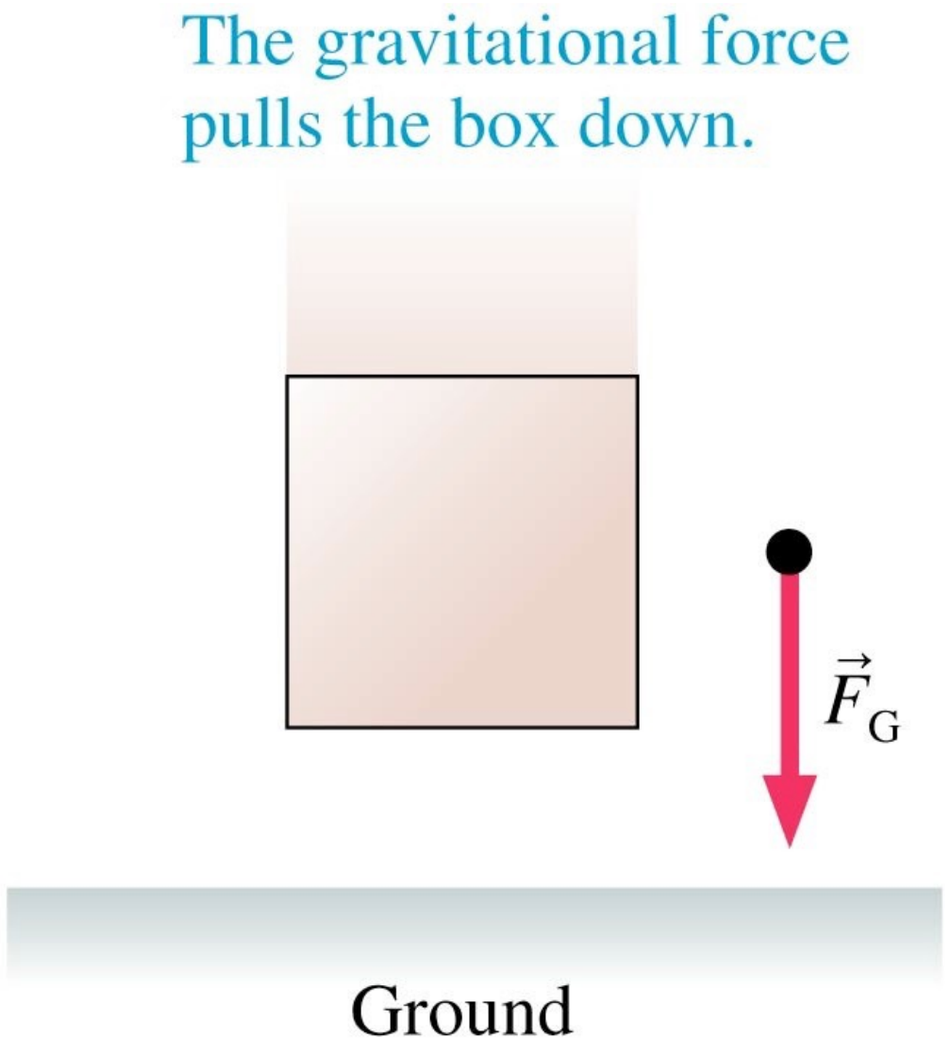
Contact Forces vs. Long-range forces

Catalogue of forces

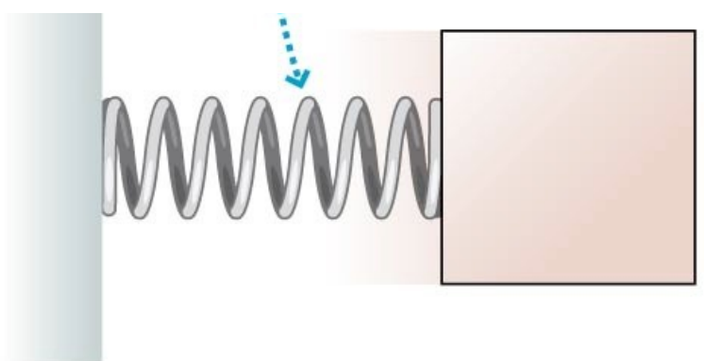
Gravity

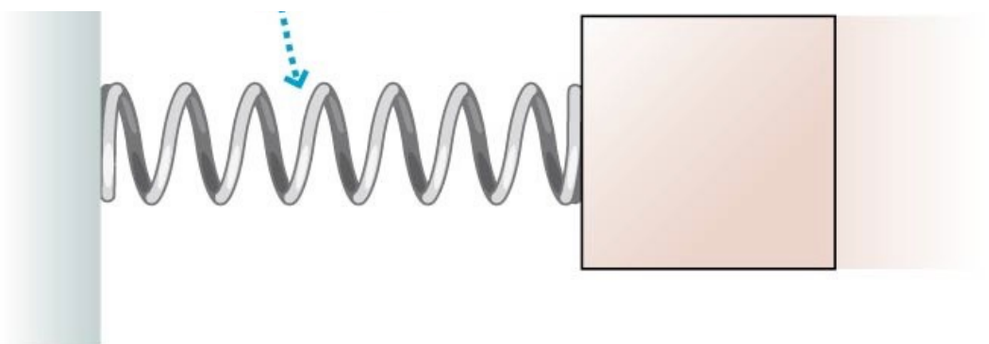
- The pull of a planet on an object near the surface is called the **gravitational force**.
- The agent for the gravitational force is the *entire planet*.
- Gravity acts on *all* objects, whether moving or at rest.
- The gravitational force vector always points vertically downward.



Spring Force

- A spring can either push (when compressed) or pull (when stretched).
- Not all springs are metal coils.
- Whenever an elastic object is flexed or deformed in some way, and then "springs" back to its original shape when you let it go, this is a **spring force**.





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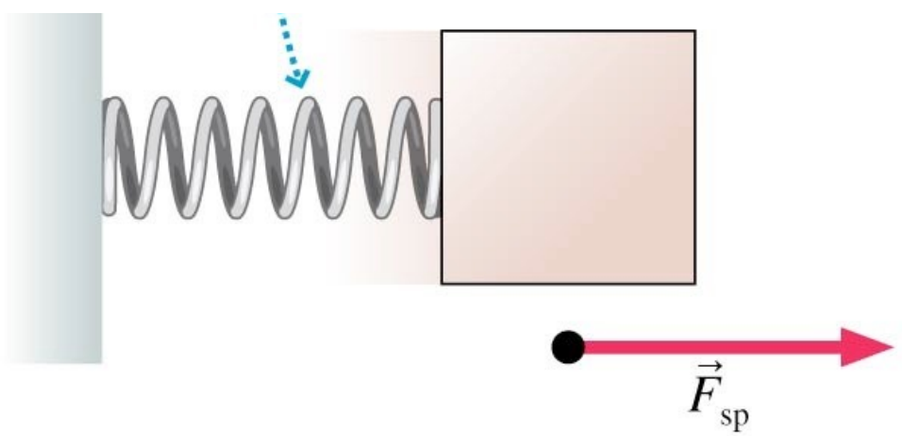

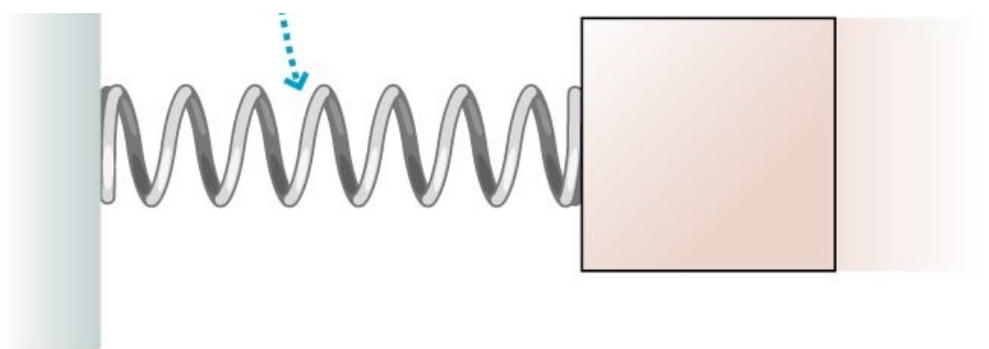

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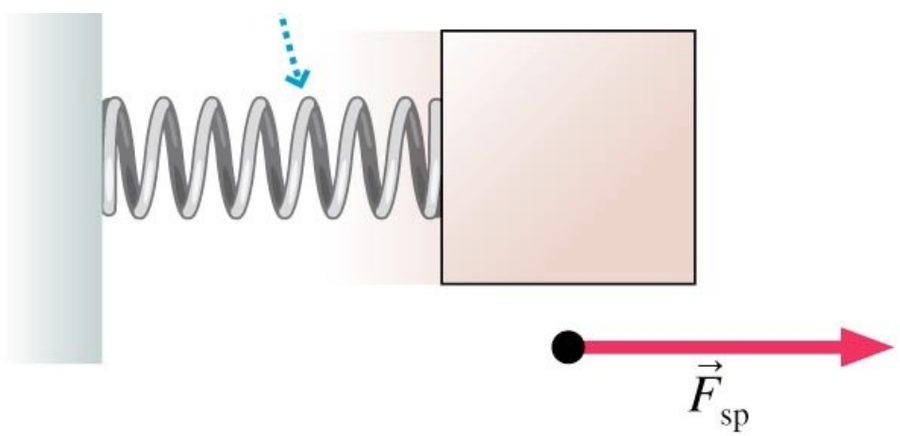
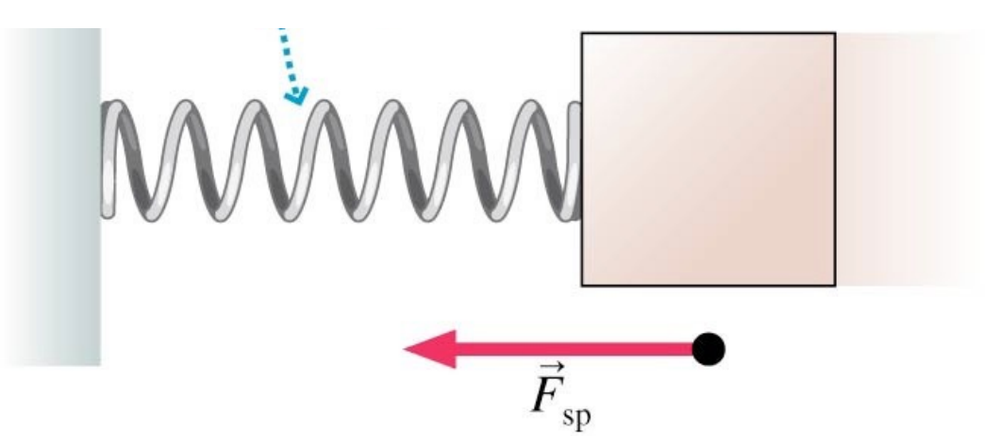
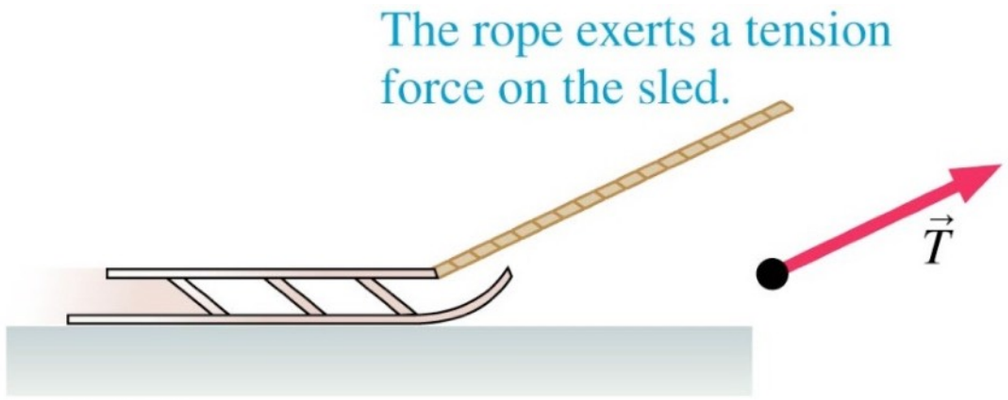
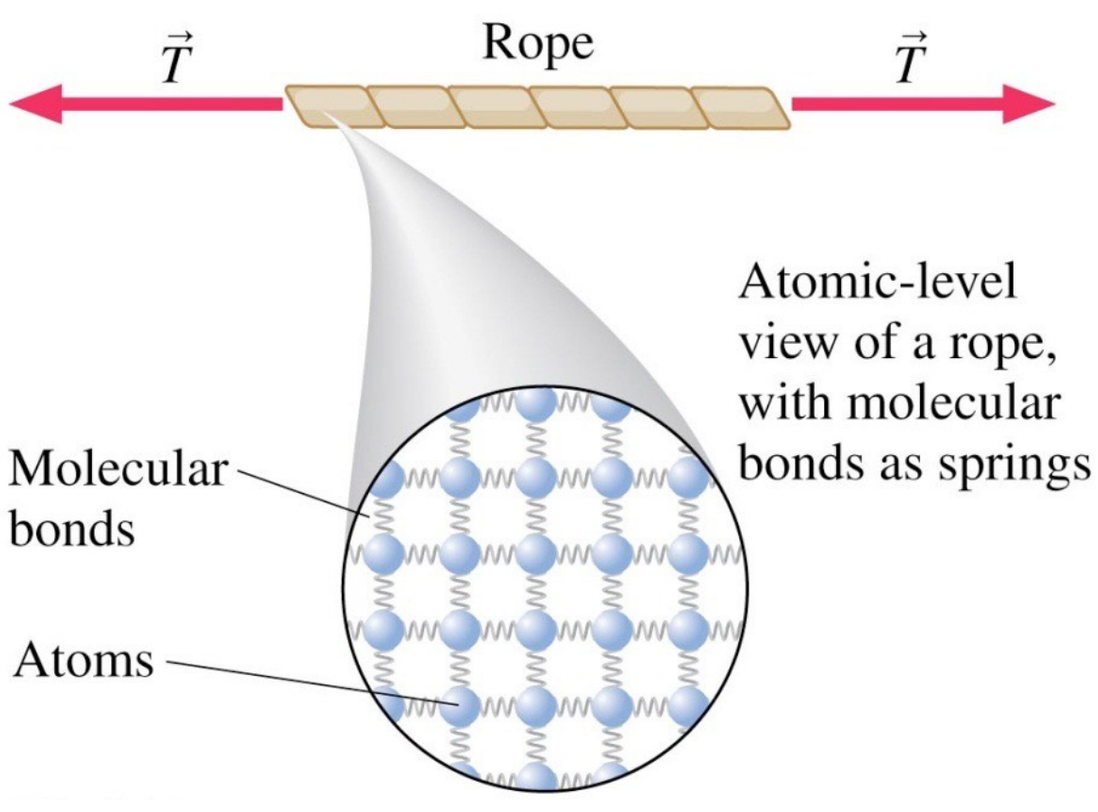




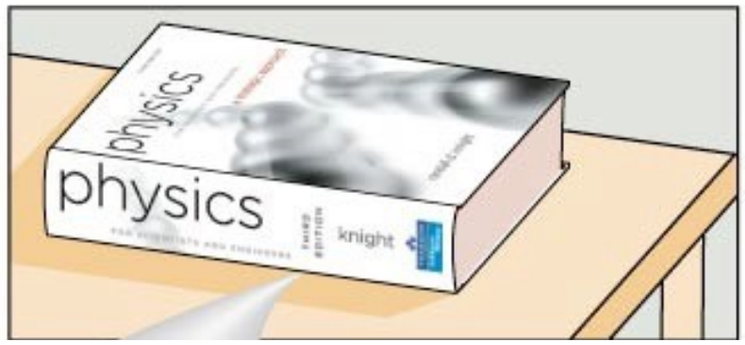
Tension Force

- When a string or rope or wire pulls on an object, it exerts a contact force called the **tension force**.
- The tension force is in the direction of the string or rope.
- A rope is made of *atoms* joined together by *molecular bonds*.
- Molecular bonds can be modeled as tiny *springs* holding the atoms together.
- Tension is a result of many molecular springs stretching ever so slightly.



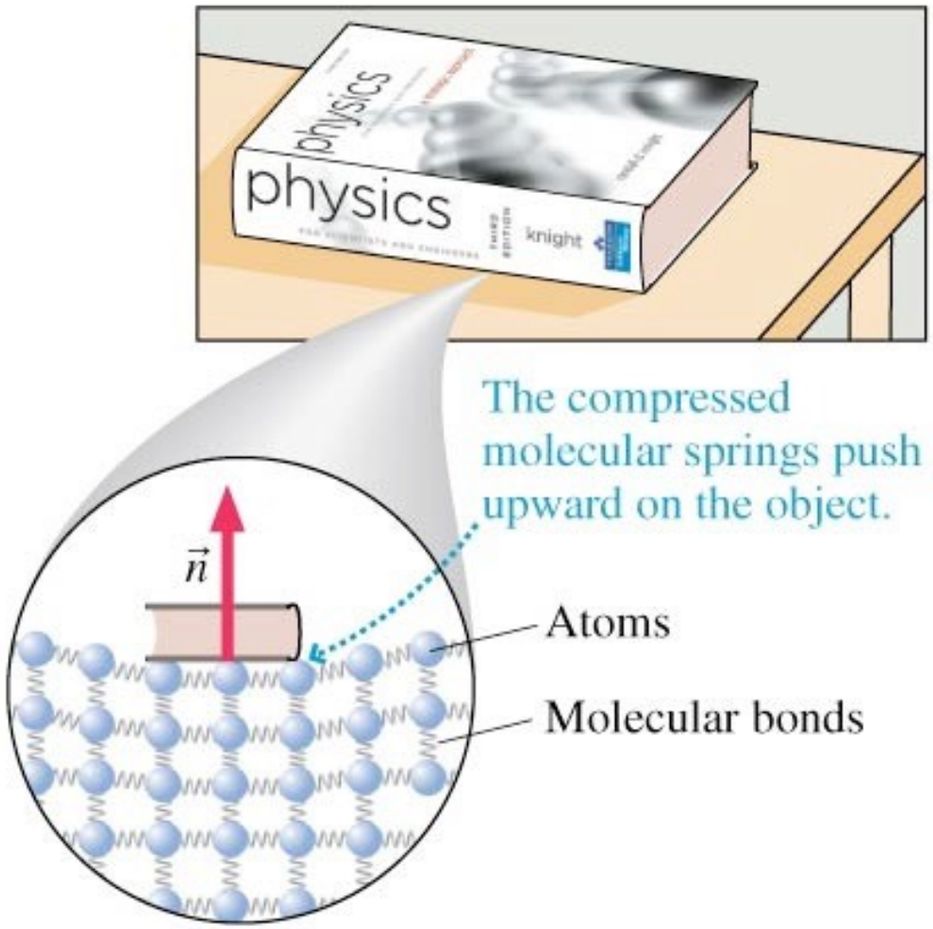


If gravity is pulling down on this book, why does it not fall downward?

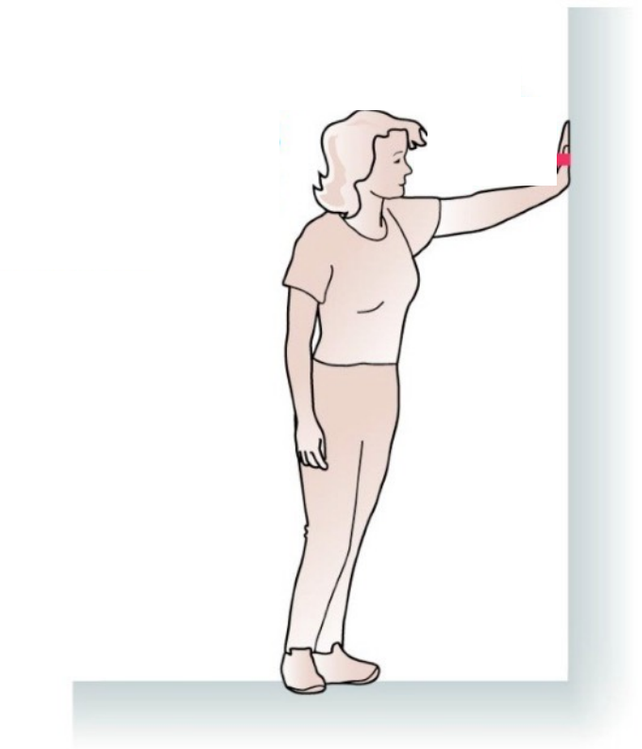


Normal Force

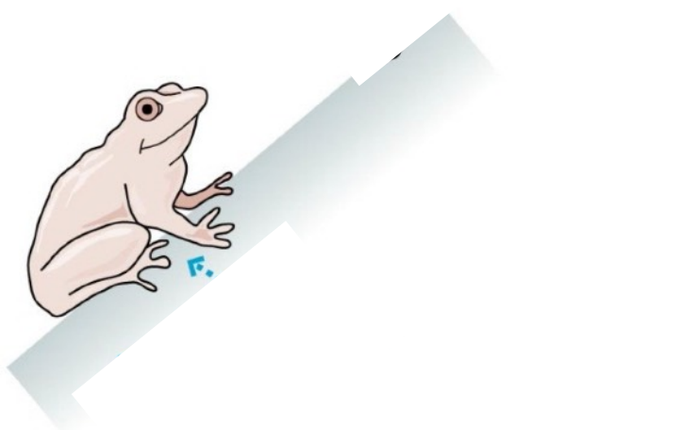
- When an object sits on a table, the table surface exerts an upward contact force on the object.
- This pushing force is directed *perpendicular* to the surface, and thus is called the **normal force**.
- A table is made of *atoms* joined together by *molecular bonds* which can be modeled as springs.
- Normal force is a result of many molecular springs being compressed ever so slightly.



Examples of Normal Forces



Which direction does the normal force point?



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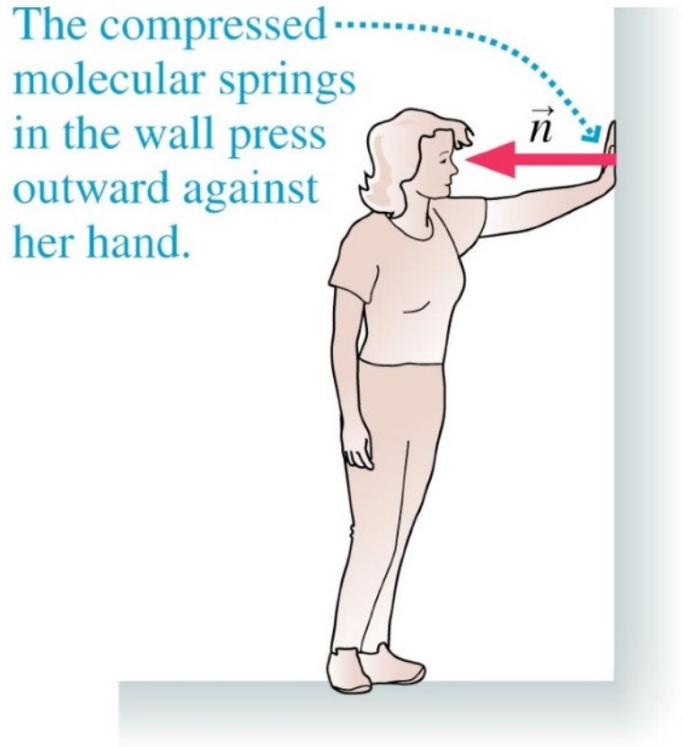

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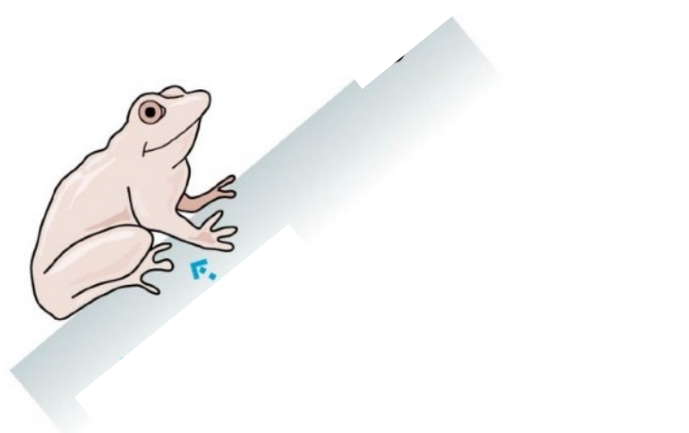
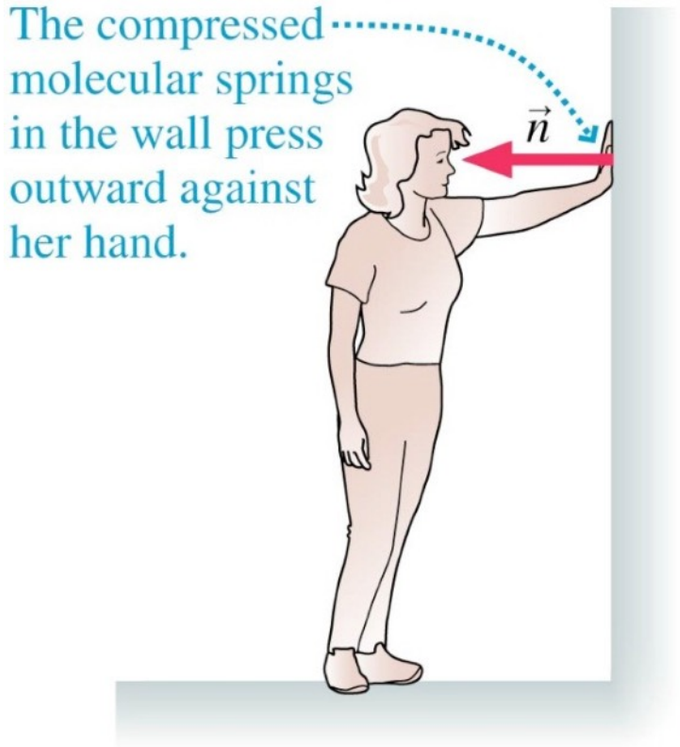


Examples of Normal Forces



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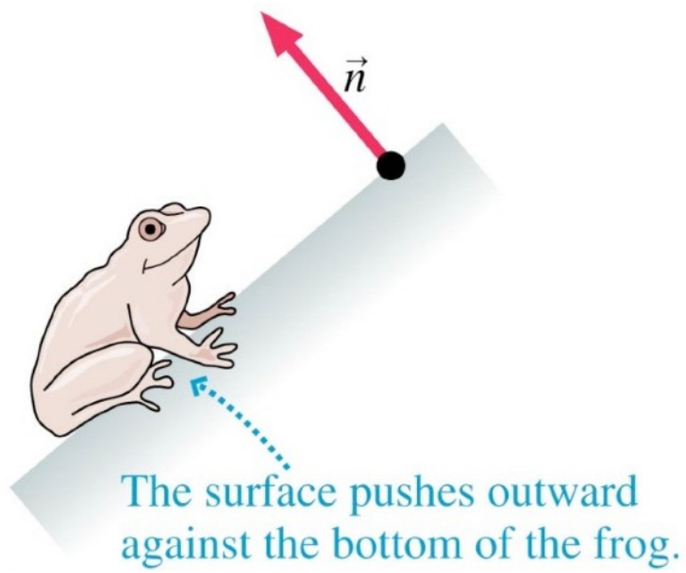
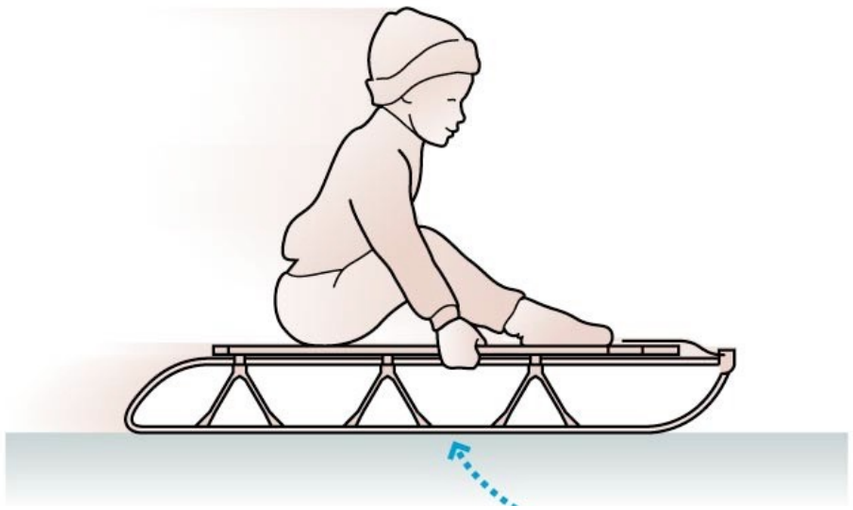
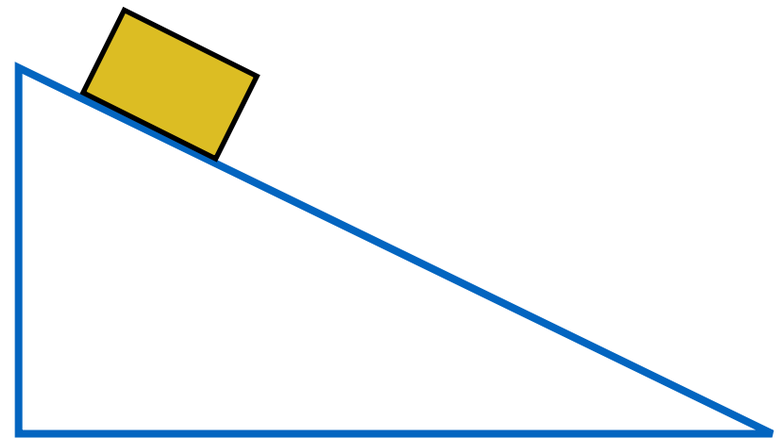
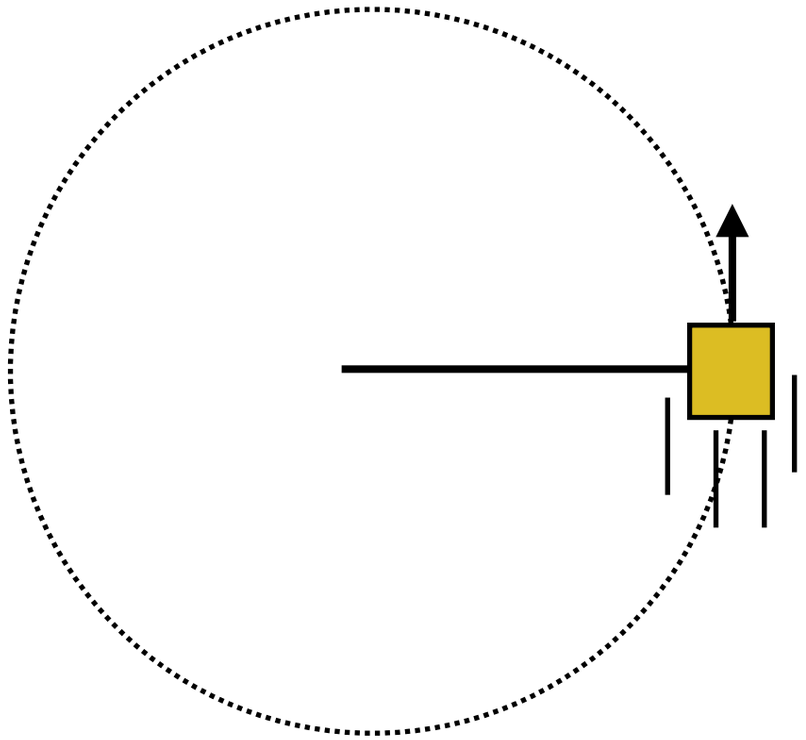


Kinetic Friction

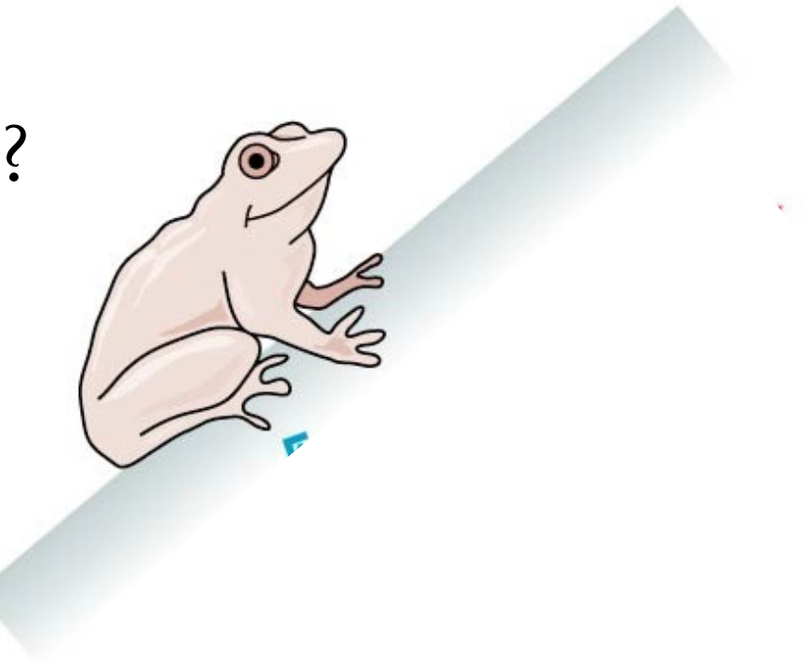






Which way does friction point?

Why doesn’t this frog fall down the incline?



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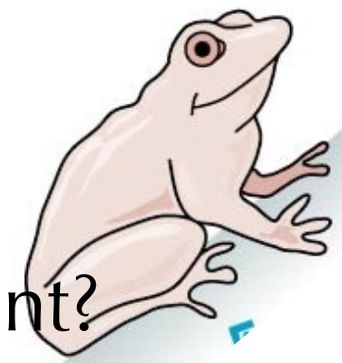
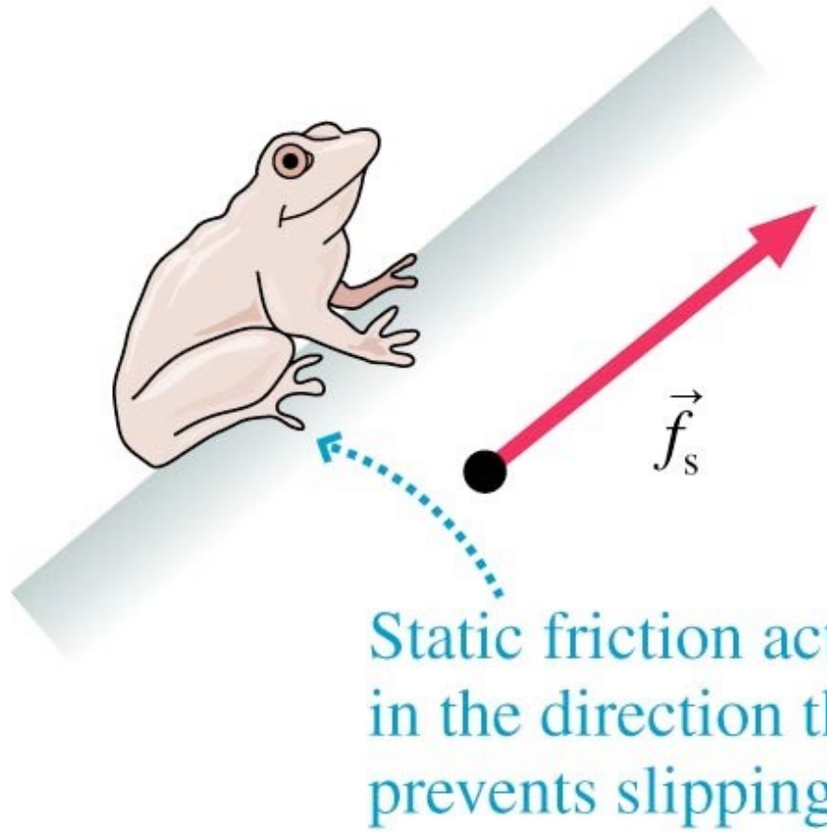


Which direction does the frictional force point?

Static Friction

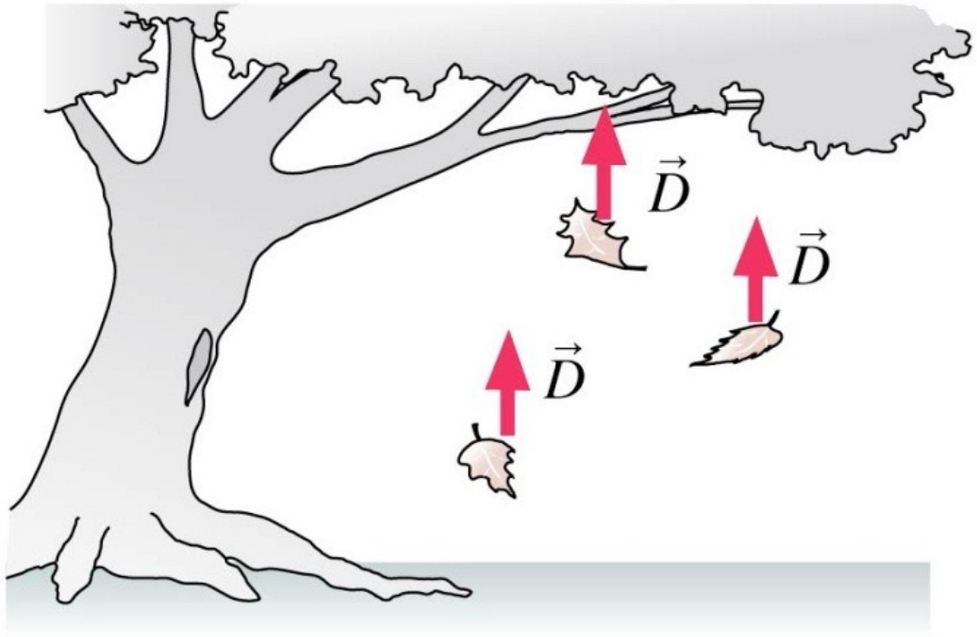
- **Static friction** is the contact force that keeps an object "stuck" on a surface, and prevents relative motion.
- The static friction force is directed *tangent* to the surface.
- Static friction points opposite the direction in which the object *would* move if there were no static friction.



Drag

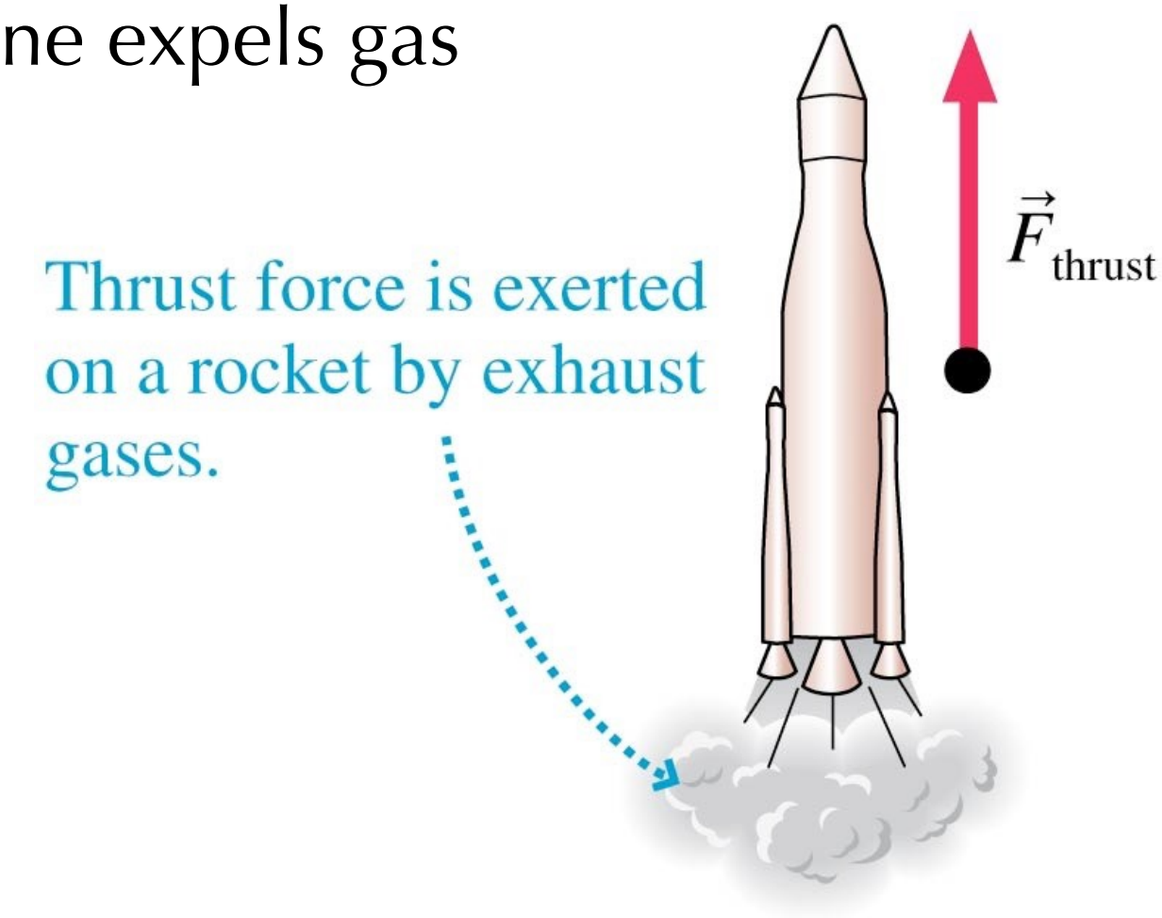
- Kinetic friction is a *resistive force*, which opposes or resists motion.
- Resistive forces are also experienced by objects moving through fluids.
- The resistive force of a fluid is called **drag**.
- Drag points opposite the direction of motion.
- For heavy and compact objects in air, drag force is fairly small.
- **You can neglect air resistance in all problems unless a problem explicitly asks you to include it**.

Air resistance is a significant force on falling leaves. It points opposite the direction of motion.



Thrust

- A jet airplane or a rocket has a **thrust** force pushing it forward during takeoff.
- Thrust occurs when an engine expels gas molecules at high speed.
- This exhaust gas exerts a contact force on the engine.
- The direction of thrust is opposite the direction in which the exhaust gas is expelled.



Symbols for forces

Force	Notation
General force	$\vec{F}$
Gravitational force	$\vec{F}_{\mathrm{G}}$
Spring force	$\vec{F}_{\mathrm{sp}}$
Tension	$\vec{T}$
Normal force	$\vec{n}$
Static friction	$\vec{f}_{\mathrm{s}}$
Kinetic friction	$\vec{f}_{\mathrm{k}}$
Drag	$\vec{D}$
Thrust	$\vec{F}_{\mathrm{thrust}}$

Newton's First Law

What is it?

Newton's First Law

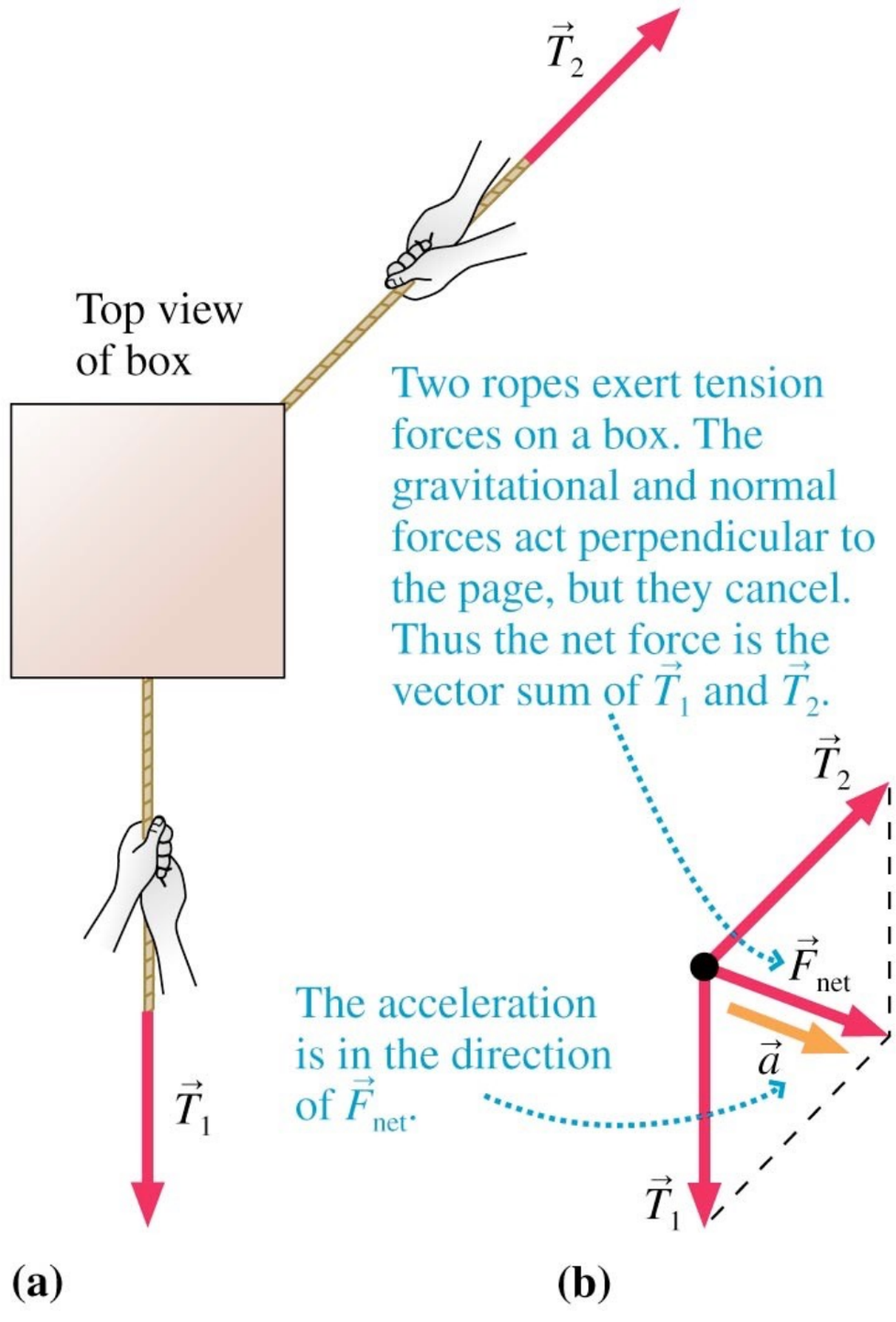
What is it?

Newton's first law: An object that is at rest will remain at rest, or an object that is moving will continue moving in a straight line with constant velocity, if and only if the net force acting on the object is zero.

- Newton's first law is also known as the *law of inertia*.
- If an object is at rest, it has a tendency to stay at rest.
- If it is moving, it has a tendency to continue moving with the *same velocity*.

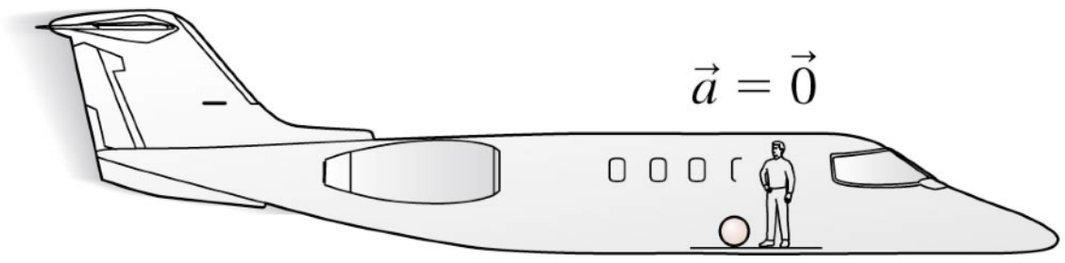
Newton's Second Law

$$\vec{F}_{\text{net}} = m\vec{a}$$

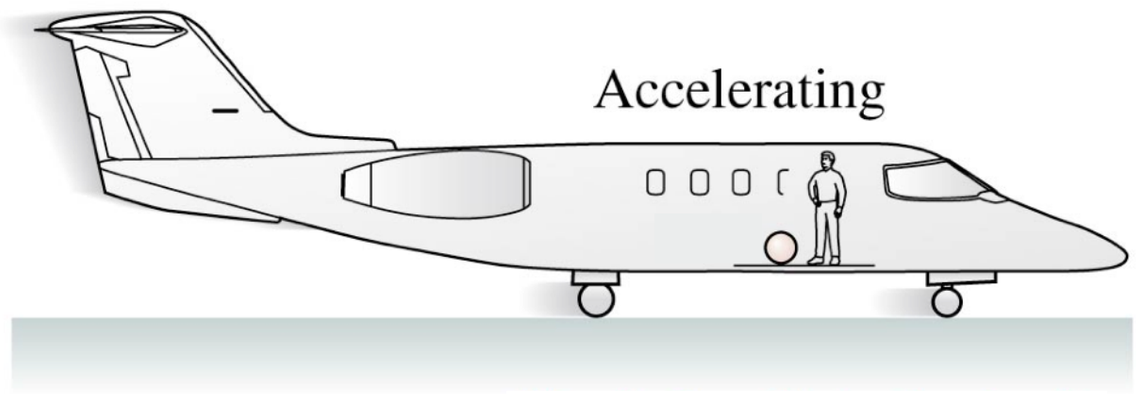


Inertial Reference Frames

Describe the motion of the ball when the plane is moving at constant speed.



Describe the motion of the ball when the plane is accelerating.



Inertial Reference Frames

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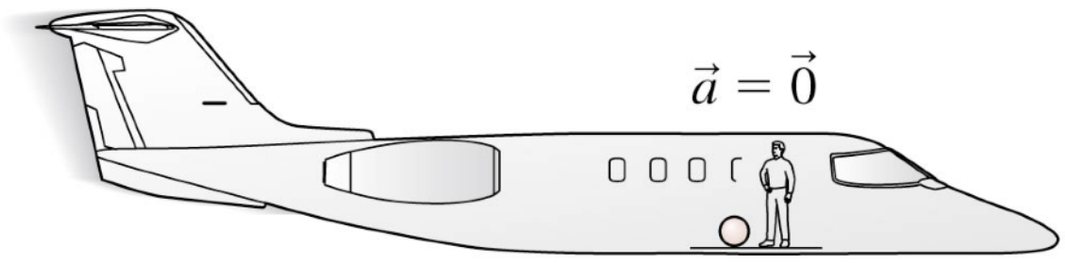

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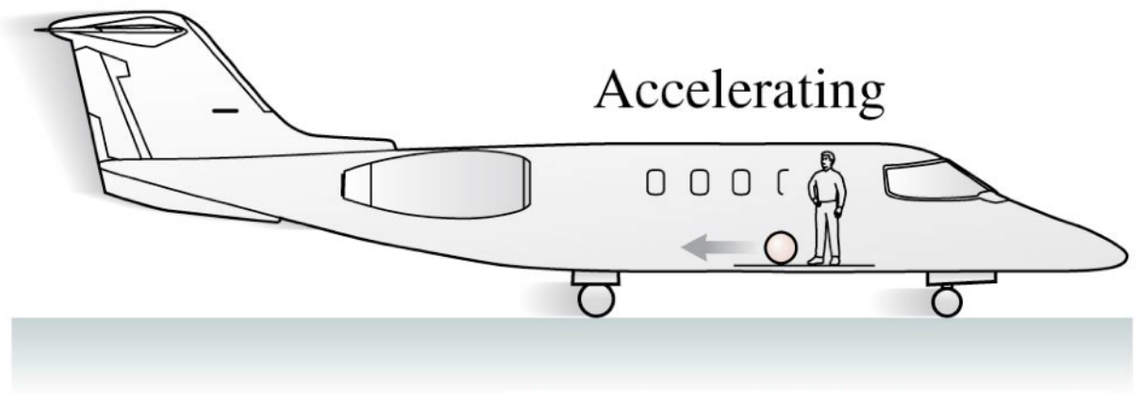


Accelerating reference frames are not inertial reference frames.

Inertial Reference Frames

Describe how the scene unfolds from the perspective of a person standing at rest on the ground.

Describe how the scene unfolds from the perspective of a person attached to the car.

You try one.

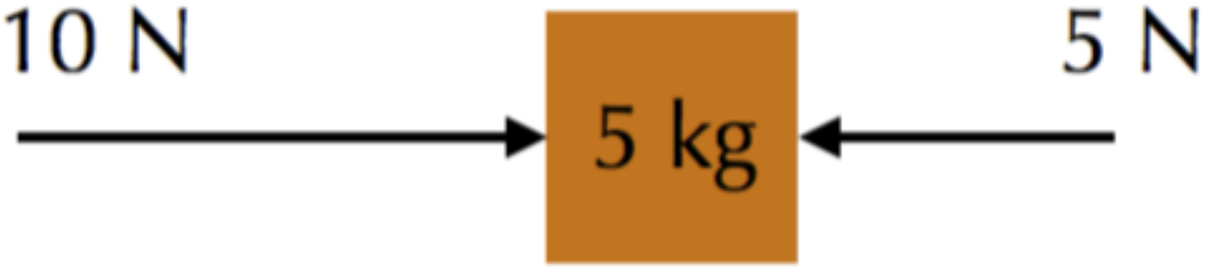
Identify all of the forces acting on this skier as she is pulled up the hill by the rope tow.

Try another

Identify all forces acting on the rocket as it lifts off.

Question #1

An object is acted on by two forces of unequal magnitude, as shown in the figure. Which statement is true?



A The acceleration vector points to the right and has magnitude 5 m/s^2

B The acceleration vector points to the right and has magnitude 1 m/s^2

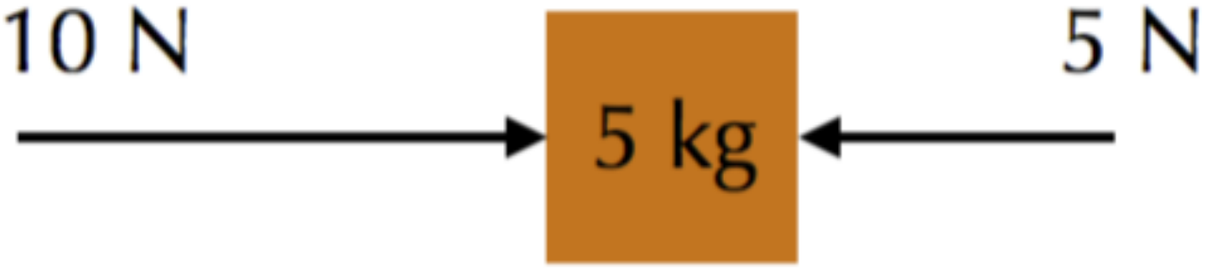
C The acceleration vector points to the left and has magnitude 1 m/s^2

D The acceleration vector points to the left and has magnitude 5 m/s^2

E The acceleration vector points to the right and has magnitude 2 m/s^2

Question #2

Now quadruple the 5 N force so that it becomes 20 N. Now which statement is true?



A The acceleration vector points to the right and has magnitude 1 m/s^2

B The acceleration vector points to the right and has magnitude 5 m/s^2

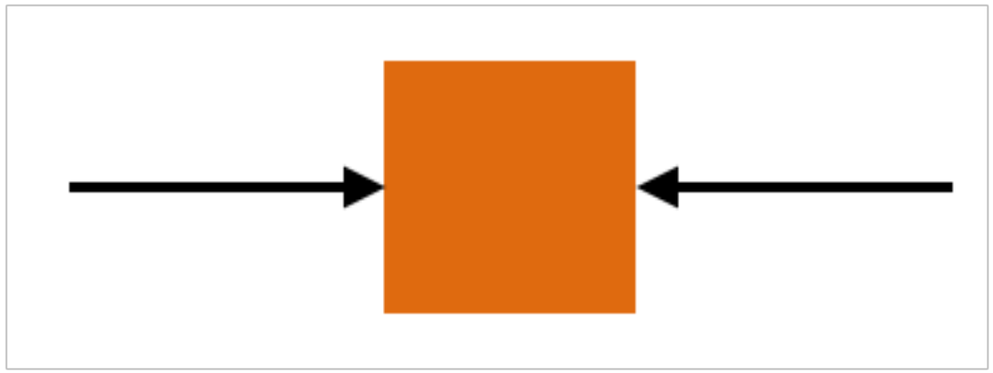
C The acceleration vector points to the left and has magnitude 1 m/s^2

D The acceleration vector points to the right and has magnitude 2 m/s^2

E The acceleration vector points to the left and has magnitude 2 m/s^2

Question #3

An object is acted on by two forces of equal magnitude, as shown in the figure. Describe the motion of the box



A The object is stationary (not moving).

B The object is moving to the right at constant speed.

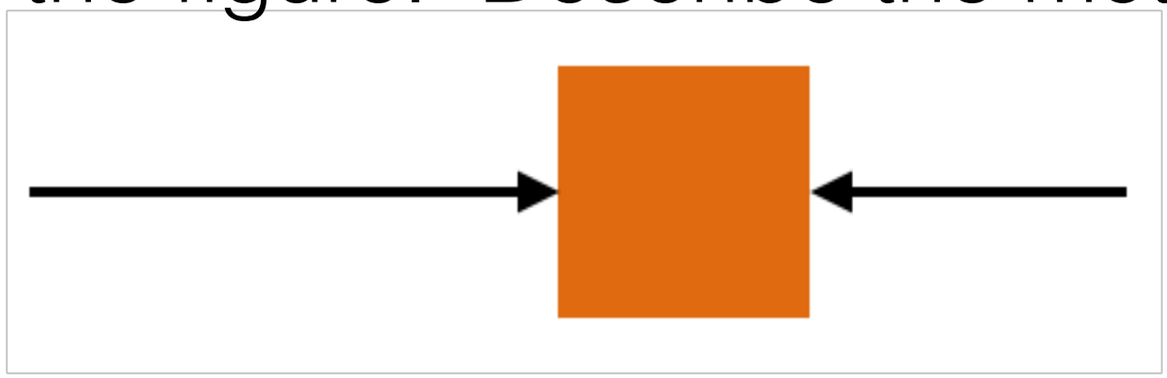
C A, B, and E are all possible.

D The object is moving and speeding up.

E The object is moving to the left at constant speed.

Question #4

An object is acted on by two forces of **unequal** magnitude, as shown in the figure. Describe the motion of the box



A B, and E are both possible.

B The object is moving to the right and its speed is increasing.

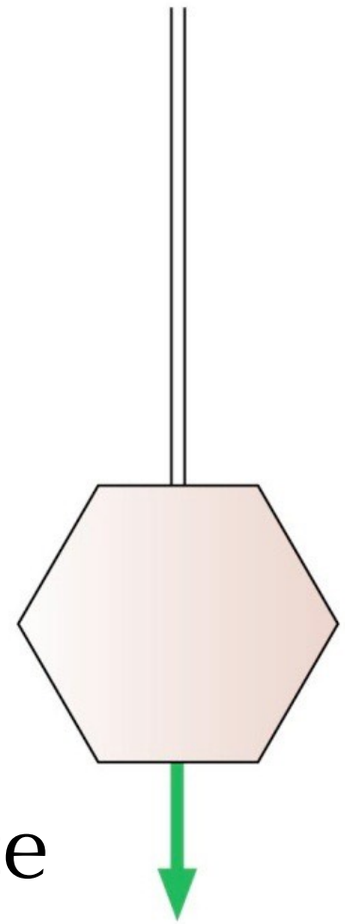
C The object is moving at constant speed.

D The object is moving to the right and its speed is decreasing.

E The object is moving to the left and its speed is decreasing.

Question #5

An object on a rope is lowered at constant speed. Which is true?



b) The rope tension is greater than the force of gravity.

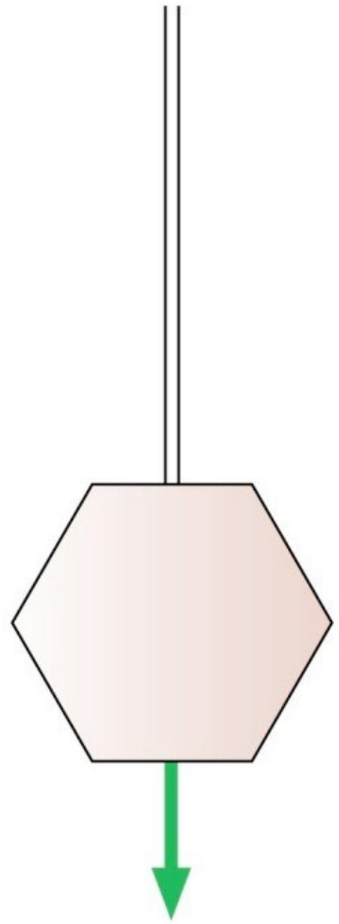
c) The rope tension can't be compared to the force of gravity.

d) The rope tension is less than the force of gravity.

e) The rope tension equals the force of gravity.

Question #6

An object on a rope is lowered at a **steadily decreasing** speed. Which is true?



a) The rope tension is greater than the force of gravity.

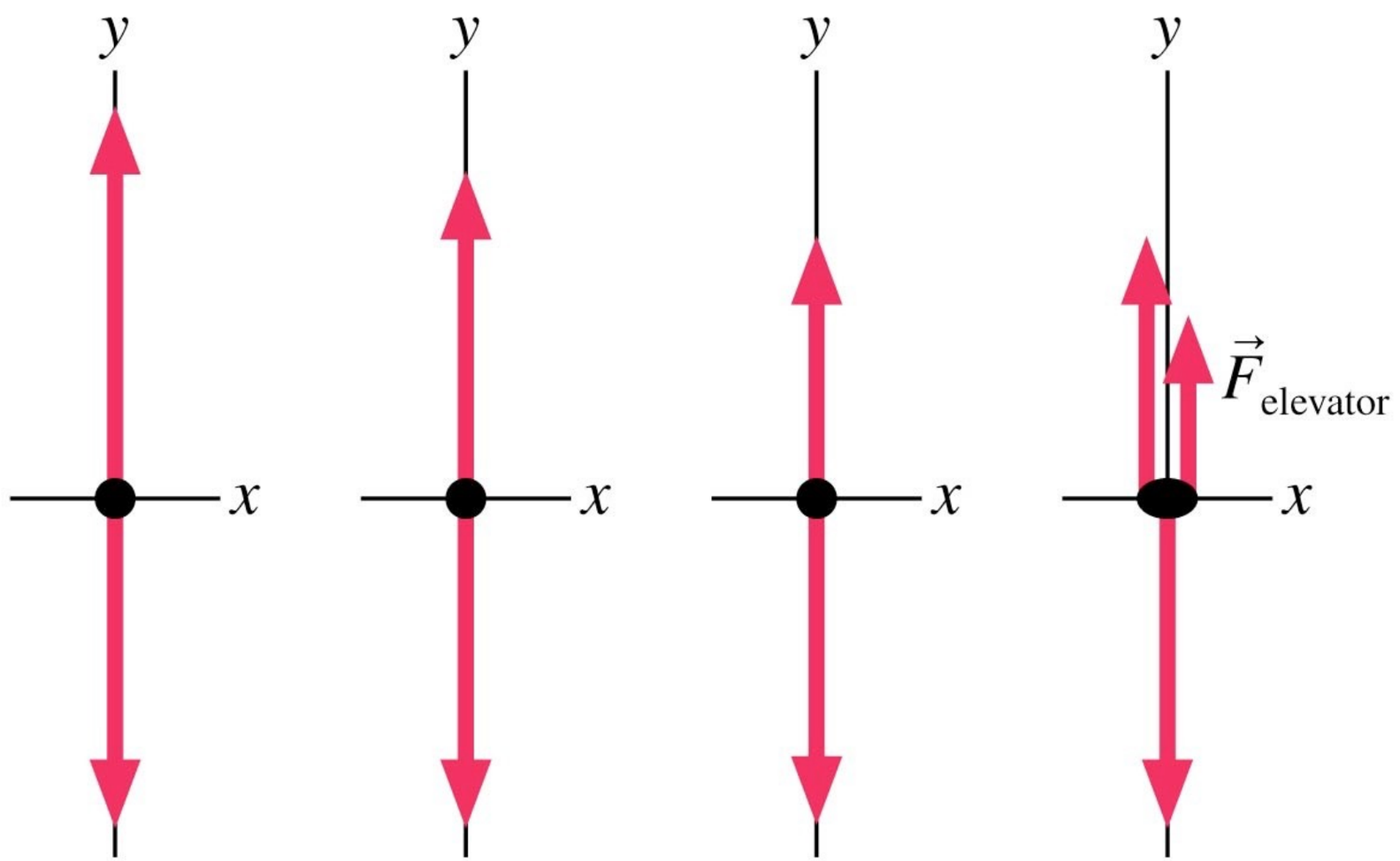
b) The rope tension equals the force of gravity.

c) The rope tension is less than the force of gravity.

d) The rope tension can't be compared to the force of gravity.

Question #7

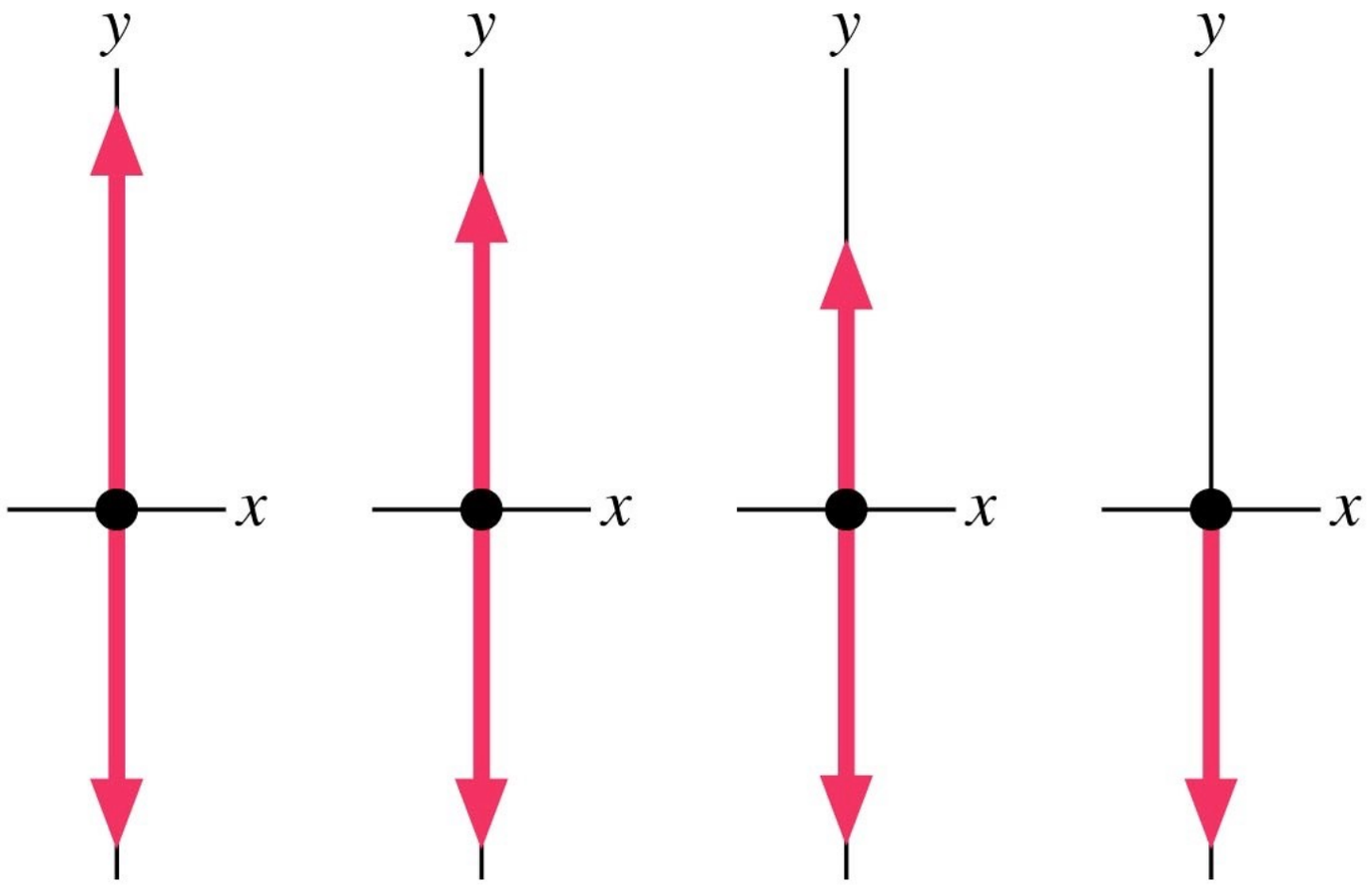
An elevator, lifted by a cable, is moving upward and slowing. Which is the correct free-body diagram?



C B E A

Question #8

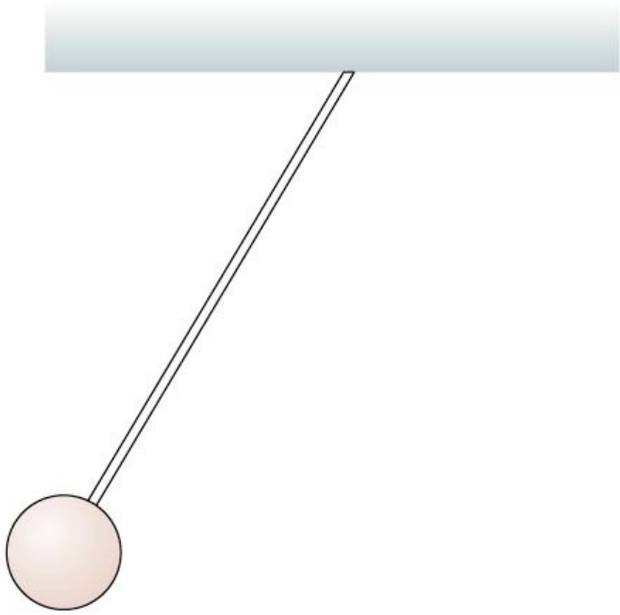
A ball has been tossed straight up. Which is the correct free-body diagram just after the ball has left the hand? Ignore air resistance.

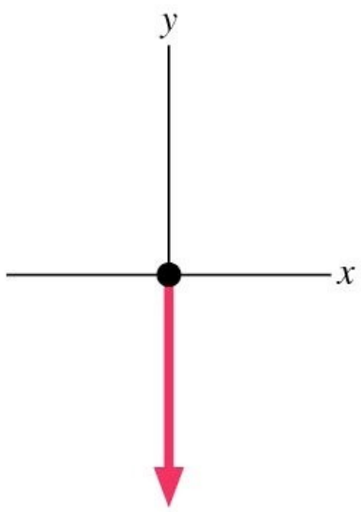


D A B C

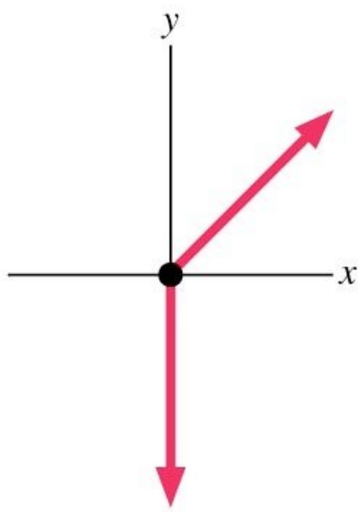
Question #9

A ball, hanging from the ceiling by a string, is pulled back and released. Which is the correct free-body diagram just after its release?

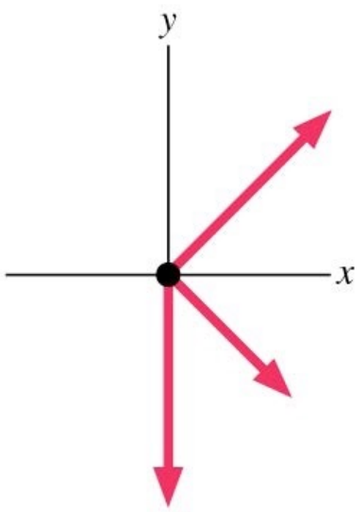




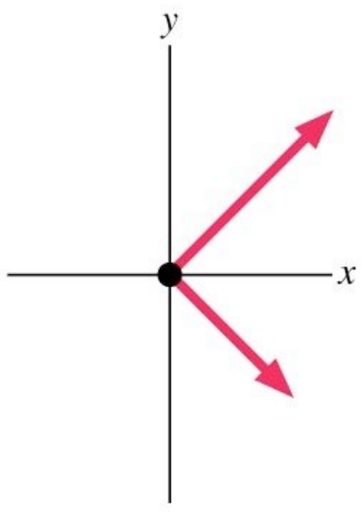
B



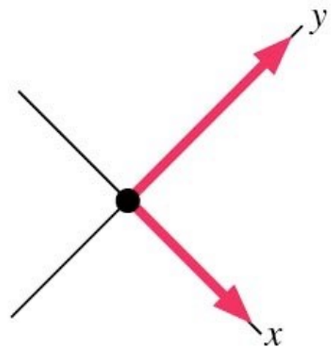
C



D



A



E

Example

You push <u>horizontally</u> on a 5 kg block which is sitting on a 30 degree, incline (friction is present). Draw a free body diagram.