

$K = 15\text{ J}$

Energy-Conservation Exercise


A block having 15 J of gravitational potential energy is dropped from rest. When the block hits the ground, it has 15 J of kinetic energy. If gravity is the only force acting on the block, how much potential energy does the block have when it hits the ground?

A small orange circle representing a block is shown in the air.
$$U_g = 15\text{ J}$$

(a) 0 J

$$K_i + U_i = K_f + U_f \Rightarrow$$

$$0 + 15\text{ J} = 15\text{ J} + U_f$$

A small orange circle representing a block is shown on a grey horizontal bar representing the ground.
$$K = 15\text{ J}$$