March 25, Week 10

Today: Chapter 7, Combination Energy Problems

Homework Assignment #7 - Due March 29

Mastering Physics: 6 problems from chapter 7

Written Questions: 7.60

Help sessions with Jonathan:

M: 1000-1100, RH 111

T: 1000-1100, RH 114

Th: 0900-1000, RH 114

General Energy Problems

The most general problems (this term) involve gravity, springs, and other forces all doing work.

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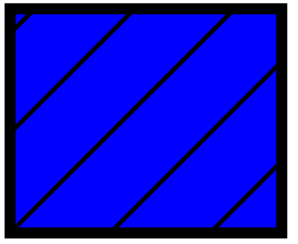

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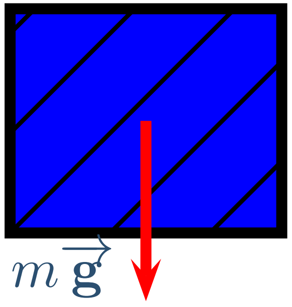

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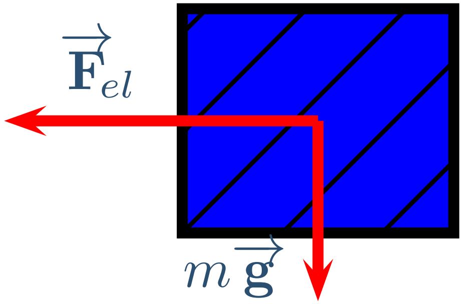

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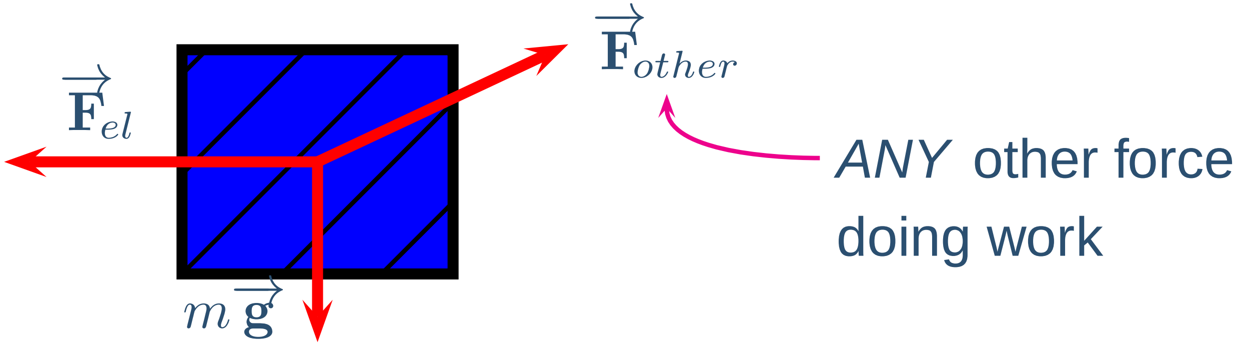

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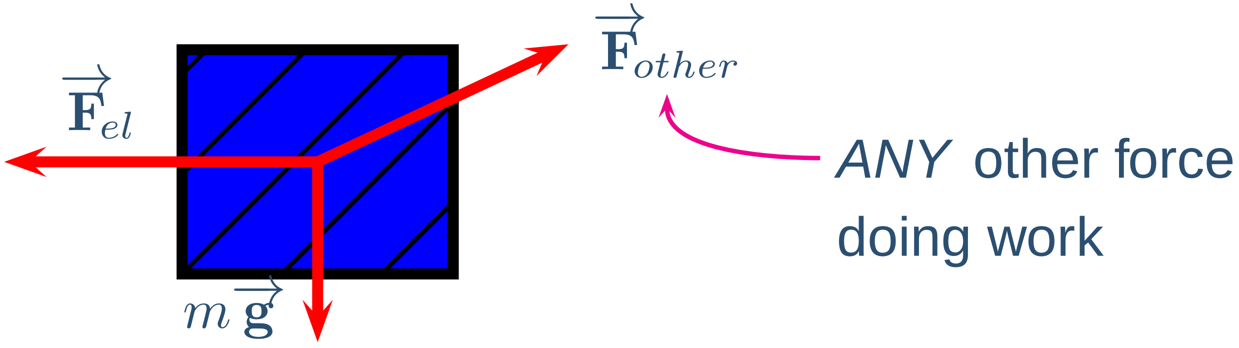

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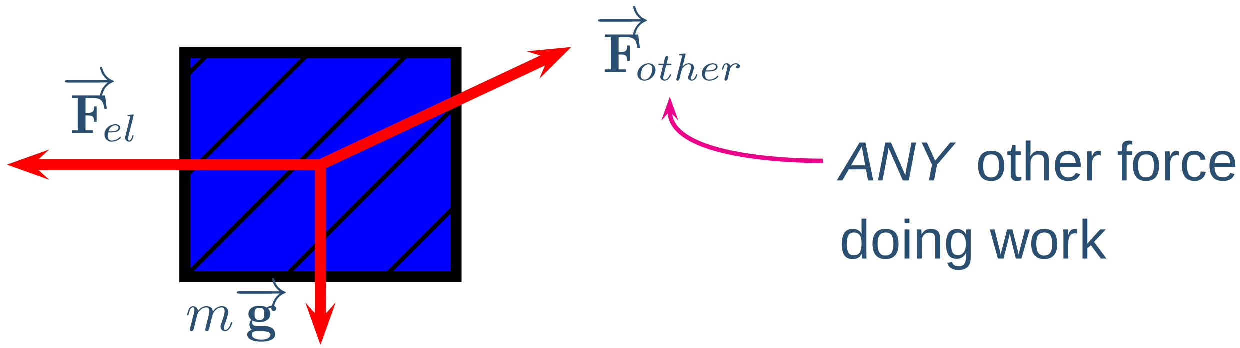

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$W_{total} \rightarrow \Delta K$

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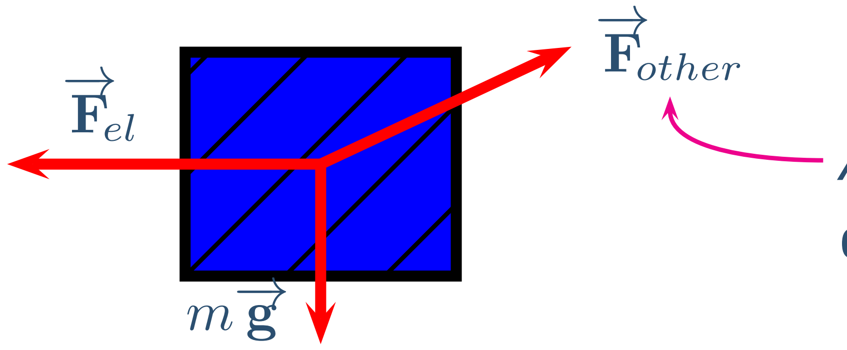

ANY other force doing work

$$W_{total} = W_g + W_{el} + W_{other}$$

$W_{total} \rightarrow \Delta K$

$W_g \rightarrow -\Delta U_g$

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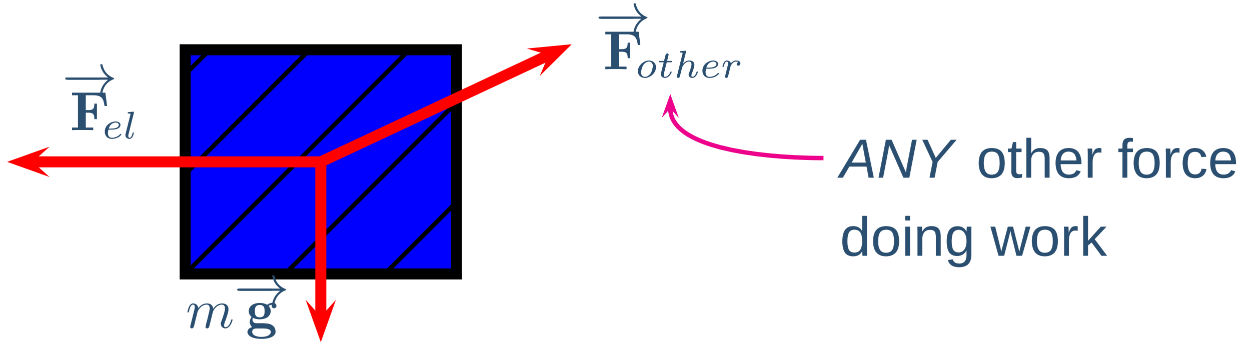

$$W_{total} = W_g + W_{el} + W_{other}$$

$W_{total} \rightarrow \Delta K$, $W_g \rightarrow -\Delta U_g$, $W_{el} \rightarrow -\Delta U_{el}$

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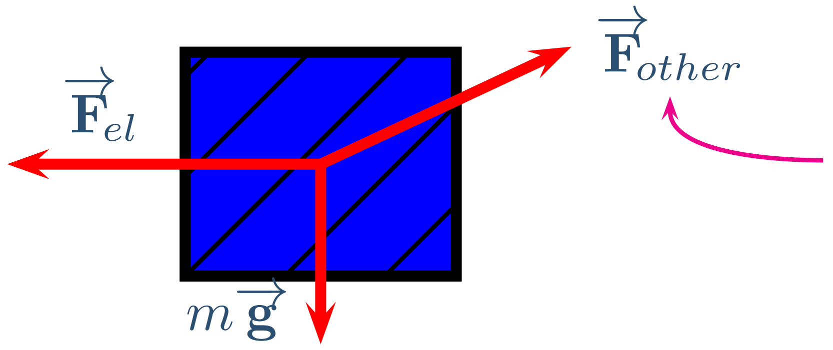

ANY other force doing work

$$W_{total} = W_g + W_{el} + W_{other}$$

ΔK $\quad -\Delta U_g \quad -\Delta U_{el}$

$$\frac{1}{2}mv_1^2 + mgy_1 + \frac{1}{2}ks_1^2 + W_{other} = \frac{1}{2}mv_2^2 + mgy_2 + \frac{1}{2}ks_2^2$$

Combination Exercise I

An $80\,kg$ man jumps onto a spring platform ($k = 18000\,N/m$) going $9\,m/s$. Ignoring friction, which of the following is the correct set of variables to find the maximum compression of the spring, d?

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(e) Both (b) and (d) would work

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$s_1 = 0$, $s_2 = -d$

$$\frac{1}{2}(80\,kg)(9\,m/s)^2 + 0 + 0 = 0 + (80\,kg)(9.8\,m/s^2)(-d) + \frac{1}{2}(1800\,N/m)d^2$$

$(900\,N/m)d^2 - (784\,N/m)d - 3240\,J = 0 \leftarrow$ Quadratic equation

$d = 0.645\,m$ or $d = -0.558\,m$

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An $80\,kg$ man skydives from a plane $500\,m$ above the ground. If he lands with a speed of $4\,m/s$ (and was essentially at rest when he jumped), how much work did his parachute do? **Hint:** $(80)(9.8)(500) = 392000$, $\quad \frac{1}{2}(80)(4)^2 = 640$.

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(c) $392000\,J - 640\,J$

$= 391360\,J$

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(d) $640\,J - 392000\,J$
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(e) $640\,J + 392000\,J = 392640\,J$

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We can recover conservation of energy by including thermal energy:

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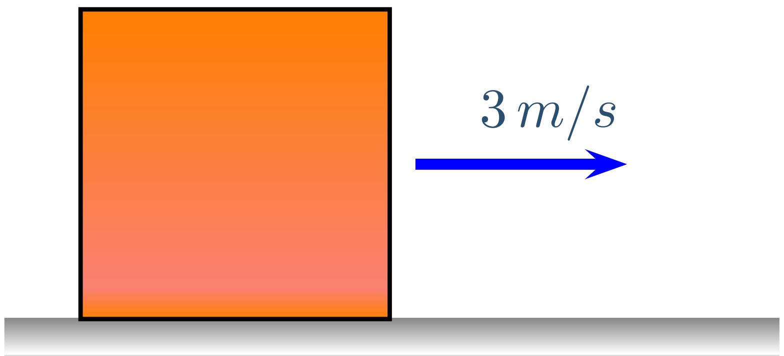
A $10\,kg$ mass sliding to the right, initially with speed $3\,m/s$, is stopped by friction. How much thermal energy will be created by this process?



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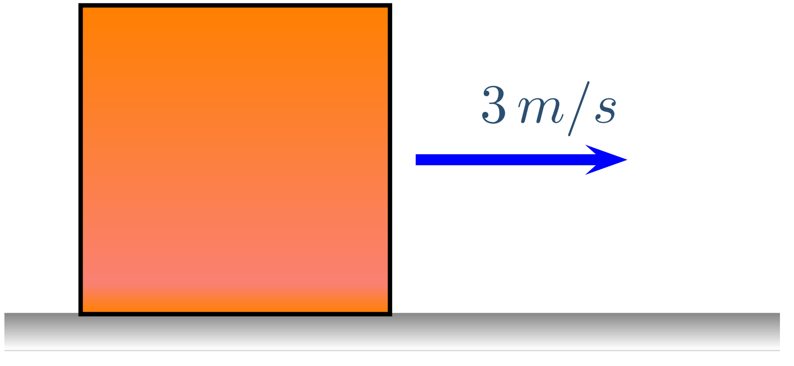

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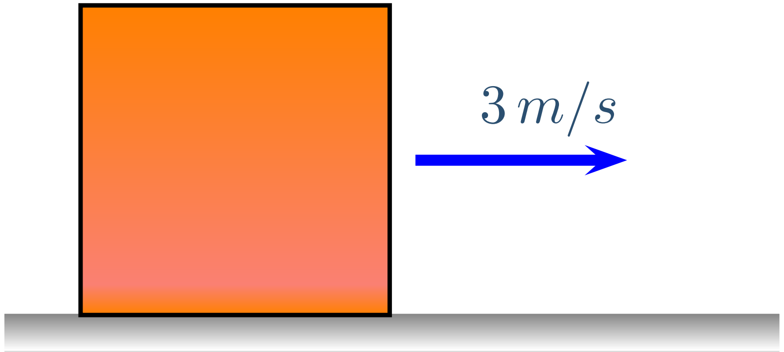
(b) $15\,J$



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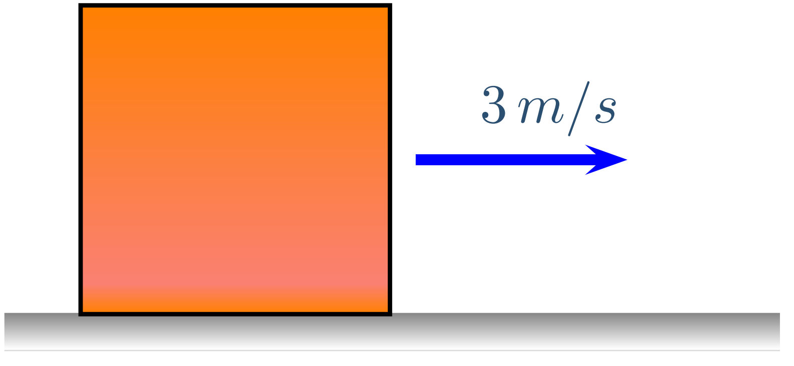

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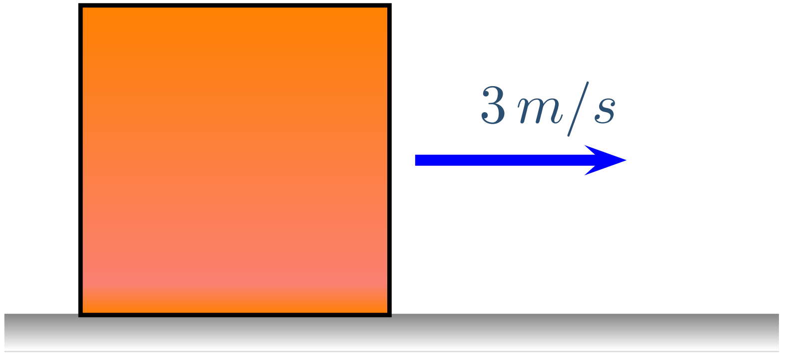

(a) $10\,J$

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(d) $45\,J$

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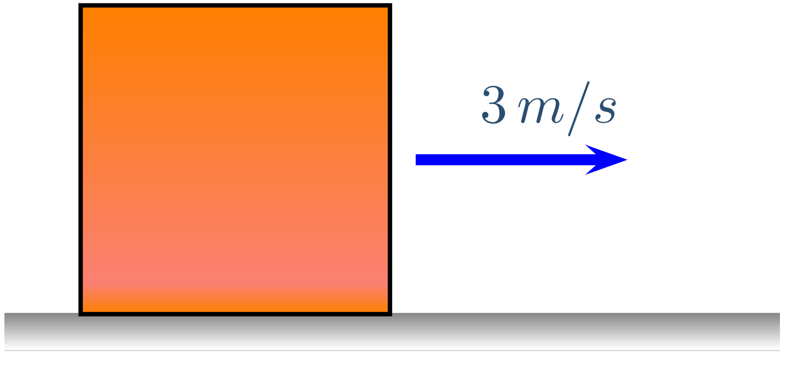

(a) $10\,J$

(b) $15\,J$

(c) $30\,J$

(d) $45\,J$

(e) $90\,J$

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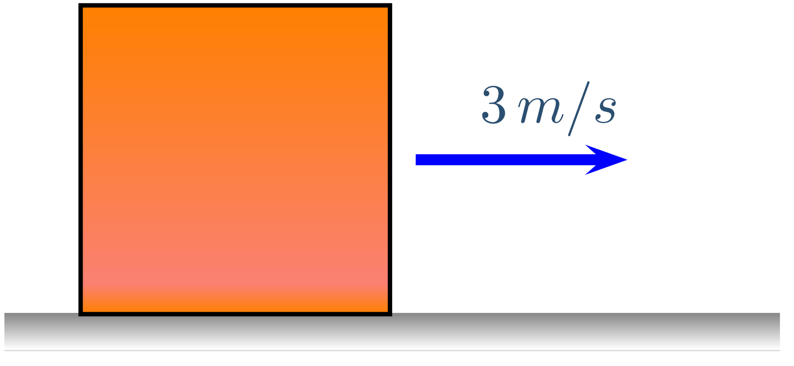
No springs or gravity $\Rightarrow \frac{1}{2}mv_i^2 = \frac{1}{2}mv_f^2 + \Delta E_{th}$

$v_i = 3\,m/s$, $v_f = 0 \Rightarrow 45\,J = 0 + \Delta E_{th}$



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Unit: $kg \cdot m/s$

Momentum

We can rewrite Newton's Second law in a slightly different way:

$$\sum \overrightarrow{\mathbf{F}} = m\overrightarrow{\mathbf{a}} \Rightarrow \sum \overrightarrow{\mathbf{F}} = m\frac{d\overrightarrow{\mathbf{v}}}{dt} \Rightarrow \sum \overrightarrow{\mathbf{F}} = \frac{d(m\overrightarrow{\mathbf{v}})}{dt}$$

Newton's Second Law: $\boxed{\sum \overrightarrow{\mathbf{F}} = \frac{d\overrightarrow{\mathbf{p}}}{dt}}$

Momentum: $\boxed{\overrightarrow{\mathbf{p}} = m\overrightarrow{\mathbf{v}}}$

Momentum measures how “hard" it is to change the velocity of an object.

Unit: $kg \cdot m/s \leftarrow$ No fancy name!

Impulse

Related to Momentum is Impulse, $\vec{\mathbf{J}}$:

Impulse

Related to Momentum is Impulse, $\overrightarrow{\mathbf{J}}$:

In terms of the average net force, $\overrightarrow{\mathbf{F}}_{av}$:

$$\boxed{\overrightarrow{\mathbf{J}} = \overrightarrow{\mathbf{F}}_{av}\Delta t}$$

Unit: $N \cdot s = kg \cdot m/s$

Impulse

Related to Momentum is Impulse, $\overrightarrow{\mathbf{J}}$:

In terms of the average net force, $\overrightarrow{\mathbf{F}}_{av}$:

$$\boxed{\overrightarrow{\mathbf{J}} = \overrightarrow{\mathbf{F}}_{av}\Delta t}$$

Unit: $N \cdot s = kg \cdot m/s$

Impulse-Momentum Theorem (Average Force Version):

Impulse

Related to Momentum is Impulse, $\overrightarrow{\mathbf{J}}$:

In terms of the average net force, $\overrightarrow{\mathbf{F}}_{av}$:

$$\boxed{\overrightarrow{\mathbf{J}} = \overrightarrow{\mathbf{F}}_{av}\Delta t}$$

Unit: $N \cdot s = kg \cdot m/s$

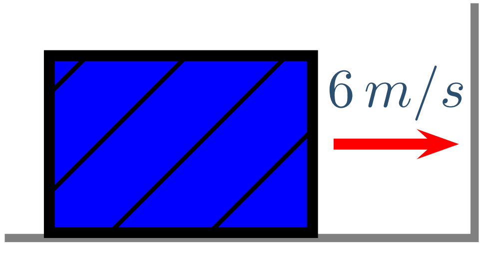
Impulse-Momentum Theorem (Average Force Version):

$$\sum \overrightarrow{\mathbf{F}} = \frac{d\overrightarrow{\mathbf{p}}}{dt} \Rightarrow \overrightarrow{\mathbf{F}}_{av} = \frac{\Delta\overrightarrow{\mathbf{p}}}{\Delta t} \Rightarrow \boxed{\overrightarrow{\mathbf{J}} = \overrightarrow{\mathbf{F}}_{av}\Delta t = \Delta\overrightarrow{\mathbf{p}}}$$

Impulse-Momentum Exercise I

$$\overrightarrow{\mathbf{J}} = \overrightarrow{\mathbf{F}}_{av}\Delta t = \Delta\overrightarrow{\mathbf{p}}$$

A 5.0-kg block is sliding on a frictionless, horizontal surface going $6.0\,m/s$ to the right when it hits a wall and stops. What impulse is imparted to the block?



BEFORE

Impulse-Momentum Exercise I

$$\overrightarrow{\mathbf{J}} = \overrightarrow{\mathbf{F}}_{av}\Delta t = \Delta\overrightarrow{\mathbf{p}}$$

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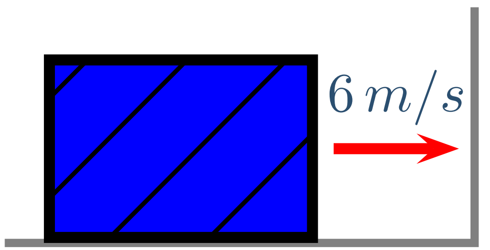
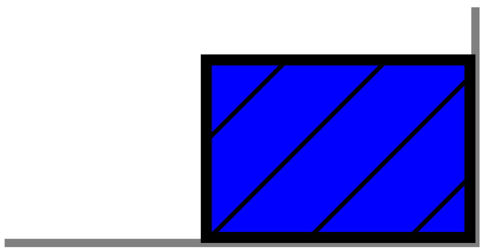


BEFORE



AFTER

Impulse-Momentum Exercise I

$$\overrightarrow{\mathbf{J}} = \overrightarrow{\mathbf{F}}_{av}\Delta t = \Delta\overrightarrow{\mathbf{p}}$$

A 5.0-kg block is sliding on a frictionless, horizontal surface going $6.0\,m/s$ to the right when it hits a wall and stops. What impulse is imparted to the block?

(a) $60\,kg \cdot m/s, \leftarrow$

Impulse-Momentum Exercise I

$$\overrightarrow{\mathbf{J}} = \overrightarrow{\mathbf{F}}_{av}\Delta t = \Delta\overrightarrow{\mathbf{p}}$$

A 5.0-kg block is sliding on a frictionless, horizontal surface going $6.0\,m/s$ to the right when it hits a wall and stops. What impulse is imparted to the block?

(a) $60\,kg \cdot m/s, \leftarrow$ (b) $60\,kg \cdot m/s, \rightarrow$

Impulse-Momentum Exercise I

$$\overrightarrow{\mathbf{J}} = \overrightarrow{\mathbf{F}}_{av}\Delta t = \Delta\overrightarrow{\mathbf{p}}$$

A 5.0-kg block is sliding on a frictionless, horizontal surface going $6.0\,m/s$ to the right when it hits a wall and stops. What impulse is imparted to the block?

(a) $60\,kg\cdot m/s, \leftarrow$ (b) $60\,kg\cdot m/s, \rightarrow$ (c) $30\,kg\cdot m/s, \leftarrow$

Impulse-Momentum Exercise I

$$\overrightarrow{\mathbf{J}} = \overrightarrow{\mathbf{F}}_{av}\Delta t = \Delta \overrightarrow{\mathbf{p}}$$

A 5.0-kg block is sliding on a frictionless, horizontal surface going $6.0\,m/s$ to the right when it hits a wall and stops. What impulse is imparted to the block?

(a) $60\,kg \cdot m/s, \leftarrow$ (b) $60\,kg \cdot m/s, \rightarrow$ (c) $30\,kg \cdot m/s, \leftarrow$

(d) $30\,kg \cdot m/s, \rightarrow$

Impulse-Momentum Exercise I

$$\overrightarrow{\mathbf{J}} = \overrightarrow{\mathbf{F}}_{av}\Delta t = \Delta\overrightarrow{\mathbf{p}}$$

A 5.0-kg block is sliding on a frictionless, horizontal surface going $6.0\,m/s$ to the right when it hits a wall and stops. What impulse is imparted to the block?

(a) $60\,kg \cdot m/s, \leftarrow$ (b) $60\,kg \cdot m/s, \rightarrow$ (c) $30\,kg \cdot m/s, \leftarrow$

(d) $30\,kg \cdot m/s, \rightarrow$ (e) $15\,kg \cdot m/s, \leftarrow$

Impulse-Momentum Exercise I

$$\boxed{\overrightarrow{\mathbf{J}} = \overrightarrow{\mathbf{F}}_{av}\Delta t = \Delta\overrightarrow{\mathbf{p}}}$$

A 5.0-kg block is sliding on a frictionless, horizontal surface going $6.0\,m/s$ to the right when it hits a wall and stops. What impulse is imparted to the block?

$$J_x = \Delta p_x = 0 - 30\,kg\cdot m/s = -30\,kg\cdot m/s$$

(a) $60\,kg\cdot m/s, \leftarrow$

(b) $60\,kg\cdot m/s, \rightarrow$

(c) $30\,kg\cdot m/s, \leftarrow$

(d) $30\,kg\cdot m/s, \rightarrow$

(e) $15\,kg\cdot m/s, \leftarrow$