How does the net force change between scenario 1 and 2?
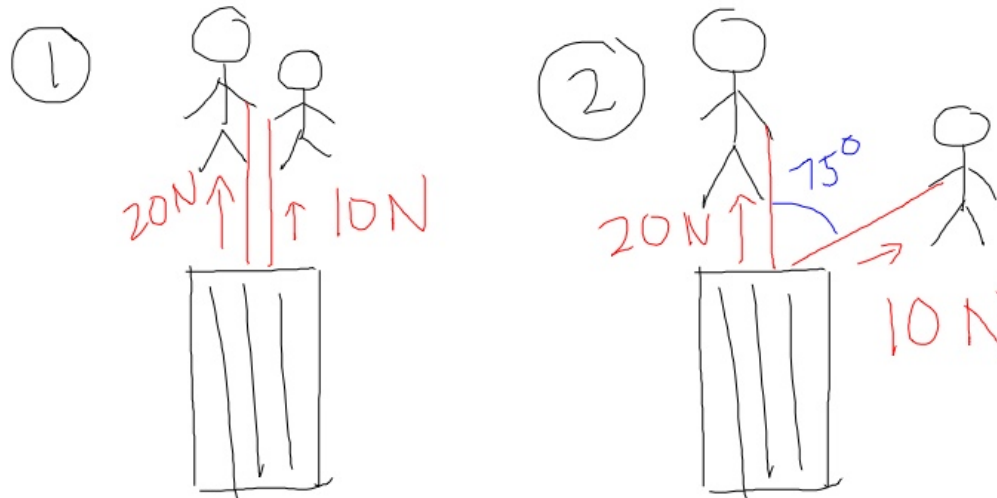
A) The magnitude decreases, the direction stays the same

B) The magnitude stays the same, the direction changes

C) The magnitude decreases AND the direction changes

D) The magnitude increases AND the direction changes

E) None of the above

Text 'PHYSJC' and your answer to 22333

Ch 4.1-2:
Newton's Laws

PHYS 1210 Prof. Jang-Condell

Announcements

- Homework #2 Due Friday

  - Please write the name of your discussion section TA on your written assignment

- At this week's lab, turn in

  - Completed Lab 0, all sections

  - Pre-lab for Lab 1

Goals for Chapter 4

- To understand the meaning of force in physics

- To view force as a vector and learn how to combine forces

- To understand the behavior of a body on which the forces balance: Newton's First Law of Motion

- To learn the relationship between mass, acceleration, and force: Newton's Second Law of Motion

- To relate mass and weight

- To see the effect of action-reaction pairs: Newton's Third Law of Motion

- To learn to make free-body diagrams

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What is a **Force**?

- Many scientific terms, such as "force," "work," and "energy" have common colloquial usages.

- In a **scientific** setting, these words have a **specific** meaning.

What is a **Force**?

- A force is a push or a pull

- A force is an interaction between two objects or between an object and its environment

- A force is a vector quantity, with magnitude (Newtons) and direction

$\vec{F}$ (force)

Push

$\vec{F}$

Pull
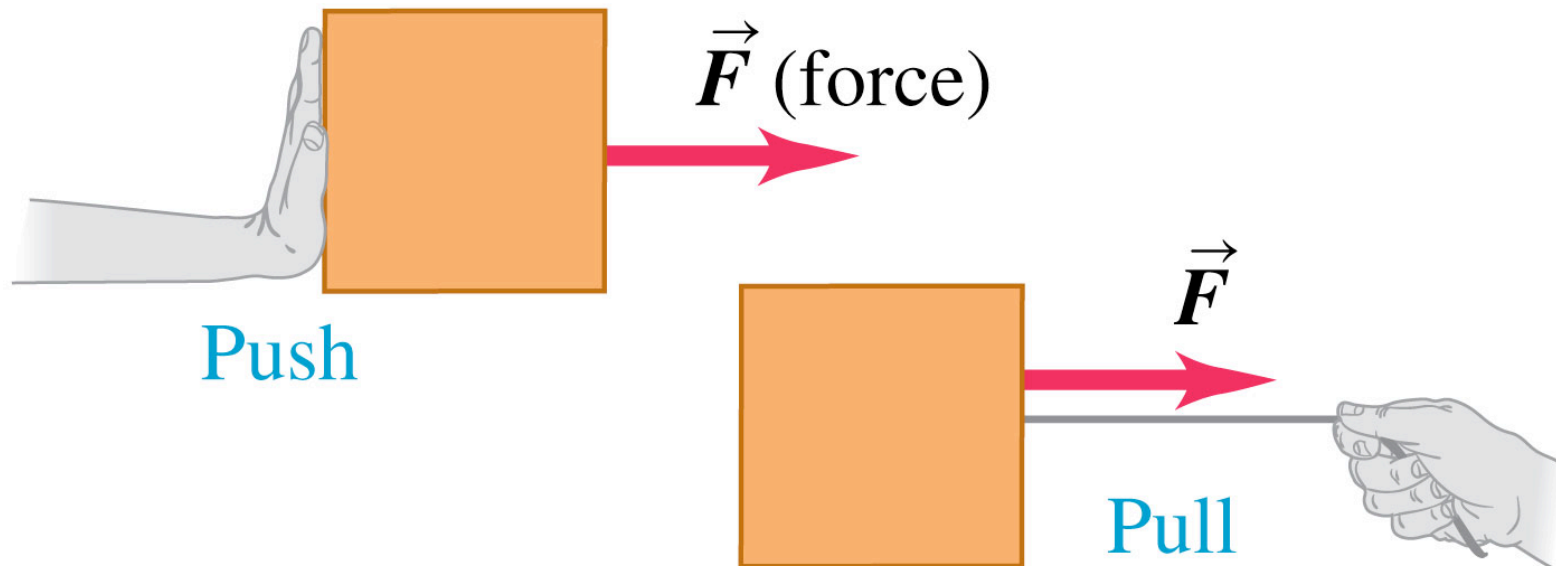
Superposition of forces—Figure 4.4

- Several forces acting at a point on an object have the same effect as their vector sum acting at the same point.
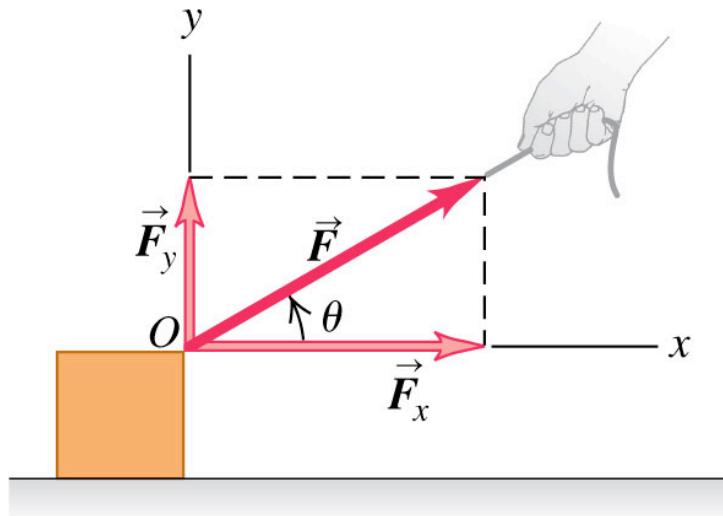
Two forces $\vec{F}_1$ and $\vec{F}_2$ acting on a body at point O have the same effect as a single force $\vec{R}$ equal to their vector sum.
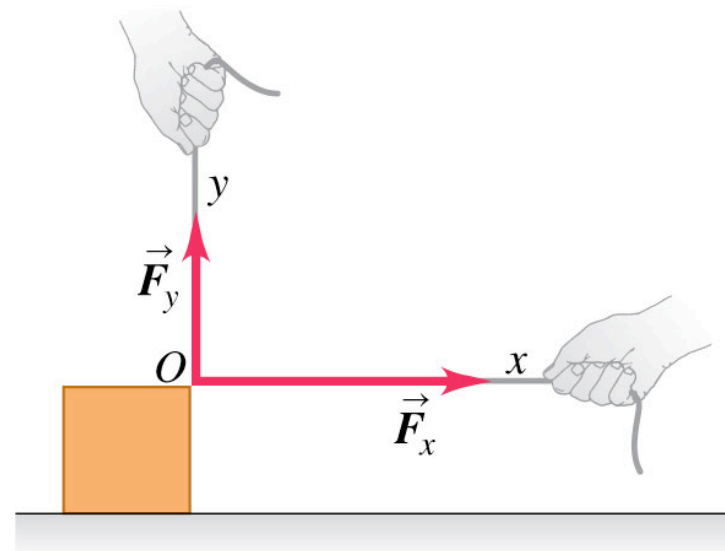
$\vec{F}_2$

$\vec{R}$

O

$\vec{F}_1$
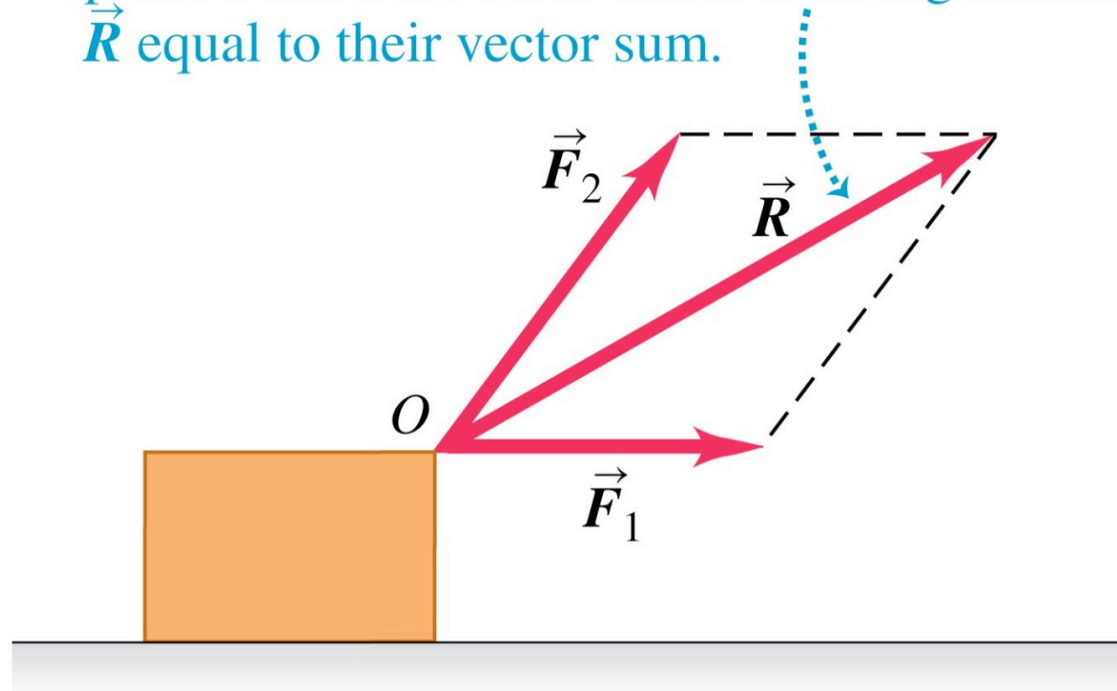
Decomposing a force into its component vectors

- Choose perpendicular x and y axes.

- F_x and F_y are the components of a force along these axes.

- Use trigonometry to find these force components.

(a) Component vectors: $\vec{F}_x$ and $\vec{F}_y$
Components: $F_x = F \cos \theta$ and $F_y = F \sin \theta$

(b) Component vectors $\vec{F}_x$ and $\vec{F}_y$ together
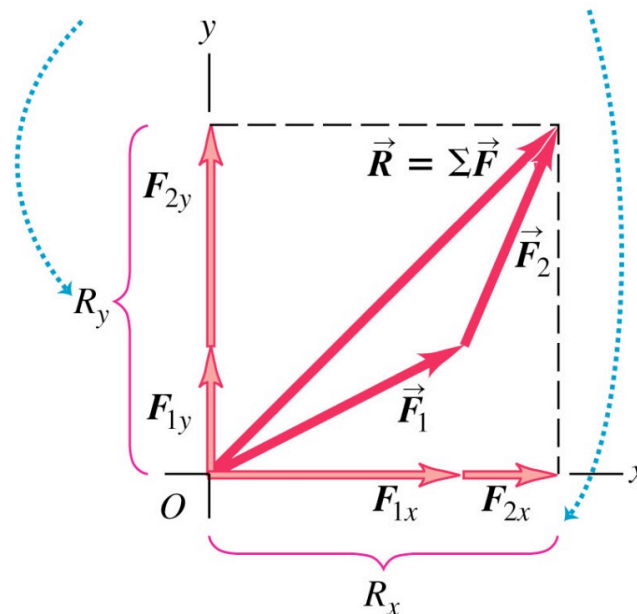have the same effect as original force $\vec{F}$.

Notation for the vector sum—Figure 4.7

- The vector sum of all the forces on an object is called the *resultant* of the forces or the *net forces*.

$$\vec{R}=\vec{F}_1+\vec{F}_2+\vec{F}_3+\cdots=\sum\vec{F}$$

$\vec{R}$ is the sum (resultant) of $\vec{F}_1$ and $\vec{F}_2$.

The *y*-component of $\vec{R}$ equals the sum of the *y*-components of $\vec{F}_1$ and $\vec{F}_2$.

The same goes for the *x*-components.

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There are four common types of forces

- The *normal force*: When an object pushes on a surface, the surface pushes back on the object perpendicular to the surface. This is a contact force.

- *Friction force*: This force occurs when a surface resists sliding of an object and is parallel to the surface. Friction is a contact force.

(a) Normal force $\vec{n}$: When an object rests or pushes on a surface, the surface exerts a push on it that is directed perpendicular to the surface.
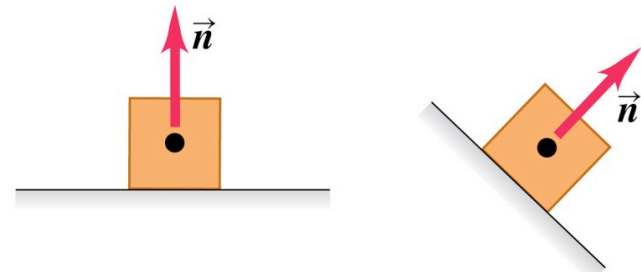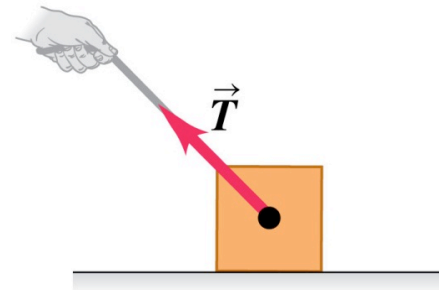
(b) Friction force $\vec{f}$: In addition to the normal force, a surface may exert a frictional force on an object, directed parallel to the surface.
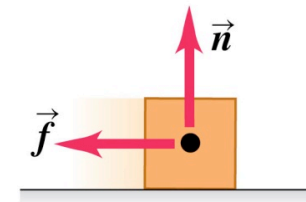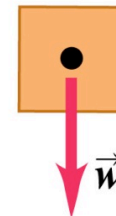
There are four common types of forces II

- *Tension force*: A pulling force exerted on an object by a rope or cord. This is a contact force.

- *Weight*: The pull of gravity on an object. This is a long-range force.

(c) **Tension force** $\vec{T}$: A pulling force exerted on an object by a rope, cord, etc.

$\vec{T}$

(d) **Weight** $\vec{w}$: The pull of gravity on an object is a long-range force (a force that acts over a distance).

$\vec{w}$

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What types of forces are acting on the orange block?

Assume block is at rest

30°

Text your answer to 22333

Types of Forces

(a) **Normal force $\vec{n}$:** When an object rests or pushes on a surface, the surface exerts a push on it that is directed perpendicular to the surface.

(b) **Friction force $\vec{f}$:** In addition to the normal force, a surface may exert a frictional force on an object, directed parallel to the surface.

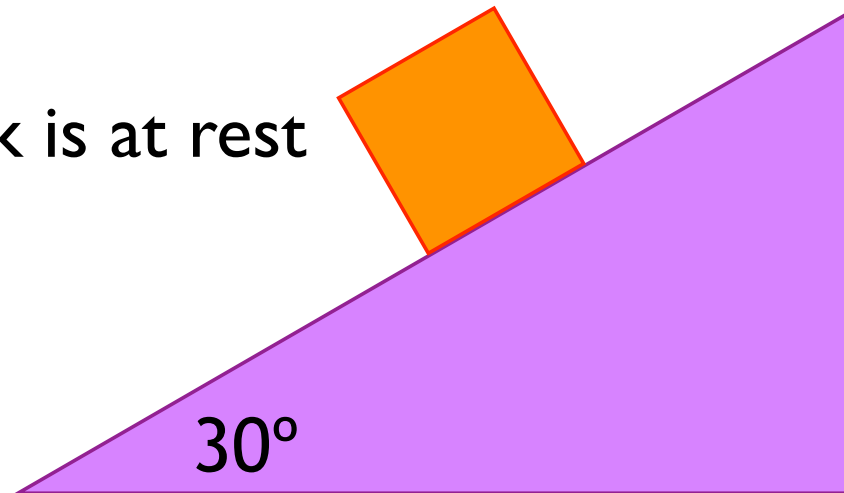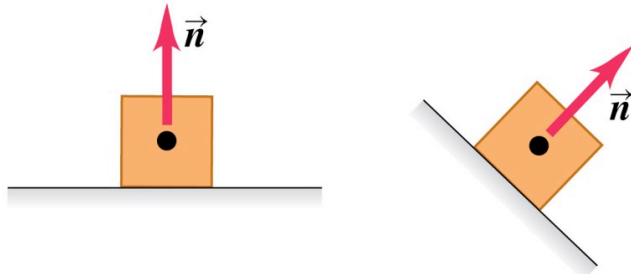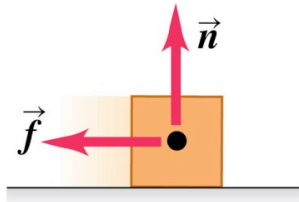(c) **Tension force $\vec{T}$:** A pulling force exerted on an object by a rope, cord, etc.
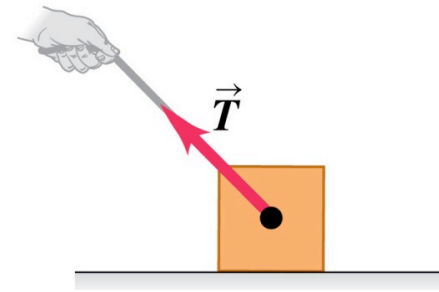
(d) **Weight $\vec{w}$:** The pull of gravity on an object is a long-range force (a force that acts over a distance).
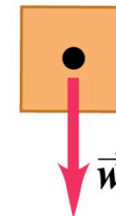
Sir Isaac Newton

- 1642-1727

- Philosophiae Naturalis Principia Mathematica

- Co-inventor of calculus
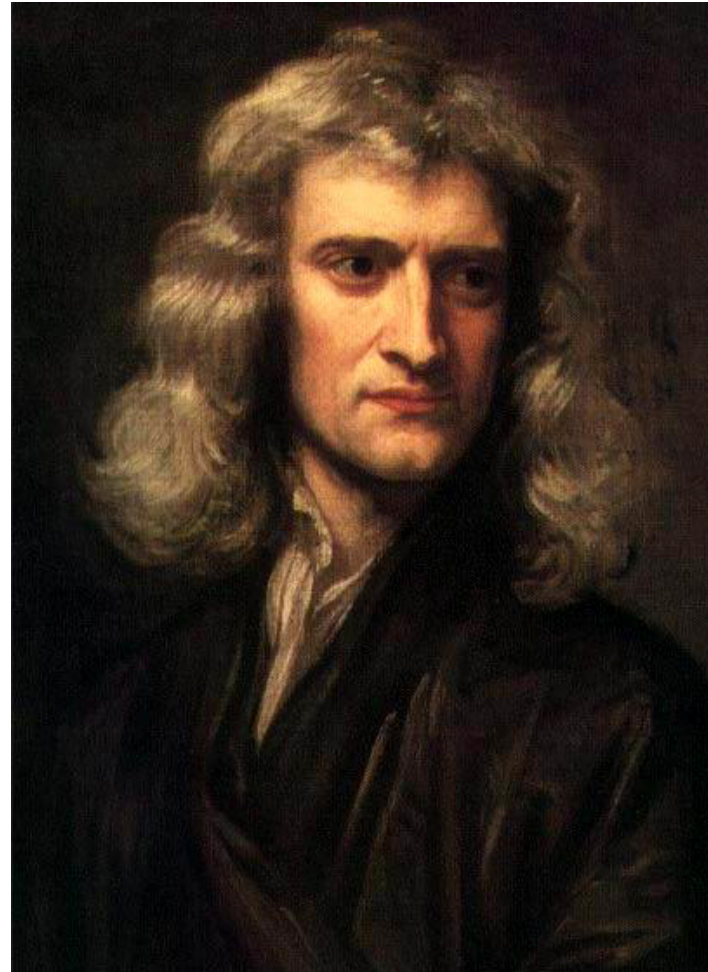
Newton's Laws

- First Law: A body acted on by no net force moves with constant velocity and zero acceleration. (Inertia)

- Second Law: The mass of a body times the acceleration of the body equals the net force vector. (F=ma)

- Third Law: If A exerts a force on B, then B exerts a force on A of the same magnitude but in the opposite direction (Action/Reaction)

Newton's First Law—Figure 4.9

- Simply stated — "An object at rest tends to stay at rest, an object in motion tends to stay in uniform motion."

- More properly, "A body acted on by zero net force moves with constant velocity and zero acceleration."

(a) Table: puck stops short.

(b) Ice: puck slides farther.

(c) Air-hockey table: puck slides even farther.
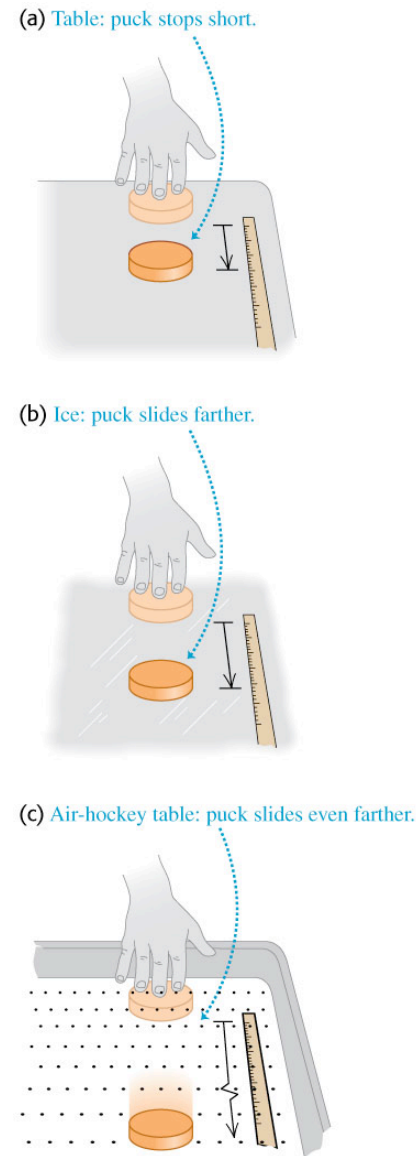
Q4.1

An elevator is being lifted at a constant speed by a steel cable attached to an electric motor. There is no air resistance, nor is there any friction between the elevator and the walls of the elevator shaft.

The upward force exerted on the elevator by the cable is

   F. greater than the downward force of gravity.

   G. equal to the force of gravity.

   H. less than the force of gravity.

   I. any of the above, depending on the speed of the elevator.
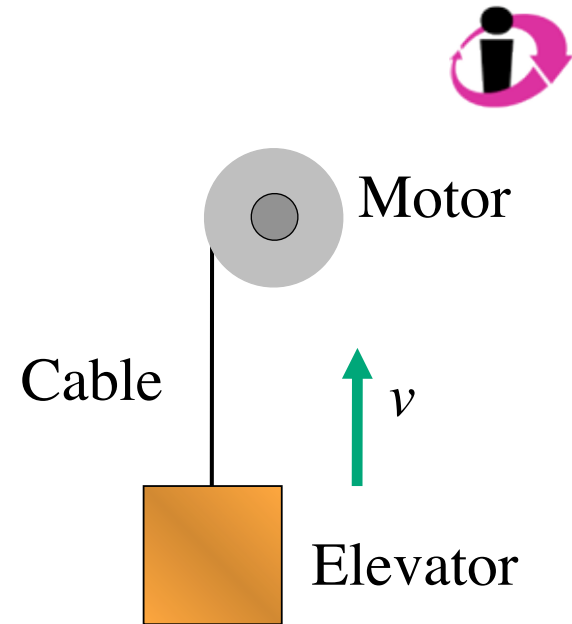
Text your answer to 22333

Q4.2

An elevator is being lowered at a constant speed by a steel cable attached to an electric motor. There is no air resistance, nor is there any friction between the elevator and the walls of the elevator shaft.

Motor

Cable

v

Elevator

The upward force exerted on the elevator by the cable is

K. greater than the downward force of gravity.

L. equal to the force of gravity.

M. less than the force of gravity.

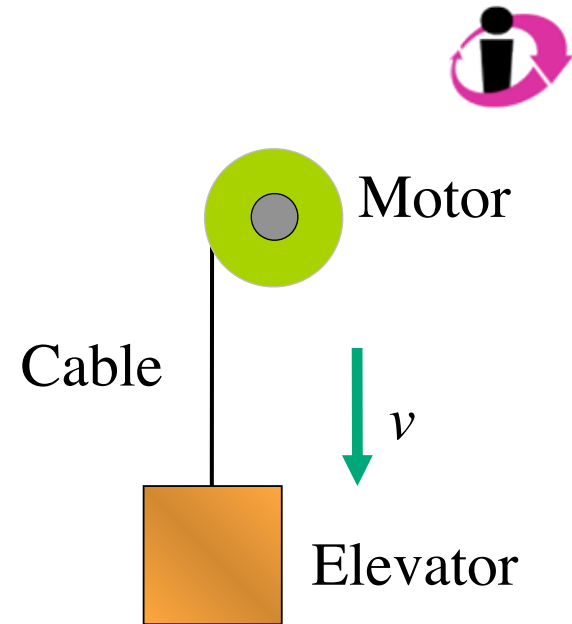N. any of the above, depending on the speed of the elevator.

Text your answer to 22333

What are the magnitudes of the normal and friction forces?

Assume block is at rest

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

And w = 10 N

$\vec{n}$

$\vec{f}$

$\vec{w}$

30°
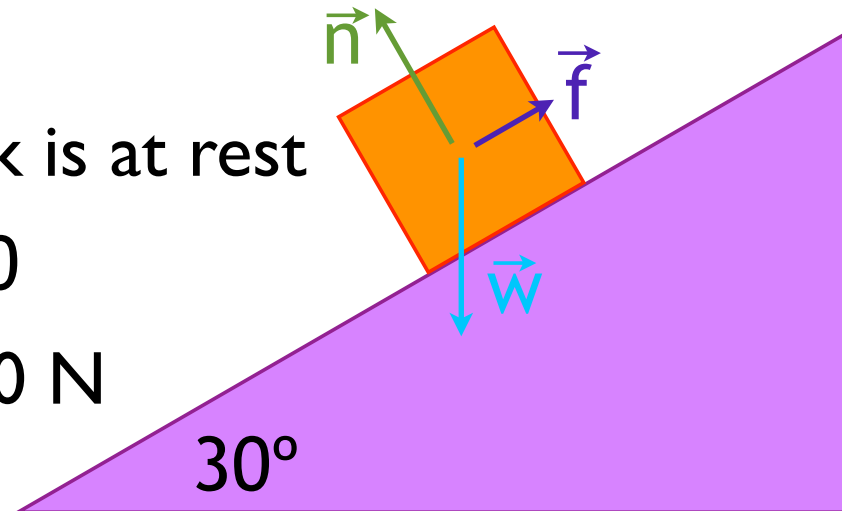
A cart shoots balls straight up in the air. I give the cart a push and let it coast. As it coasts, it shoots the ball into the air. Where will the ball land?
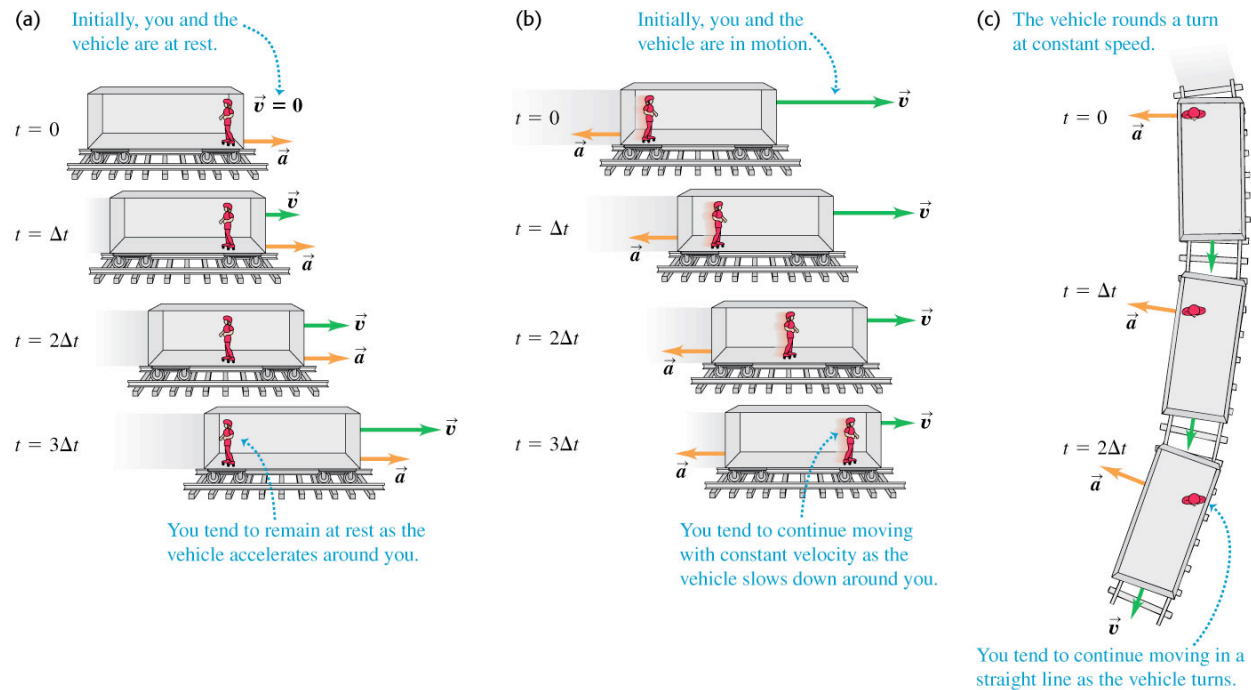
Q. In front of the cart

R. Behind the cart

S. Right back into the cart

T. Need more information

When is Newton's first law valid?

- In Figure 4.11 no net force acts on the rider, so the rider maintains a constant velocity. But as seen in the *non-inertial* frame of the accelerating vehicle, it appears that the rider is being pushed.

- Newton's first law is valid only in non-accelerating *inertial* frames.

(a) Initially, you and the vehicle are at rest.

$t = 0$ $\vec{v} = 0$ $\vec{a}$

$t = \Delta t$ $\vec{v}$ $\vec{a}$

$t = 2\Delta t$ $\vec{v}$ $\vec{a}$

$t = 3\Delta t$ $\vec{v}$ $\vec{a}$

You tend to remain at rest as the vehicle accelerates around you.

(b) Initially, you and the vehicle are in motion.

$t = 0$ $\vec{v}$ $\vec{a}$

$t = \Delta t$ $\vec{v}$ $\vec{a}$

$t = 2\Delta t$ $\vec{v}$ $\vec{a}$

$t = 3\Delta t$ $\vec{v}$ $\vec{a}$

You tend to continue moving with constant velocity as the vehicle slows down around you.

(c) The vehicle rounds a turn at constant speed.

$t = 0$ $\vec{a}$

$t = \Delta t$ $\vec{a}$

$t = 2\Delta t$ $\vec{a}$

$\vec{v}$

You tend to continue moving in a straight line as the vehicle turns.

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Newton's second law of motion

- The acceleration of an object is directly proportional to the net force acting on it, and inversely proportional to the mass of the object.

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

- The SI unit for force is the newton (N).

$$1 \text{ N} = 1 \text{ kg·m/s}^2$$