Today: 4.3, 4.4

$\boxed{L12}$

Today: $\underbrace{4.3}_{}$, 4.4

$\boxed{L12}$

Newton's 2nd Law

Today: 4.3, $\underbrace{4.4}$ $\boxed{L12}$

Mass and weight

$\boxed{L12}$

Today: 4.3, 4.4

Wednesday: 4.5, 4.6

Today: 4.3, 4.4

Wednesday: 4.5, 4.6

Newton's

3rd law

L12

Today: 4.3, 4.4

Wednesday: 4.5, 4.6

Free-body diagrams

Today: 4.3, 4.4

$\boxed{L12}$

Wednesday: 4.5, 4.6

HW 5 has been posted on Canvas

Today: 4.3, 4.4

$\boxed{L12}$

Wednesday: 4.5, 4.6

HW 5 has been posted on Canvas & is due

Monday Sept. 28th

[Next monday]

Correction to previous lecture

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$\vec{F} = m\vec{a}$

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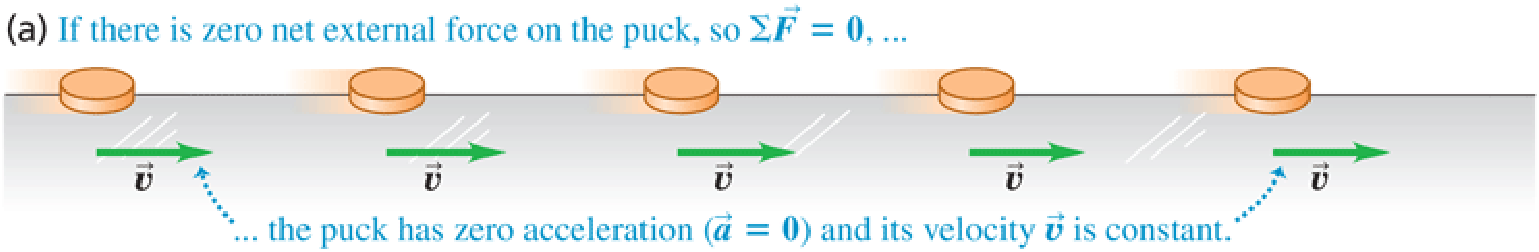
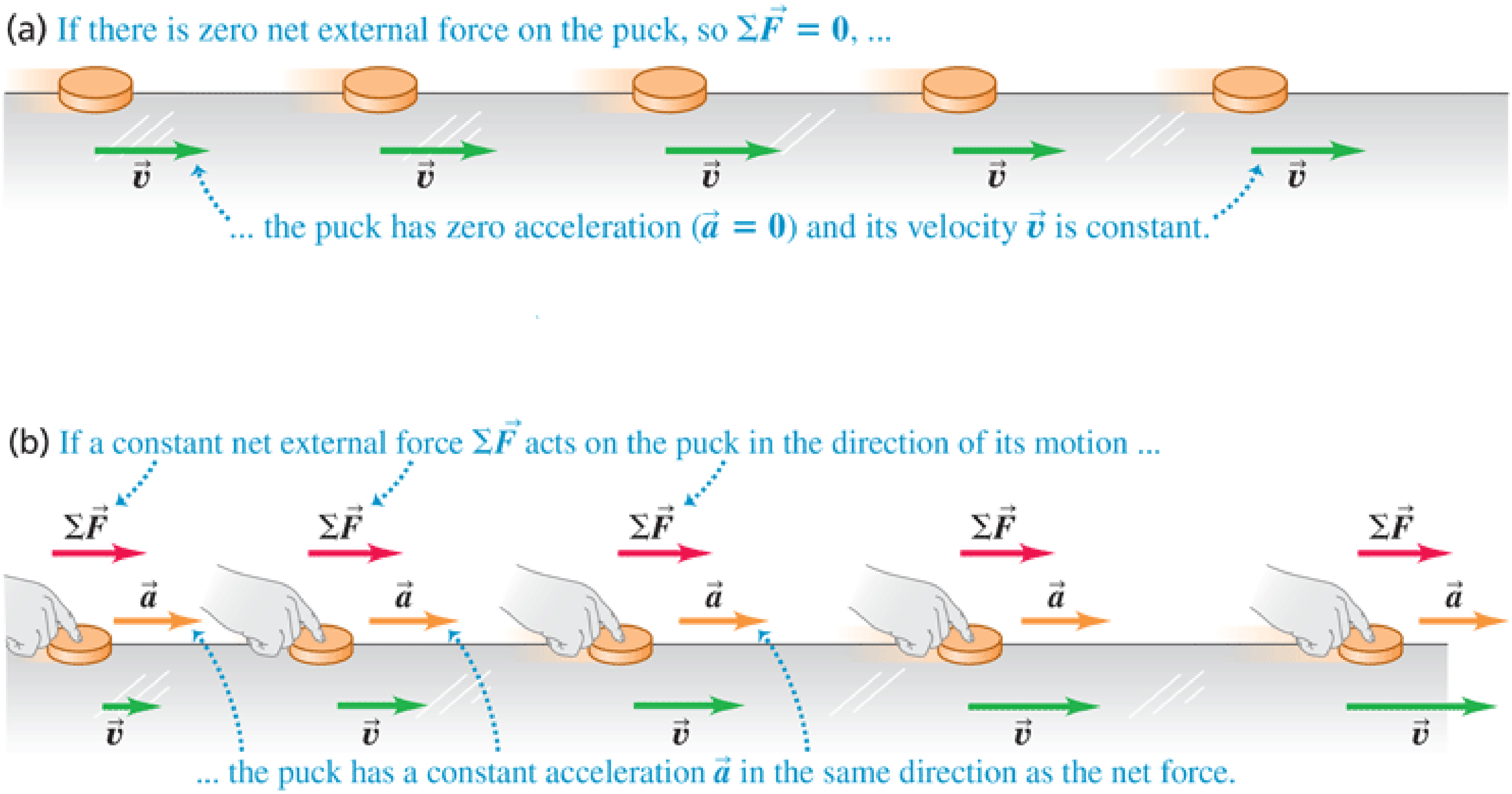
Newtons 2nd law

$\Sigma \vec{F} = m\vec{a}$ ← 2nd law implies the first law $\left[\Sigma \vec{F} = 0 \Rightarrow \vec{a} = 0\right]$


(a) If there is zero net external force on the puck, so $\Sigma\vec{F} = \mathbf{0}$, ...
$\vec{v}$
$\vec{v}$
$\vec{v}$
$\vec{v}$
$\vec{v}$
... the puck has zero acceleration ($\vec{a} = \mathbf{0}$) and its velocity $\vec{v}$ is constant.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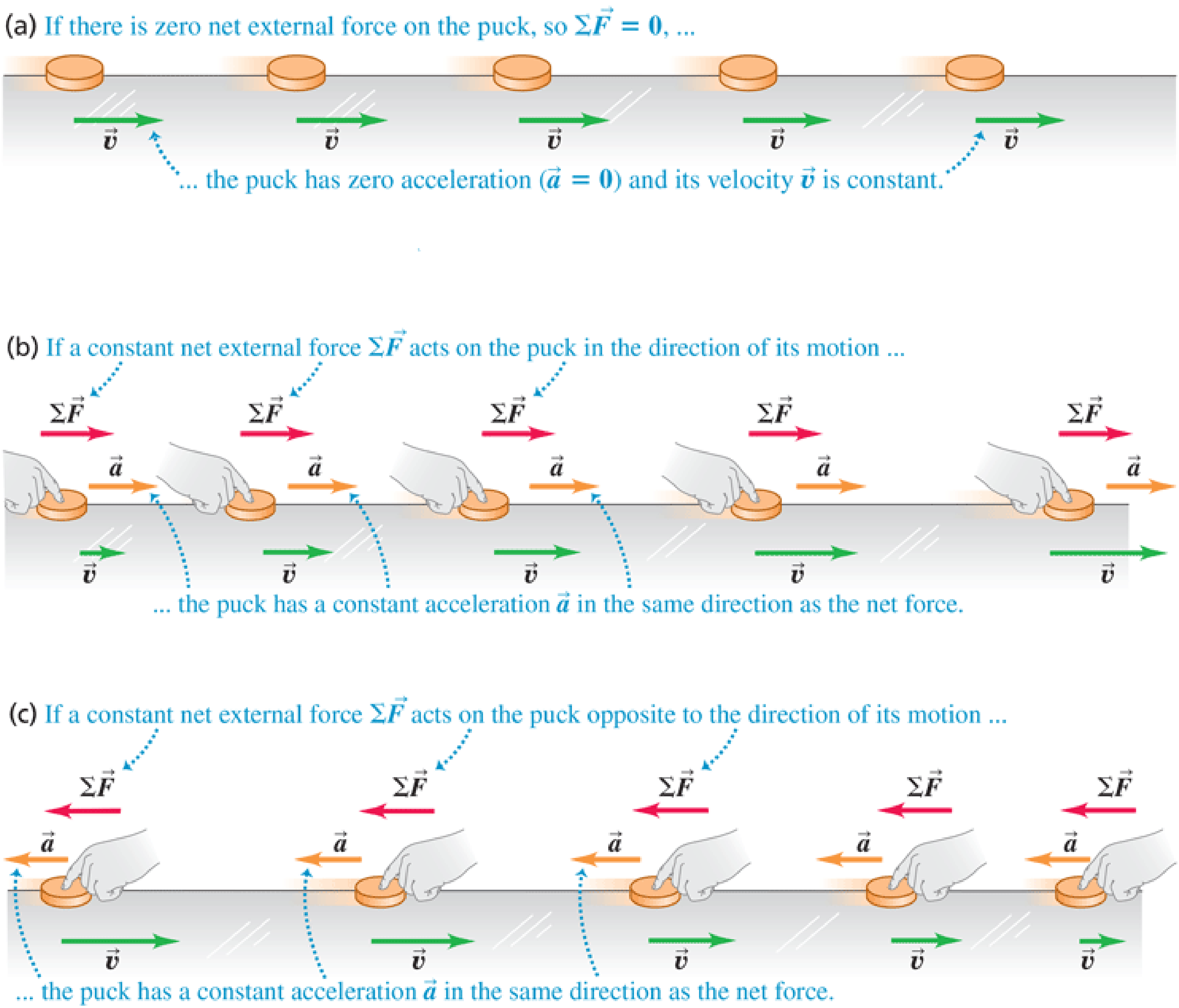
... the puck has zero acceleration ($\vec{a} = \mathbf{0}$) and its velocity $\vec{v}$ is constant.
(b) If a constant net external force $\Sigma\vec{F}$ acts on the puck in the direction of its motion ...
$\Sigma\vec{F}$
$\vec{a}$
$\vec{v}$
... the puck has a constant acceleration $\vec{a}$ in the same direction as the net force.


(a) If there is zero net external force on the puck, so $\Sigma\vec{F} = 0$, ...
$\vec{v}$
... the puck has zero acceleration ($\vec{a} = 0$) and its velocity $\vec{v}$ is constant.
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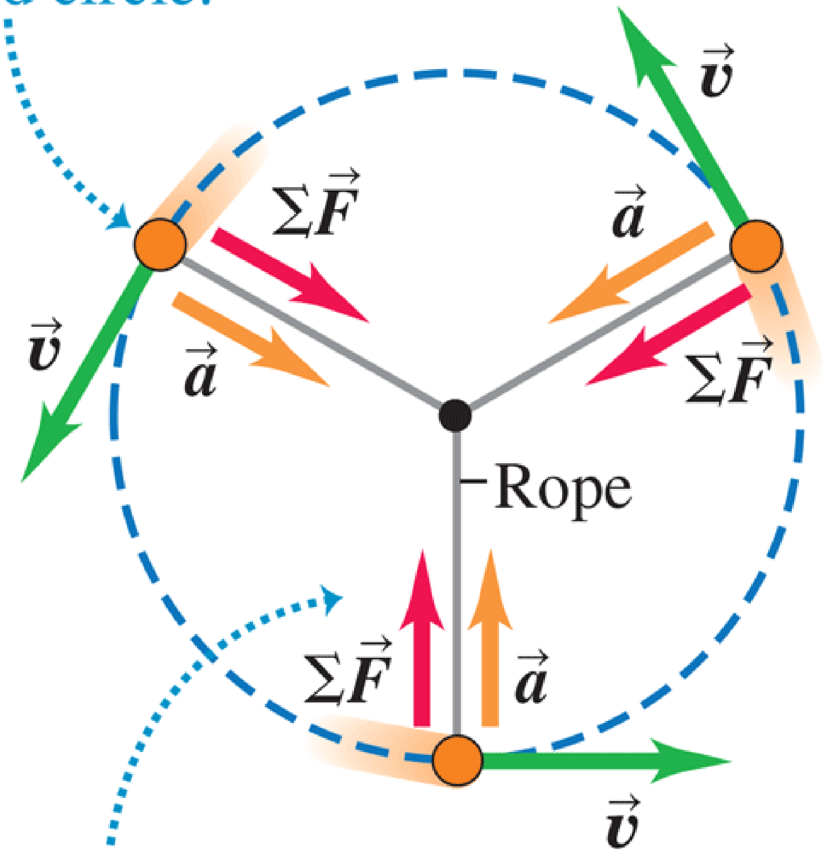
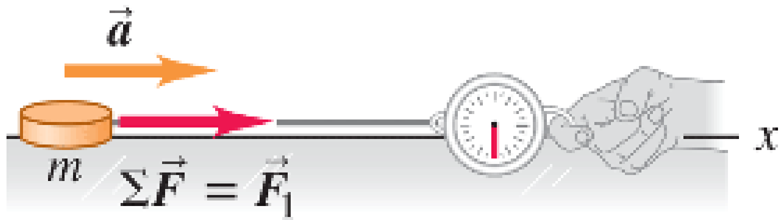
$\Sigma\vec{F}$
$\vec{a}$
$\vec{v}$
... the puck has a constant acceleration $\vec{a}$ in the same direction as the net force.
(c) If a constant net external force $\Sigma\vec{F}$ acts on the puck opposite to the direction of its motion ...
$\Sigma\vec{F}$
$\vec{a}$
$\vec{v}$
... the puck has a constant acceleration $\vec{a}$ in the same direction as the net force.

Puck moves at constant speed around circle.



At all points, the acceleration $\vec{a}$ and the net external force $\Sigma\vec{F}$ point in the same direction—always toward the center of the circle.

(a) A constant net external force $\Sigma\vec{F}$ causes a constant acceleration $\vec{a}$.



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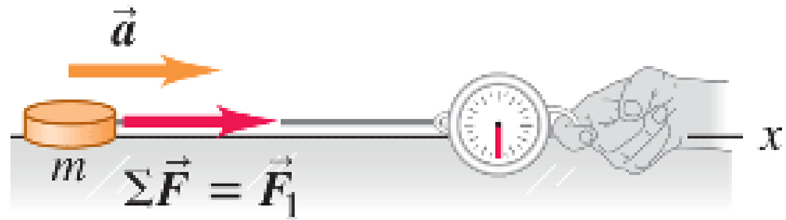
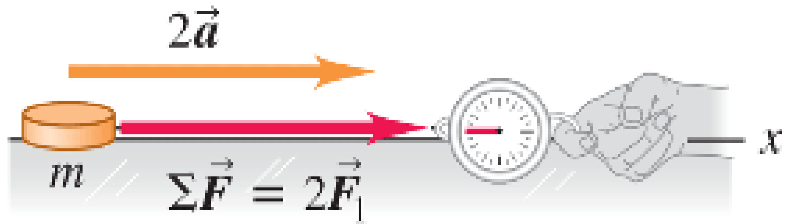


(b) Doubling the net external force doubles the acceleration.



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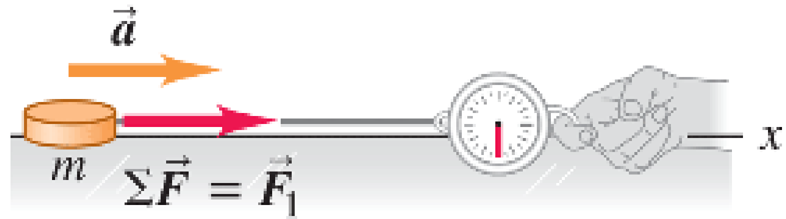

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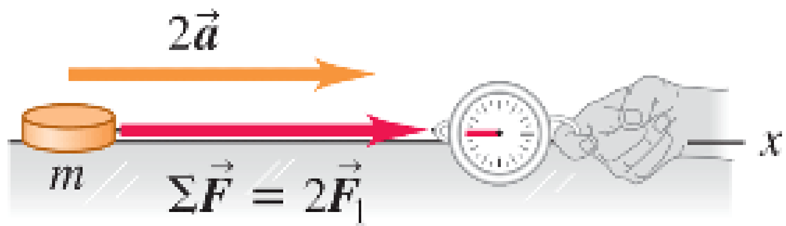
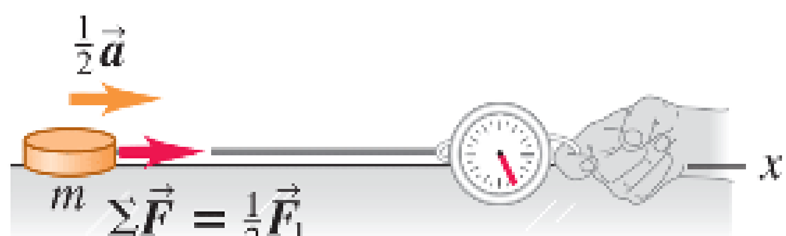


(c) Halving the net external force halves the acceleration.



Mass and Force

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SI unit of mass = kg

Mass and Force

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Mass and Force

Since $\sum \vec{F} = m\vec{a}$ then $m = \dfrac{|\sum \vec{F}|}{|\vec{a}|}$

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SI unit of force = $N = \dfrac{Kg \cdot m}{s^2}$

Mass and Force

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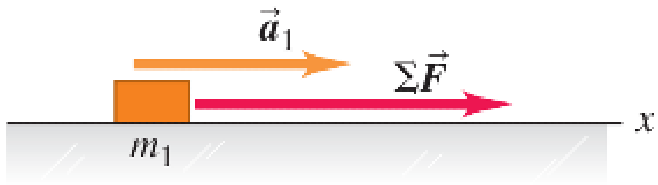
Note: kg is a mass & pound is a force

ASU

(a) A known net external force $\Sigma\vec{F}$ causes an object with mass m_1 to have an acceleration $\vec{a}_1$.



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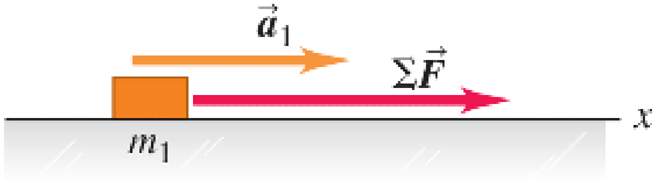

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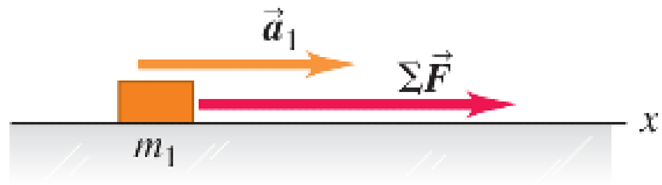

(b) Applying the same net external force $\Sigma \vec{F}$ to a second object and noting the acceleration allow us to measure the mass.

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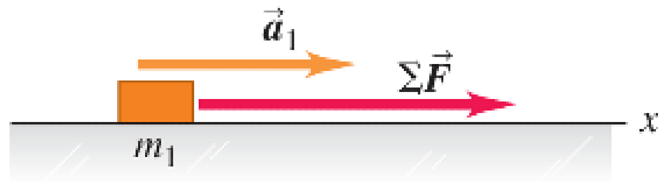

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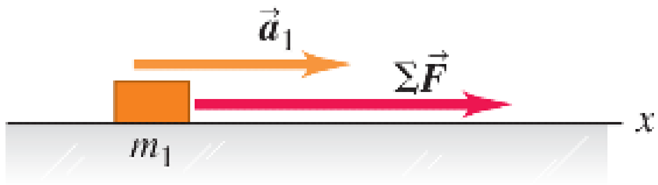

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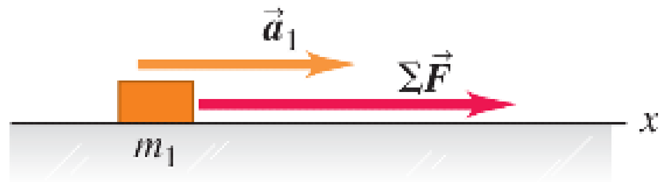

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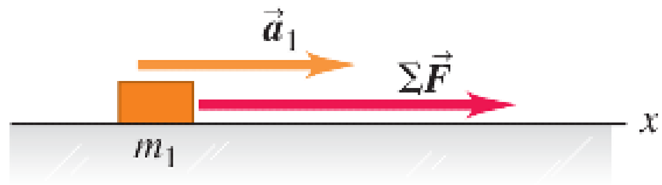

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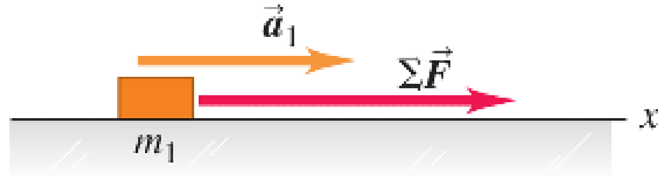

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Also

$\sum F_x = ma_x$

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Also

$\sum F_x = ma_x$ & $\sum F_y = ma_y$

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<u>Note</u>: $m\vec{a}$ is <u>NOT</u> a force

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Note: $m\vec{a}$ is NOT a force. The acceleration $\vec{a}$ of mass m is the result of a net force $\sum \vec{F}$

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$$\sum \vec{F} = m\vec{a}$$

A worker applies a constant horizontal force with magnitude 20 N to a box with mass 40 kg resting on a level, freshly waxed floor with negligible friction. What is the acceleration of the box?

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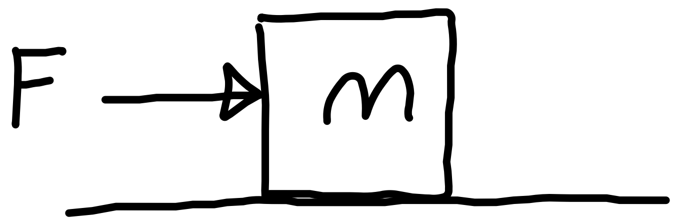

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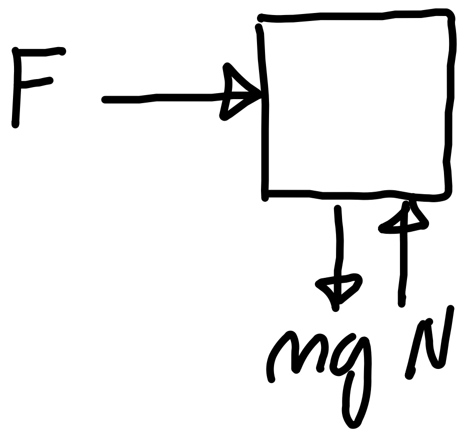

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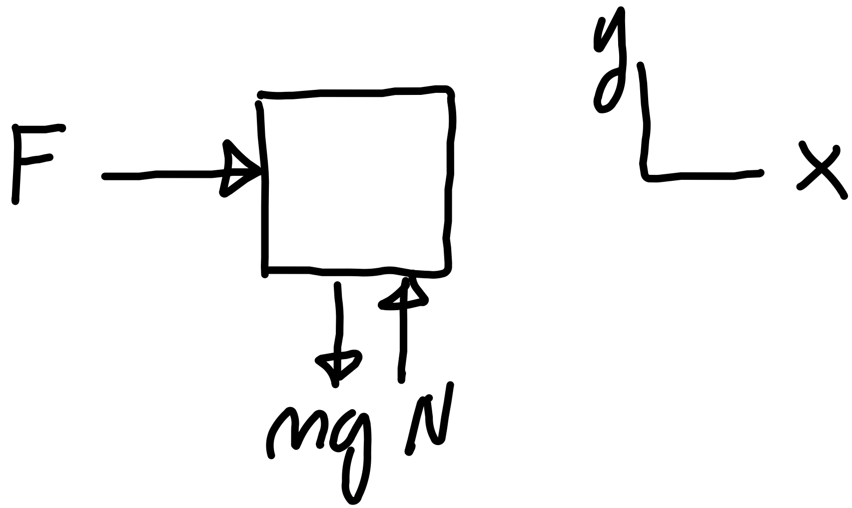

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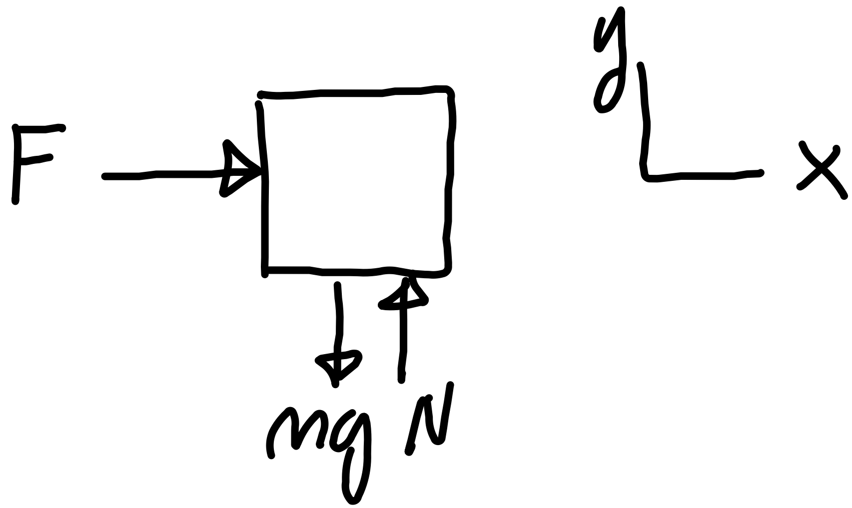

$\sum F_x = m a_x$

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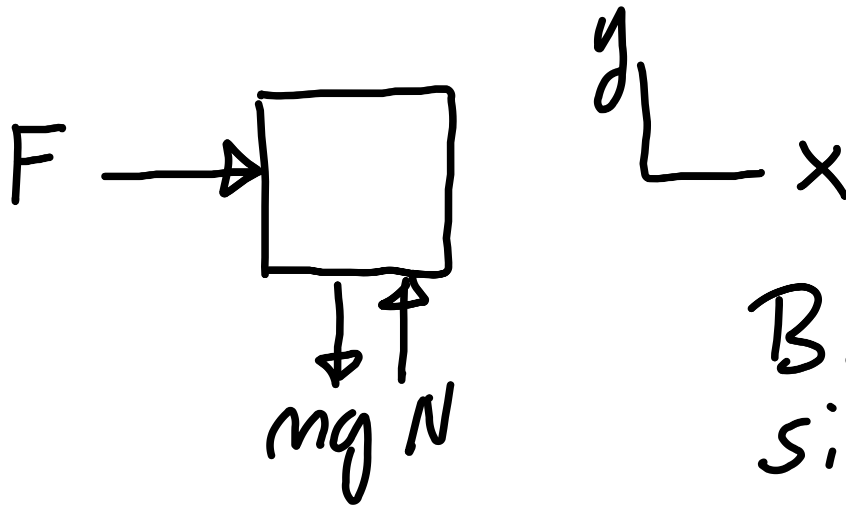

$\sum F_x = ma_x$

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But $a_y = 0$ since floor supports weight of box

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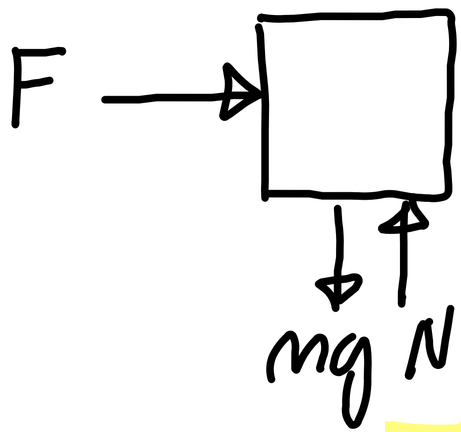

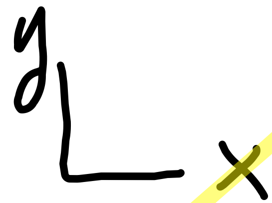

$$\boxed{\Sigma F_x = m a_x}$$

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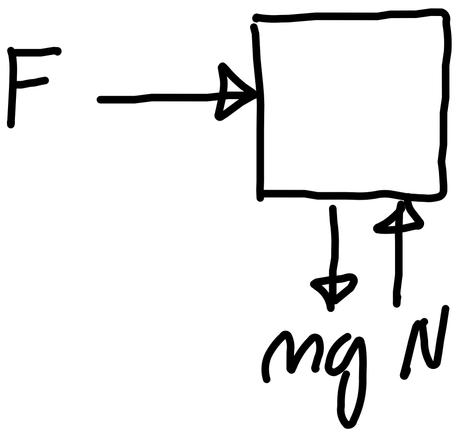

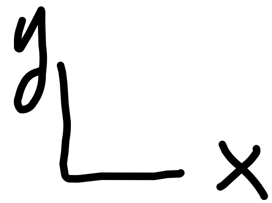

$\Sigma F_x = m a_x$

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But $a_y = 0$ since floor supports weight of box

Now $F = m a_x$ & $N - mg = 0$

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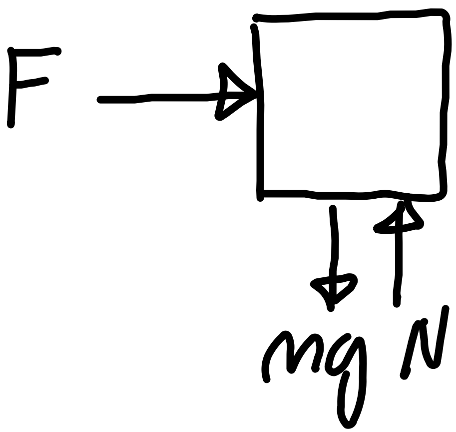

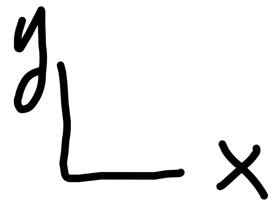

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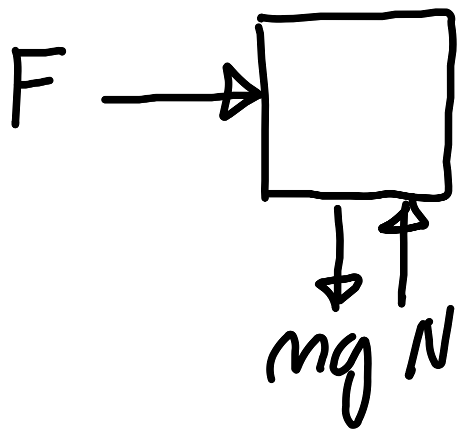

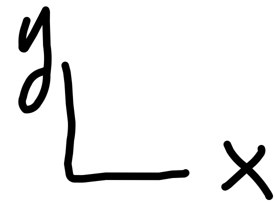

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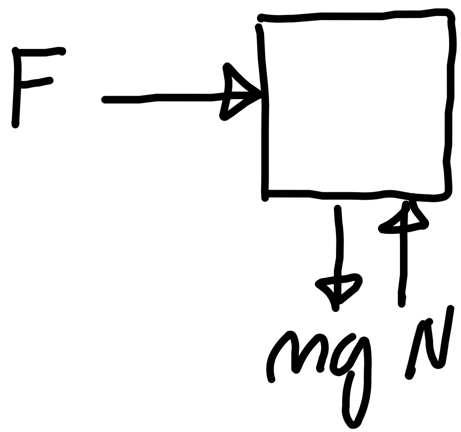

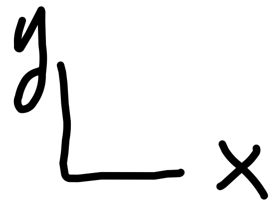

$\sum F_x = ma_x$

$\sum F_y = ma_y$

But $a_y = 0$ since floor supports weight of box

Now $F = ma_x$ & $N - mg = 0$

$\Rightarrow a_x = \frac{F}{m} \Rightarrow a_x = \frac{20N}{40kg}$

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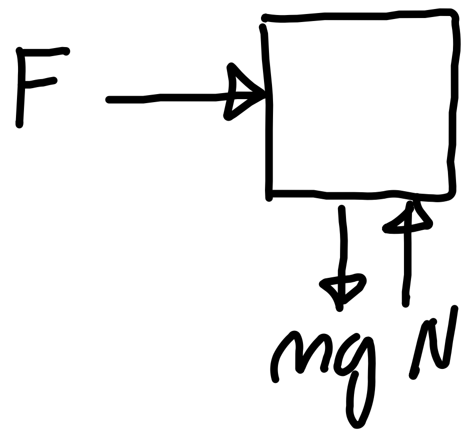

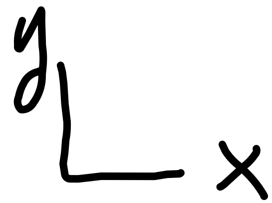

$\sum F_x = m a_x$

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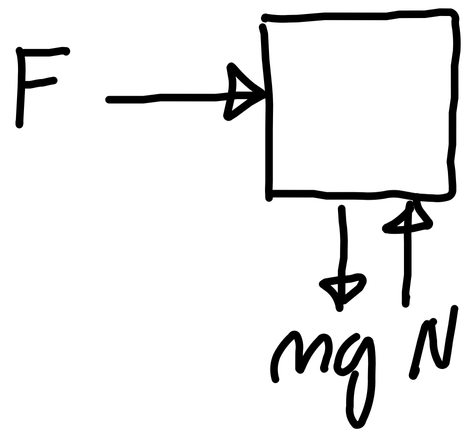
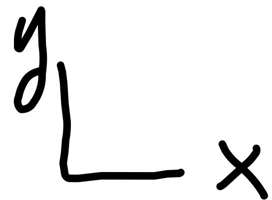
Now $F = m a_x$ & $N - mg = 0$

$\Rightarrow a_x = \frac{F}{m} \Rightarrow a_x = \frac{20\,\frac{kg \cdot m}{s^2}}{40\,kg}$

A worker applies a constant horizontal force with magnitude 20 N to a box with mass 40 kg resting on a level, freshly waxed floor with negligible friction. What is the acceleration of the box?

$F = 20N,\ m = 40kg$





$\Sigma F_x = ma_x$

$\Sigma F_y = ma_y$

But $a_y = 0$ since floor supports weight of box

Now $F = ma_x$ & $N - mg = 0$

$\Rightarrow a_x = \frac{F}{m} \Rightarrow a_x = \frac{20 \frac{kg \cdot m}{s^2}}{40kg} = 0.5\, m/s^2$

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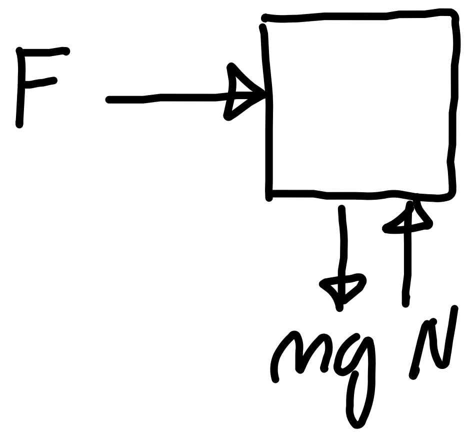
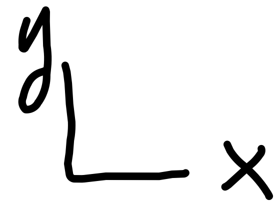
$F = 20N$, $m = 40kg$





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A waitress shoves a ketchup bottle with mass 0.45 kg to her right along a smooth, level lunch counter. The bottle leaves her hand moving at 2.0 m/s, then slows down as it slides because of a constant horizontal friction force exerted on it by the countertop. It slides for 1.0 m before coming to rest. What are the magnitude and direction of the friction force acting on the bottle?

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A waitress shoves a ketchup bottle with mass 0.45 kg to her right along a smooth, level lunch counter. The bottle leaves her hand moving at 2.0 m/s, then slows down as it slides because of a constant horizontal friction force exerted on it by the countertop. It slides for 1.0 m before coming to rest. What are the magnitude and direction of the friction force acting on the bottle? $M = 0.45\ \text{Kg}$

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$M = 0.45\,kg, \; V_0 = 2\,m/s$

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$M = 0.45\,kg, \; V_0 = 2\,m/s, \; \Delta x = 1\,m$

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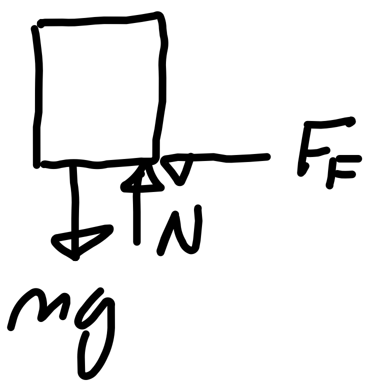

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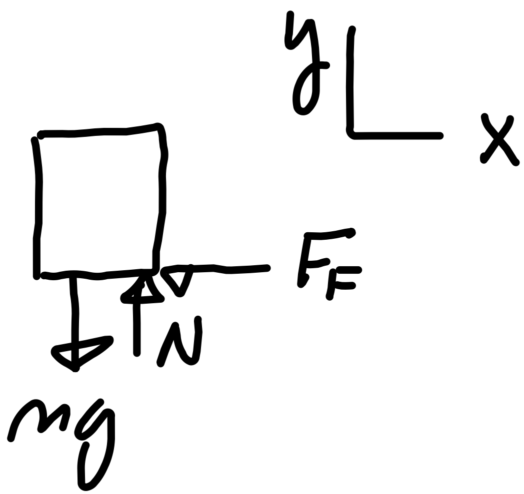

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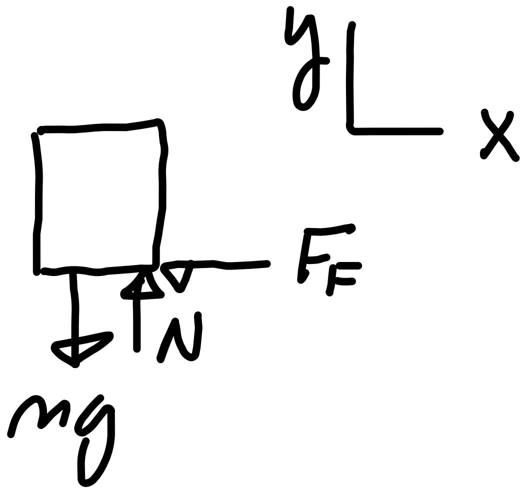
$M = 0.45\,\text{Kg},\ V_0 = 2\,\text{m/s},\ \Delta x = 1\,\text{m}$



$\sum F_y = m a_y$

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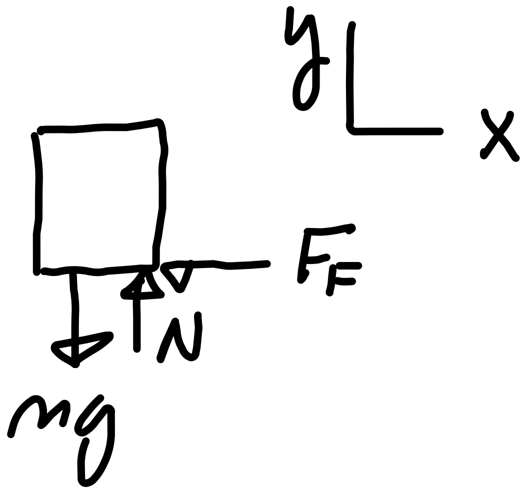

$\sum F_y = m\cancel{a_y}^{\,0}$

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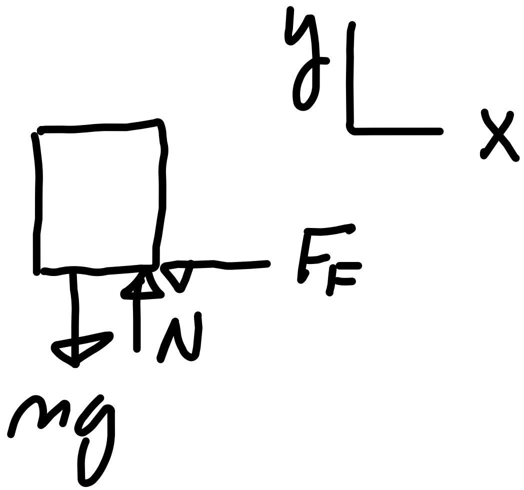
$m = 0.45\,\text{kg},\ V_0 = 2\,\text{m/s},\ \Delta x = 1\,\text{m}$



$\sum F_y = m a_y = 0$

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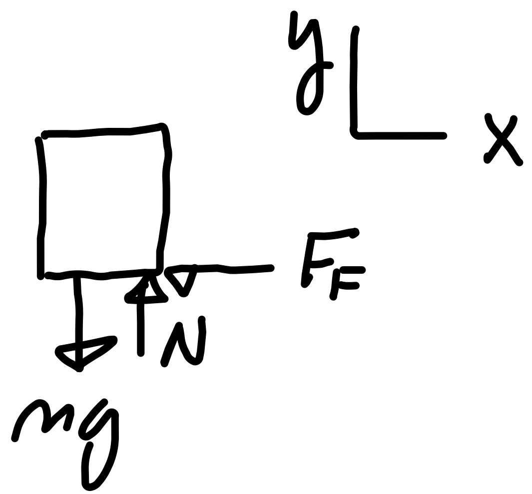

$\sum F_y = m a_y = 0$ ¢

$\sum F_x = m a_x \Rightarrow$

$-F_F = m a_x$

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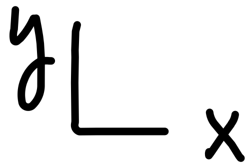

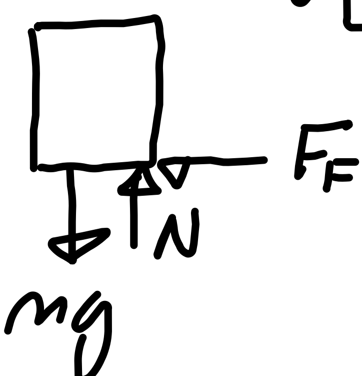

$$\sum F_y = m a_y = 0$$

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Since $a = v \frac{\partial v}{\partial x}$

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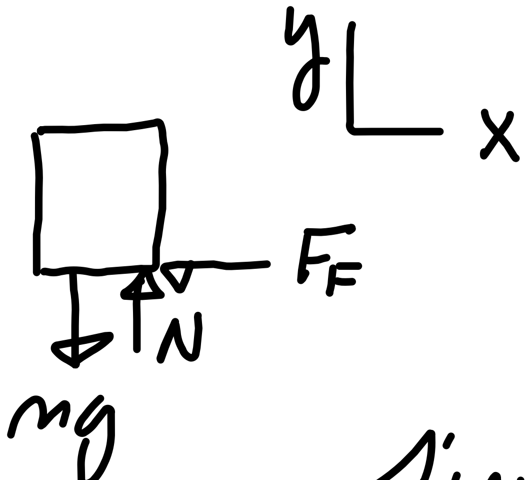

$\sum F_y = m a_y = 0$ &

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Since $a = v\frac{dv}{dx}$ then

$\int a\,dx = \int v\,dv$

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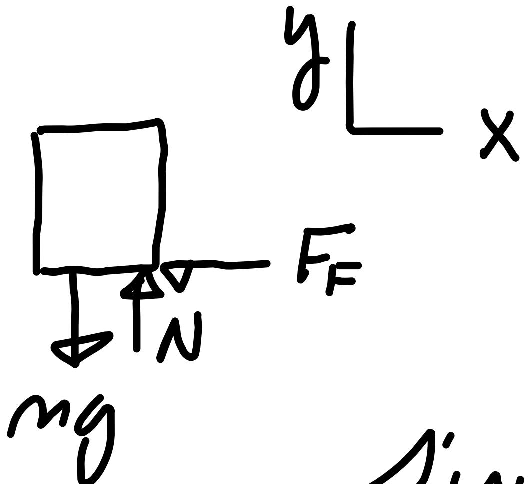

$\sum F_y = m a_y = 0$ &

$\sum F_x = m a_x \Rightarrow$

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Since $a = v\frac{dv}{dx}$ then

$\int a\,dx = \int v\,dv$

But $a = \text{const}$

A waitress shoves a ketchup bottle with mass 0.45 kg to her right along a smooth, level lunch counter. The bottle leaves her hand moving at 2.0 m/s, then slows down as it slides because of a constant horizontal friction force exerted on it by the countertop. It slides for 1.0 m before coming to rest. What are the magnitude and direction of the friction force acting on the bottle?

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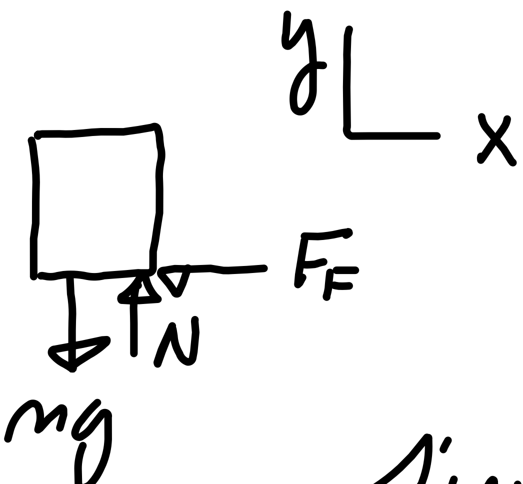

$\sum F_y = m a_y = 0$ &

$\sum F_x = m a_x \Rightarrow$

$-F_F = m a_x$

Since $a = v\frac{dv}{dx}$ then

$\int a\,dx = \int v\,dv$

But $a = const$ due to $F = const.$

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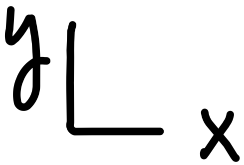
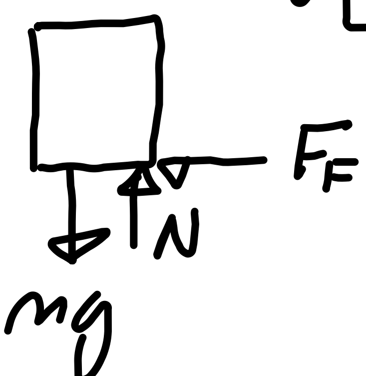


$\sum F_y = m\cancel{a_y} = 0$ &



$\sum F_x = m a_x \Rightarrow$

$-F_F = m a_x$

Since $a = v\dfrac{dv}{dx}$ then

$\int a\,dx = \int v\,dv$

But $a = \text{const}$ due to $F = \text{const}$.

$\Rightarrow \int a\,dx = a\int dx$

A waitress shoves a ketchup bottle with mass 0.45 kg to her right along a smooth, level lunch counter. The bottle leaves her hand moving at 2.0 m/s, then slows down as it slides because of a constant horizontal friction force exerted on it by the countertop. It slides for 1.0 m before coming to rest. What are the magnitude and direction of the friction force acting on the bottle?

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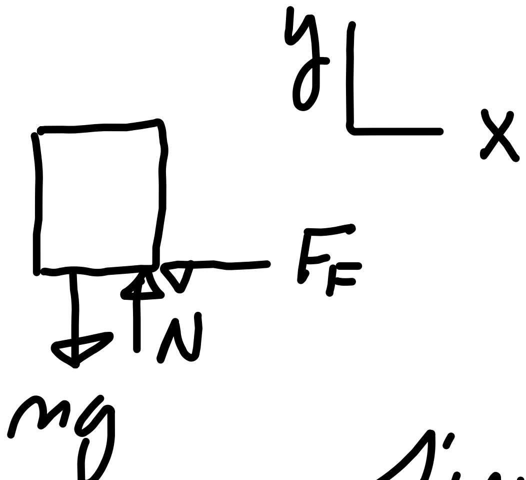

$\sum F_y = m\cancel{a_y}\ 0$ &

$\sum F_x = m a_x \Rightarrow$

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Since $a = v\frac{dv}{dx}$ then

$\int a\,dx = \int v\,dv$

But $a = \text{const}$ due to $F = \text{const.}$

$\Rightarrow \int a\,dx = a\int dx = a\Delta x$

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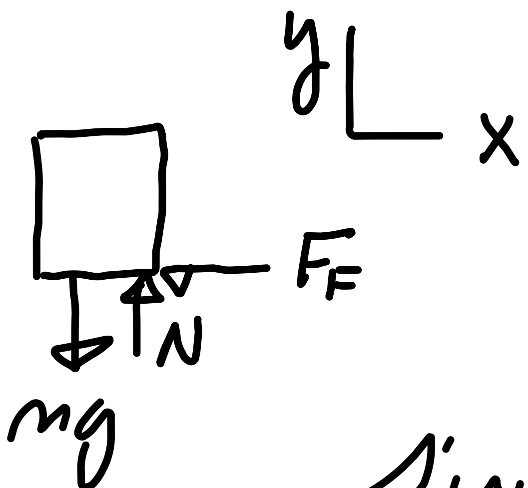

$\sum F_y = m\cancel{a_y} = 0$ &

$\sum F_x = m a_x \Rightarrow$

$-F_F = m a_x$

Since $a = v\dfrac{dv}{dx}$ then

$\int a\,dx = \int v\,dv \Rightarrow a\Delta x = \frac{1}{2}V_F^2 - \frac{1}{2}V_0^2$

A waitress shoves a ketchup bottle with mass 0.45 kg to her right along a smooth, level lunch counter. The bottle leaves her hand moving at 2.0 m/s, then slows down as it slides because of a constant horizontal friction force exerted on it by the countertop. It slides for 1.0 m before coming to rest. What are the magnitude and direction of the friction force acting on the bottle?

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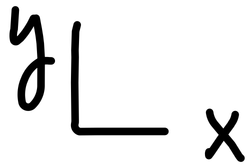
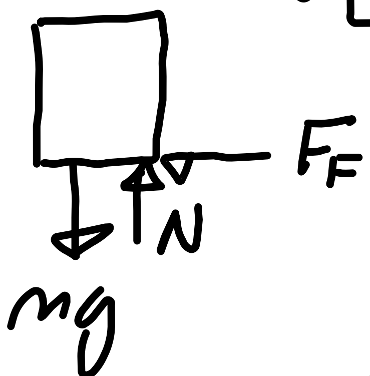


$\sum F_y = m a_y$ &



$\sum F_x = m a_x \Rightarrow$

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Since $a = v \frac{dv}{dx}$ then

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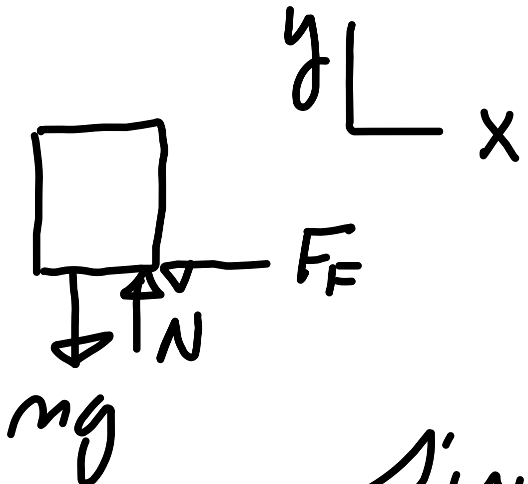
$M = 0.45\,\text{Kg},\ V_0 = 2\,\text{m/s},\ \Delta x = 1\,\text{m}$



$\sum F_y = m \cancelto{0}{a_y}$ &

$\sum F_x = m a_x \Rightarrow$

$-F_F = m a_x$

Since $a = v \frac{dv}{dx}$ then

$\int a\,dx = \int v\,dv \Rightarrow a \Delta x = \frac{1}{2}\cancelto{0}{V_F^2} - \frac{1}{2}V_0^2 \Rightarrow a = \frac{-V_0^2}{2\Delta x}$

A waitress shoves a ketchup bottle with mass 0.45 kg to her right along a smooth, level lunch counter. The bottle leaves her hand moving at 2.0 m/s, then slows down as it slides because of a constant horizontal friction force exerted on it by the countertop. It slides for 1.0 m before coming to rest. What are the magnitude and direction of the friction force acting on the bottle?

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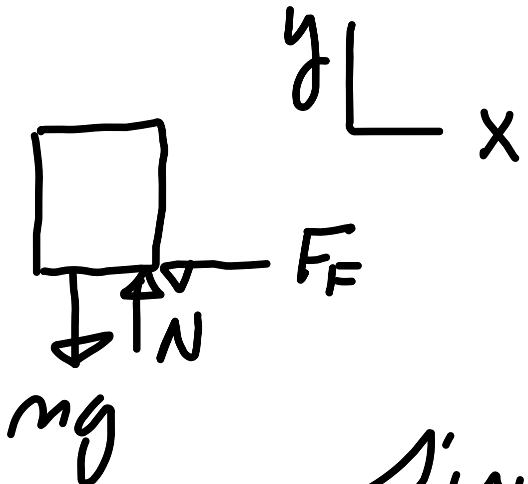

$\sum F_y = m\cancel{a_y} \; 0$ &

$\sum F_x = m a_x \Rightarrow$

$-F_F = m a_x$

Since $a = v\frac{dv}{dx}$ then

$\int a\,dx = \int v\,dv \Rightarrow a\Delta x = \cancel{\frac{1}{2}V_F^2} \, 0 - \frac{1}{2}V_0^2 \Rightarrow a = \frac{-V_0^2}{2\Delta x}$

So $-F_F = m\left(\frac{-V_0^2}{2\Delta x}\right)$

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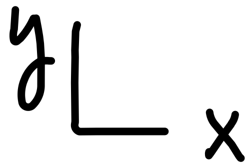

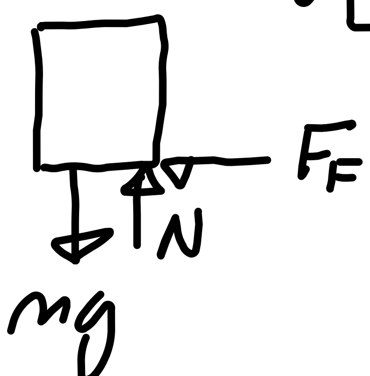

$\sum F_y = m\cancel{a_y}$ 0 &

$\sum F_x = m a_x \Rightarrow$

$-F_F = m a_x$

Since $a = v\dfrac{dv}{dx}$ then

$\int a\,dx = \int v\,dv \Rightarrow a\Delta x = \cancel{\tfrac{1}{2}V_F^2} - \tfrac{1}{2}V_0^2 \Rightarrow a = \dfrac{-V_0^2}{2\Delta x}$

So $-F_F = m\left(\dfrac{-V_0^2}{2\Delta x}\right) = (0.45)\left(\dfrac{-4}{2}\right)N$

A waitress shoves a ketchup bottle with mass 0.45 kg to her right along a smooth, level lunch counter. The bottle leaves her hand moving at 2.0 m/s, then slows down as it slides because of a constant horizontal friction force exerted on it by the countertop. It slides for 1.0 m before coming to rest. What are the magnitude and direction of the friction force acting on the bottle?

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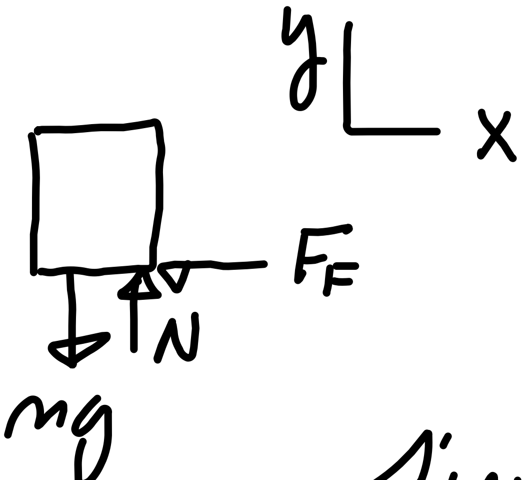

$\sum F_y = m\cancel{a_y} = 0$ &

$\sum F_x = m a_x \Rightarrow$

$-F_F = m a_x$

Since $a = v\frac{dv}{dx}$ then

$\int a\,dx = \int v\,dv \Rightarrow a\Delta x = \cancel{\frac{1}{2}V_F^2} - \frac{1}{2}V_0^2 \Rightarrow a = \frac{-V_0^2}{2\Delta x}$

So $-F_F = m\left(\frac{-V_0^2}{2\Delta x}\right) = (0.45)\left(\frac{-4}{2}\right)N = -0.90\,N$

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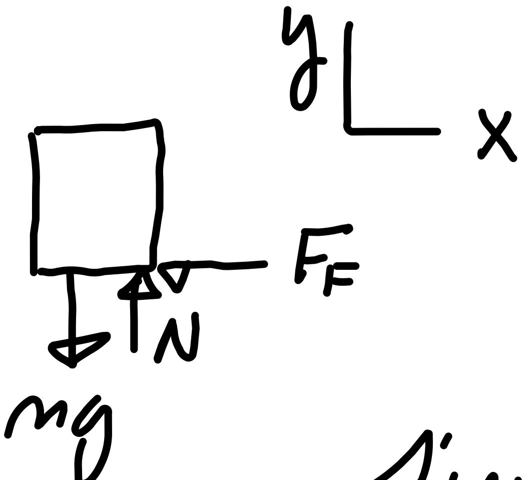
$M = 0.45\,\mathrm{kg},\ V_0 = 2\,\mathrm{m/s},\ \Delta x = 1\,\mathrm{m}$



$\sum F_y = m a_y \to 0$ &

$\sum F_x = m a_x \Rightarrow$

$-F_F = m a_x$

Since $a = v\dfrac{dv}{dx}$ then

$\int a\,dx = \int v\,dv \Rightarrow a\Delta x = \frac{1}{2}V_F^2 - \frac{1}{2}V_0^2 \Rightarrow a = \dfrac{-V_0^2}{2\Delta x}$ ($V_F \to 0$)

So $-F_F = m\left(\dfrac{-V_0^2}{2\Delta x}\right) = (0.45)\left(\dfrac{-4}{2}\right)\mathrm{N} = -0.90\,\mathrm{N}$

Mass and Weight

Mass and Weight

Mass $\neq$ Weight

Mass and Weight

!! Mass $\neq$ Weight !!

Do NOT

confuse

mass with

weight

Mass and Weight

Mass $\neq$ Weight

weight $\vec{w} = m\vec{g}$

Mass and Weight

!! Mass $\neq$ Weight !!

Weight $\vec{w} = m\vec{g}$

Note: $\vec{w}$ depends on $\vec{g}$

Mass and Weight

!! Mass $\neq$ Weight !!

Weight $\vec{w} = m\vec{g}$

Note: $\vec{w}$ depends on $\vec{g}$

But m has no dependence on $\vec{g}$

Mass and Weight

!! Mass $\neq$ Weight ¡¡

Weight $\vec{w} = m\vec{g}$

Note: $\vec{w}$ depends on $\vec{g}$

But m has no dependence on $\vec{g}$

Mass is a fundamental property of matter

Mass and Weight

!! Mass $\neq$ Weight ¡¡

Weight $\vec{w} = m\vec{g}$

Note: $\vec{w}$ depends on $\vec{g}$

But m has no dependence on $\vec{g}$

Mass is a fundamental property of matter, weight is not

A 2.45×10^4 N truck traveling in the $+x$-direction makes an emergency stop; the x-component of the net external force acting on it is -1.83×10^4 N. What is its acceleration?

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$W = 2.45 * 10^4 N$

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$\Rightarrow \boxed{a = -7.32 m/s^2}$

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