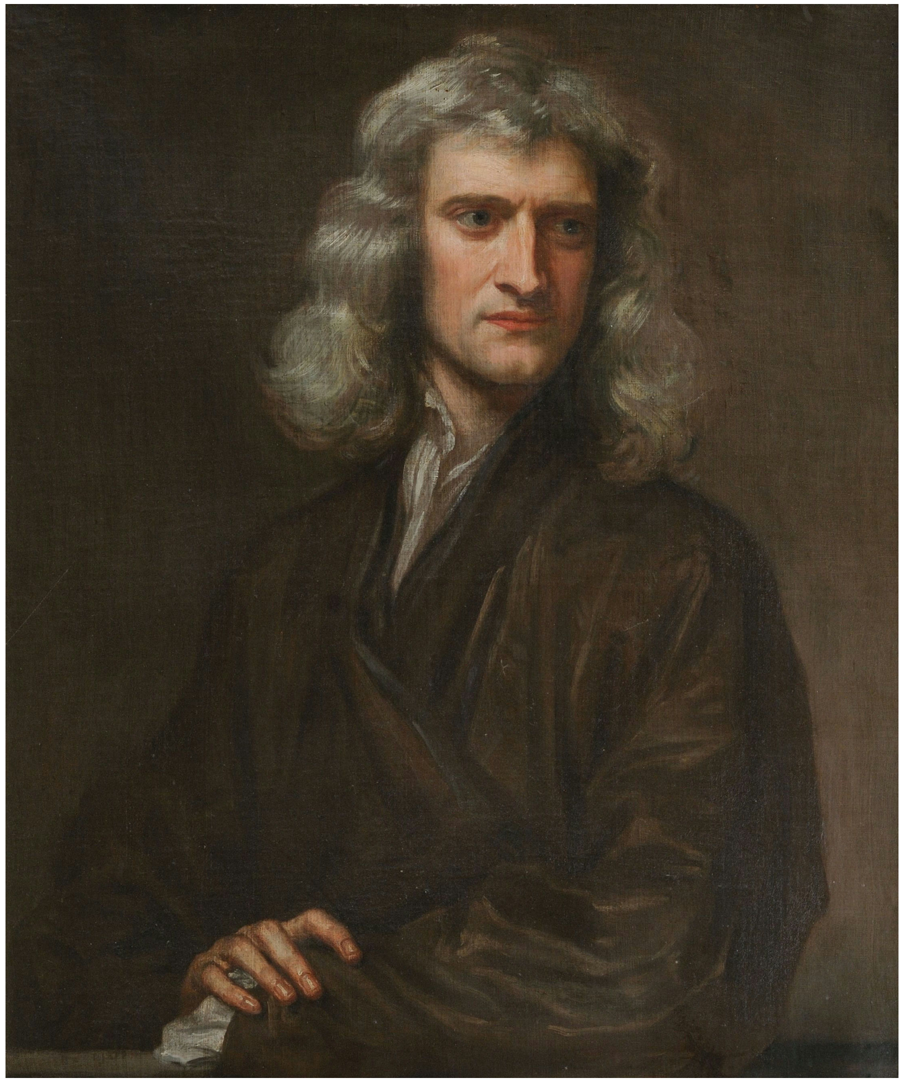
General Physics: Mechanics

PHYS-101(en)

Lecture 2b: Newton’s laws of motion



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September 16th, 2025

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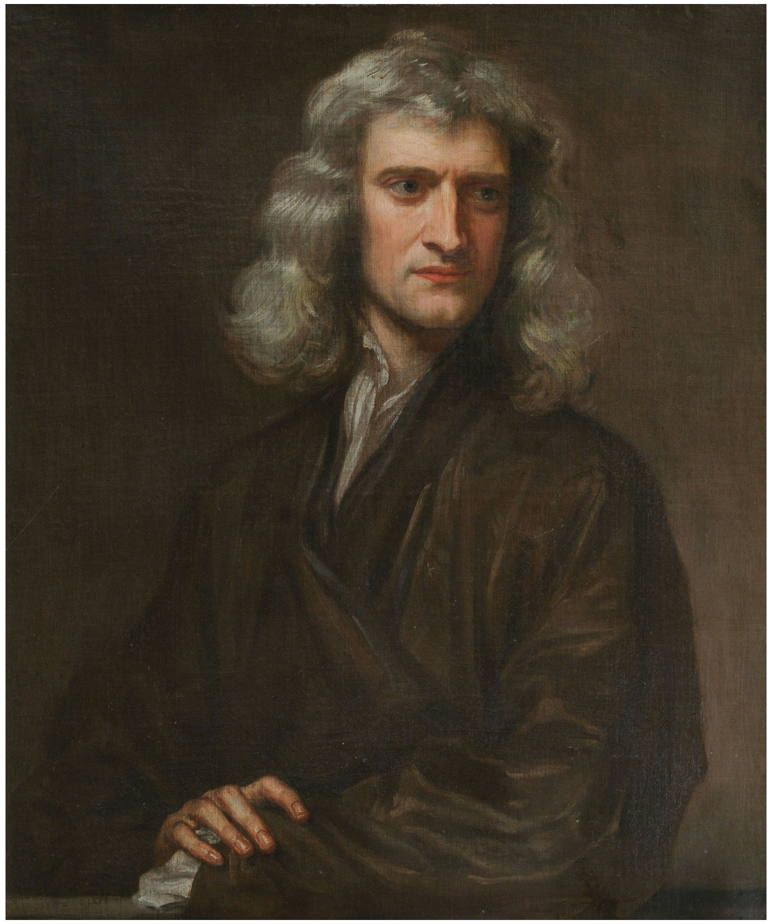
Reminder

- Office hours
  - Tuesdays at **11h15** in room **INF 019**
    - Right after this class!
  - Possibility to discuss any question you might have.
    - No questions about exercises for this week (discuss at Exercise session on Wednesday!)

Today’s agenda (Serway 5, MIT 7-8)

Newton’s laws of motion:

1. Newton’s 1st law of motion
2. Newton’s 2nd law of motion
3. Newton’s 3rd law of motion



Today's agenda (Serway 5, MIT 7-8)

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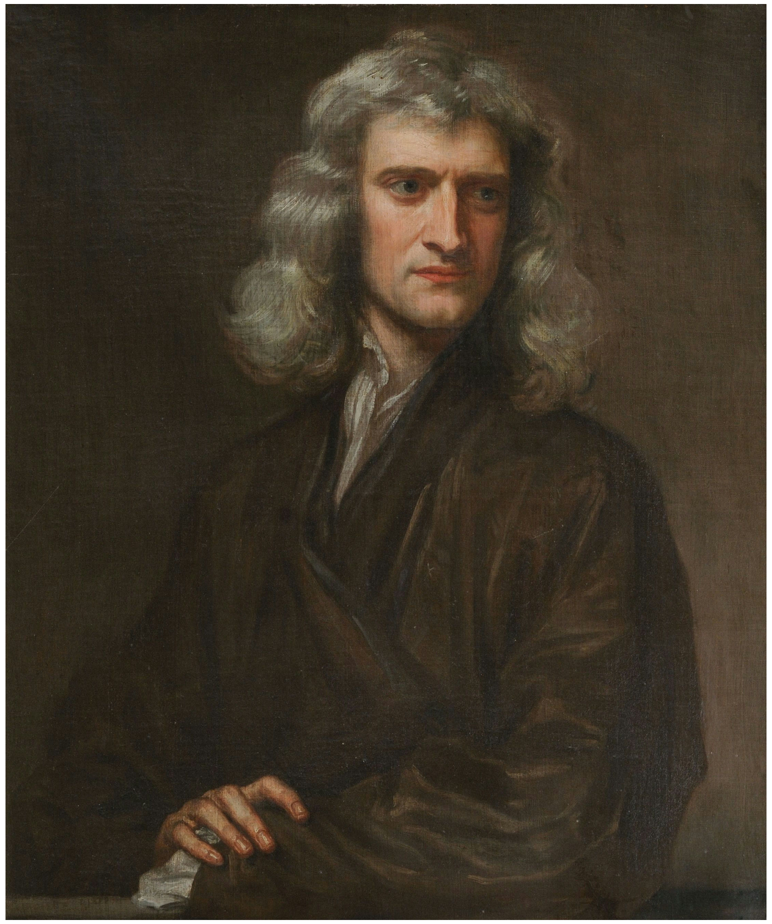
Newton's laws of motion:

1. ~~Newton's 1st law of motion~~
2. ~~Newton's 2nd law of motion~~
3. Newton's 3rd law of motion



Newton's 3rd law of motion

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the force exerted by object 1 on object 2
is equal and opposite to
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$$\overrightarrow{F}_{12} = -\overrightarrow{F}_{21}$$

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- **Action-reaction pairs must act on different objects!**

Examples of action-reaction pairs

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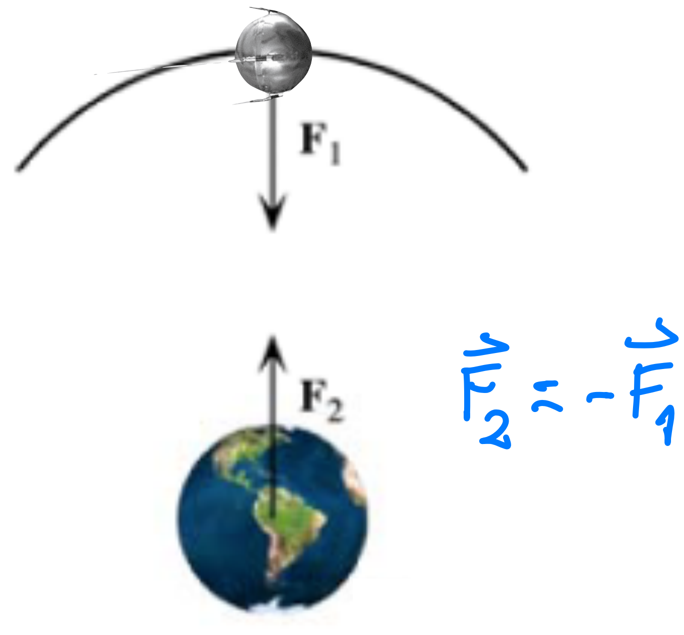
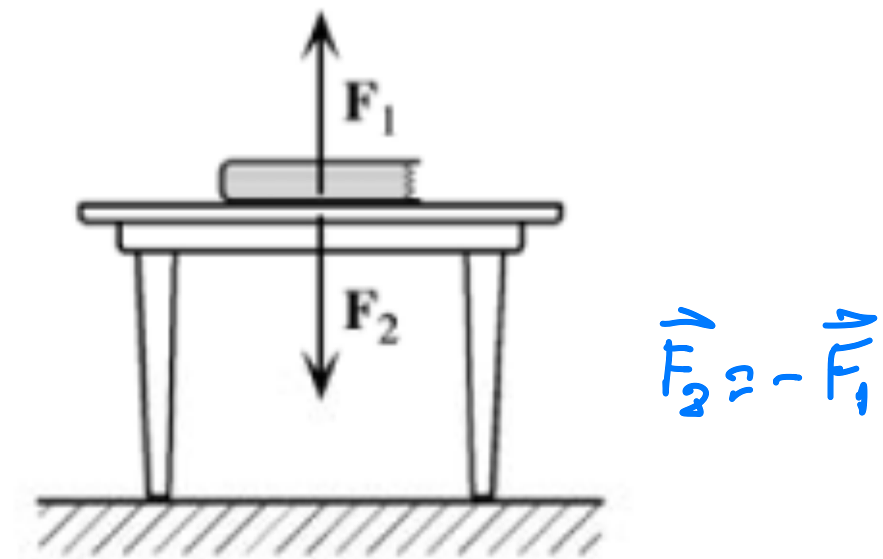
Gravitational forces between Earth and a satellite



Normal forces between a book and a table



Examples of action-reaction pairs

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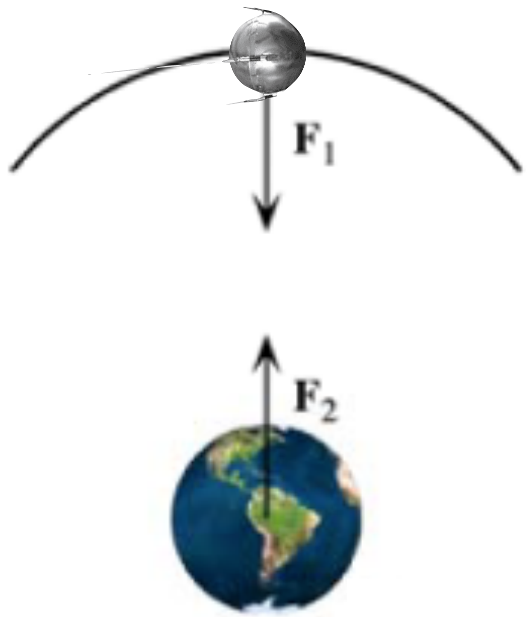

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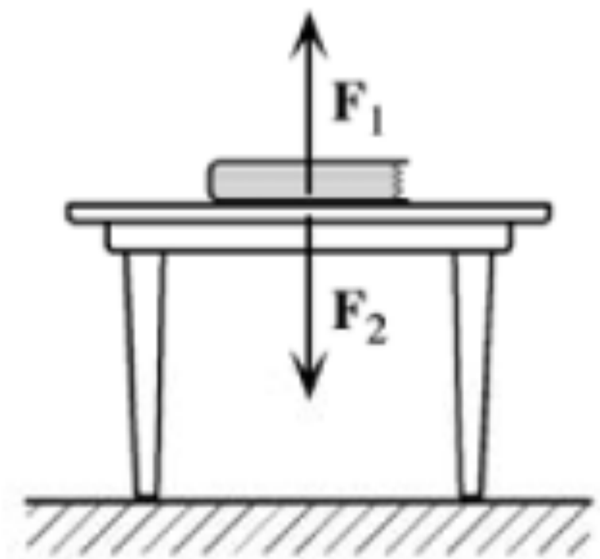


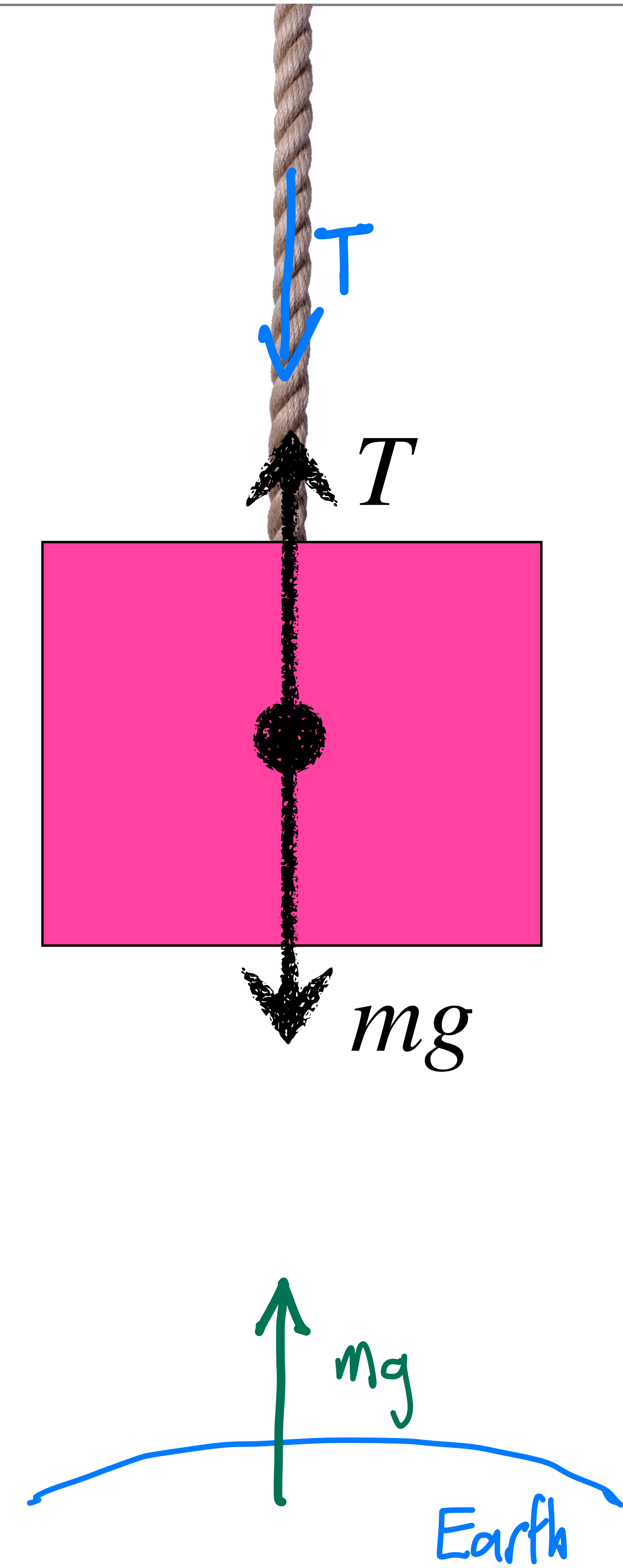
- To test if two forces are action-reaction pairs, try stating the forces in your head, e.g.
  - "The **gravitational** force of the **Earth** on the **satellite** and the **gravitational** force of the **satellite** on the **Earth**"
  - "The **normal** force of the **table** on the **book** and the **normal** force of the **book** on the **table**"

Conceptual question

Here is a stationary pink box hanging from a rope.

Are the two forces shown (i.e. the tension force from the rope and the gravitational force on the box) action-reaction pairs?

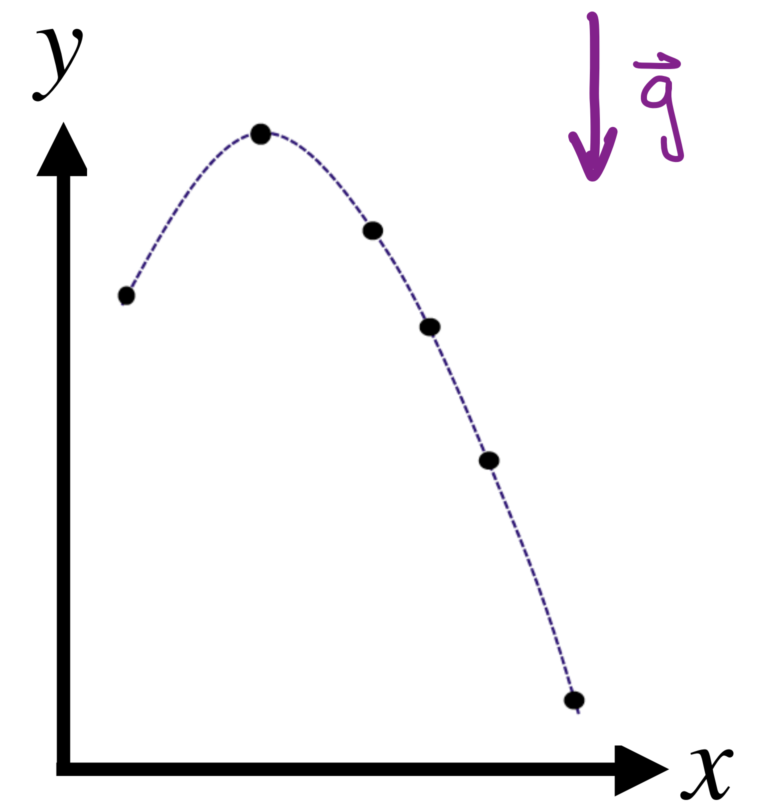
A. Yes
B. No
C. Maybe



Conceptual question

A projectile moves through the air under gravitational acceleration. At the highest point in its arc, which of the following is true? Neglect the effects of air resistance.

A. The speed and acceleration are zero.
B. The speed is equal to zero, and the acceleration is constant and not equal to zero.
C. The speed is at a minimum but not equal to zero and the acceleration is zero.
D. The speed is at a minimum but not equal to zero and the acceleration is constant and not equal to zero.
E. Neither the acceleration nor speed has yet attained its minimum value.

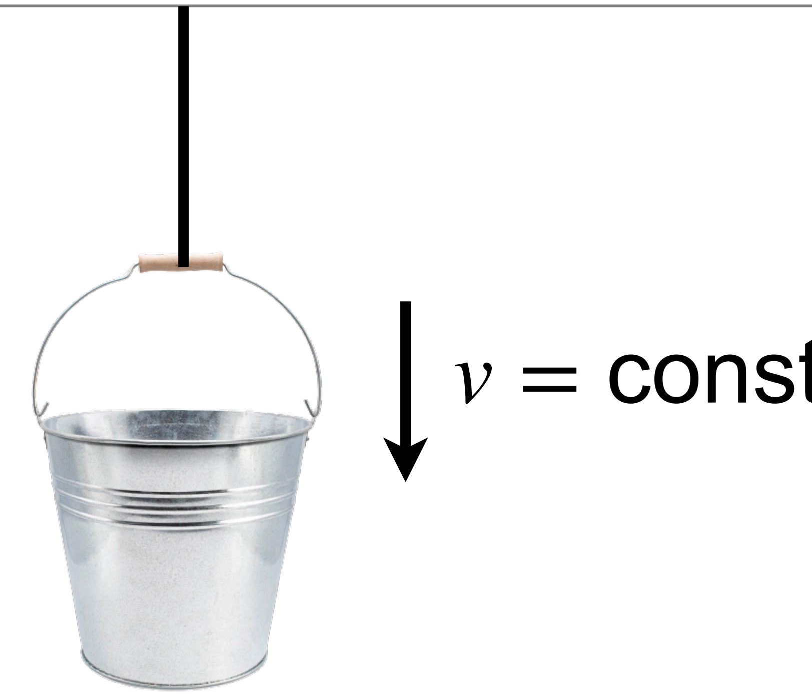


$$\vec{v} = v_x \hat{x} + v_y(t)\hat{y}$$

$$v = |\vec{v}| = \sqrt{v_x^2 + v_y(t)^2}$$

Conceptual question

A bucket is lowered by a rope at a constant speed.



The net force on the bucket is…

A. upwards.

B. downwards.

C. zero.

D. Not enough information given.

$\vec{v} = \text{const} \Rightarrow \frac{d\vec{v}}{dt} = 0 = \vec{a}$

$\sum \vec{F} = m_B \vec{a} = 0$

Conceptual question

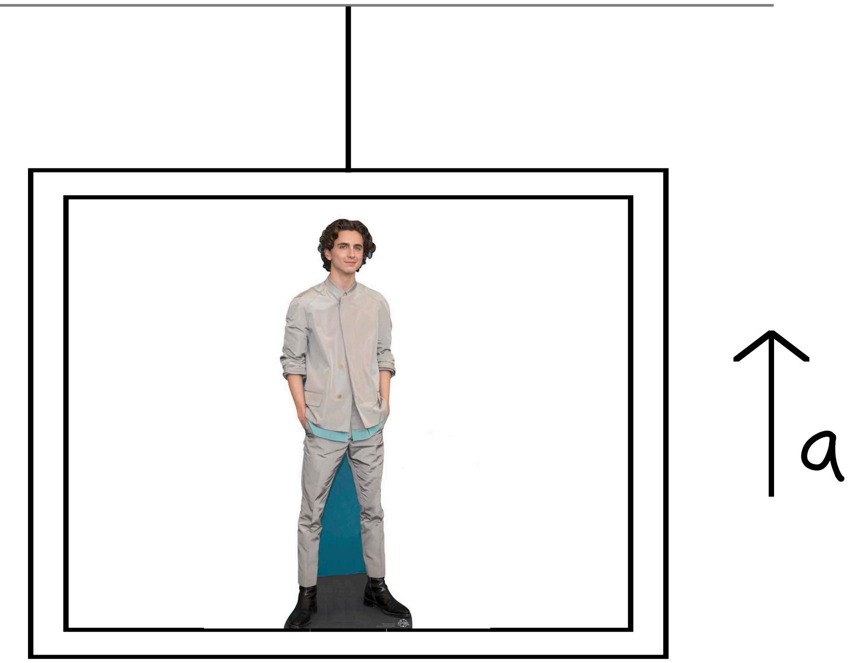
A person is standing in an elevator that is accelerating upwards. The magnitude of the normal force N exerted by the elevator floor on the person is…

A. larger than…

B. identical to…

C. smaller than…

the weight of the person.



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

In $\hat{y}$: $N - m_T g = m_T a$

$$\Rightarrow N = m_T (g + a) > m_T g$$

Conceptual question

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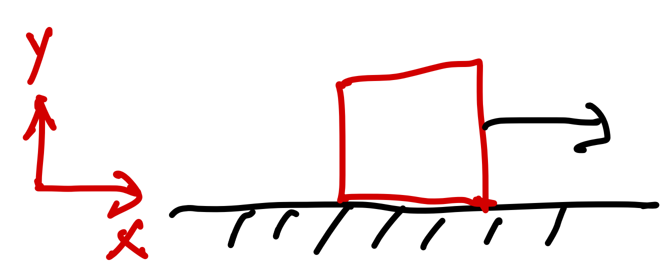
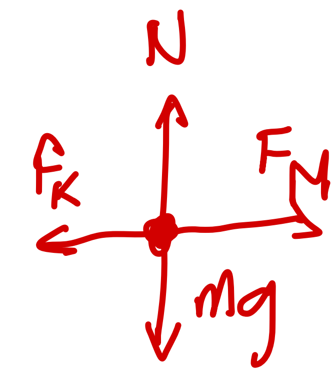
You are pushing a wooden crate across the floor at constant speed. You decide to turn the crate on end, reducing by half the surface area in contact with the floor. In the new orientation, to push the same crate across the same floor with the same speed, the force that you apply must be about…

A. four times as great…
B. twice as great…
C. equally great…
D. half as great…
E. one-fourth as great…





In $\hat{y}$: $N - mg = 0 \Rightarrow N = mg$

In $\hat{x}$: $F_M - f_K = 0 \Rightarrow F_M = f_K = \mu_K N = \mu_K mg$

as the force required before you changed the crate's orientation.

Conceptual question

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A person pulls a box across the floor. Which is the correct analysis of the situation?

A. The box moves forwards because the person pulls forwards slightly harder on the box than the box pulls backwards on the person.
B. The person gets the box to move by giving it a tug, during which the force on the box from the person is momentarily greater than the force exerted by the box on the person.
C. The force from the person on the box is as strong as the force of the box on the person, but the frictional force between the floor and person is forward and large, while the backward frictional force between the box and floor is small.
D. The person can pull the box forwards only if they weigh more than the box.

See you tomorrow at 17h15 for the Exercises!

Conceptual question

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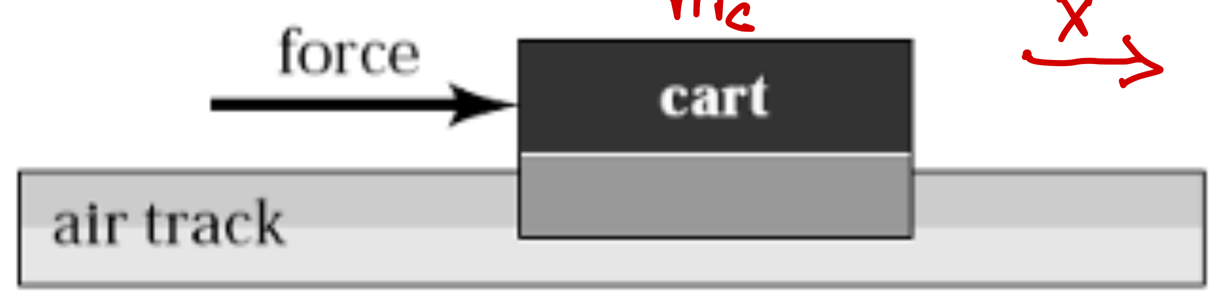
A constant force is exerted on a cart that is initially at rest on an air track. Friction between the cart and the track is negligible. The force acts for a short time interval and gives the cart a certain final speed.

To reach the same final speed with a force that is only half as big, the force must be exerted on the cart for a time interval…

A. four times as long as…
B. twice as long as…
C. equal to…
D. half as long as…
E. a quarter as long as…

that for the stronger force.



m_c, $\hat{x}$

$F = m_c a_c \Rightarrow a_c = \frac{1}{m_c} F$ (= const)

Also, $a_c = \frac{dv}{dt} \Rightarrow v(t) = a_c t + v_0$, $v_0 = 0$

$\Rightarrow t_F = \frac{v_F}{a_c} = \frac{m_c v_F}{F}$

$\frac{m_c v_F}{F/2} = 2 \frac{m_c v_F}{F} = 2 t_F$

Conceptual question

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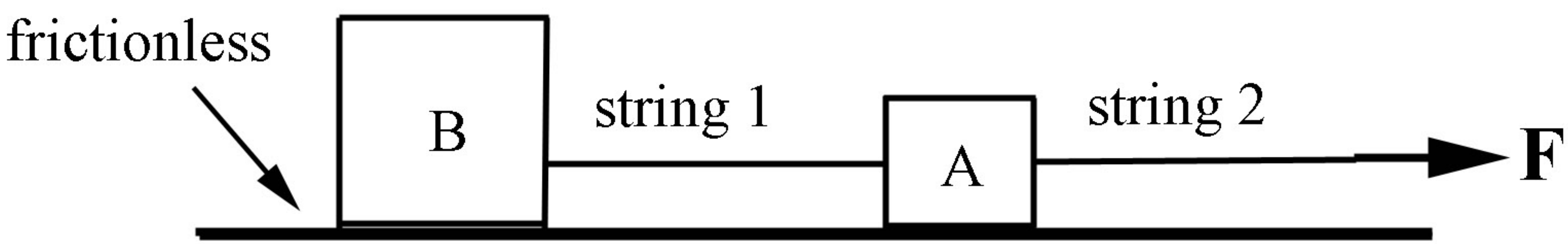
In the situation below, a person pulls a string attached to block A, which is in turn attached to another, heavier block B via a second string. Assume the strings are massless and inextensible and ignore friction.



The magnitude of the acceleration of block A…

A. is greater than the magnitude of the acceleration of block B.
B. equal to the magnitude of the acceleration of block B.
C. less than the magnitude of the acceleration of block B.
D. Do not have enough information to decide.

Conceptual question

You are a passenger in a car and not wearing your seat belt. Without increasing or decreasing its speed, the car makes a sharp left turn, and you find yourself colliding with the right-hand door.

Which is the correct analysis of the situation?

A. Before and after the collision, there is a rightward force pushing you into the door.
B. Starting at the time of collision, the door exerts a leftward force on you.
C. Both of the above.
D. Neither of the above.