

Contact Forces vs. Long-range forces

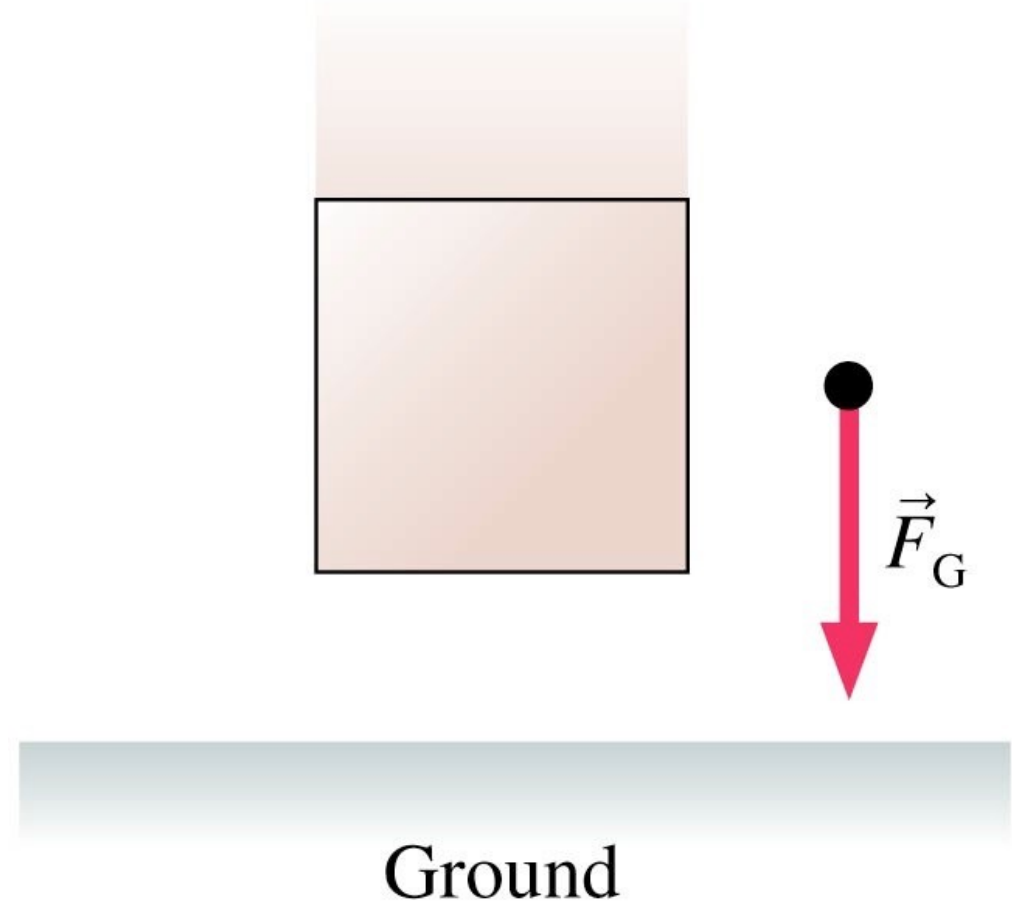


Catalogue of forces

Gravity

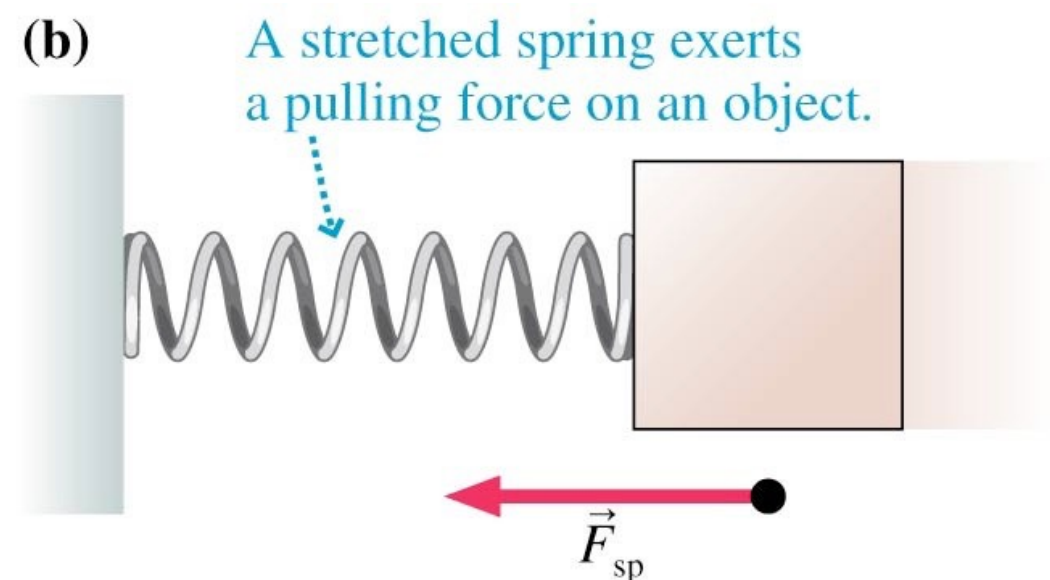
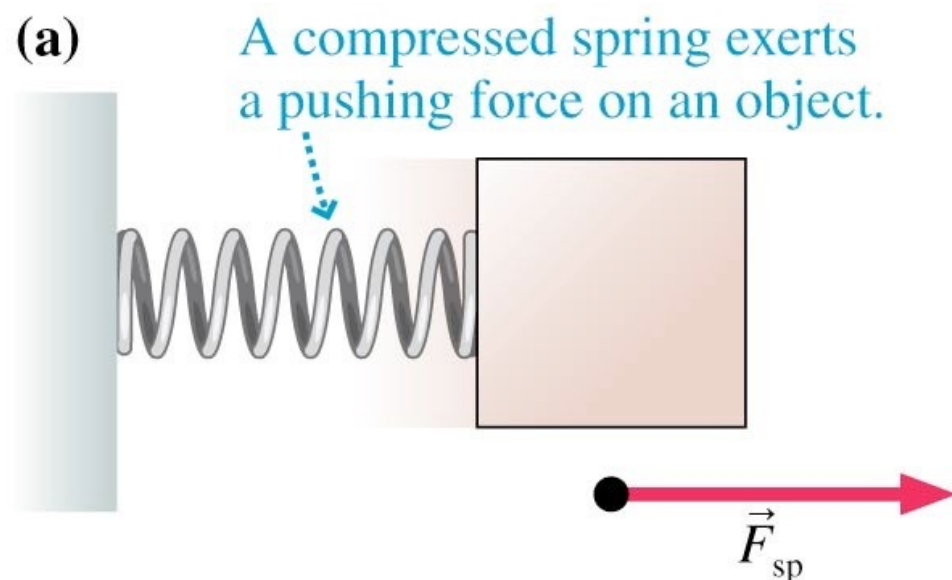
- The pull of a planet on an object near the surface is called the **gravitational force**.
- The agent for the gravitational force is the *entire planet*.
- Gravity acts on *all* objects, whether moving or at rest.
- The gravitational force vector always points vertically downward.

The gravitational force pulls the box down.



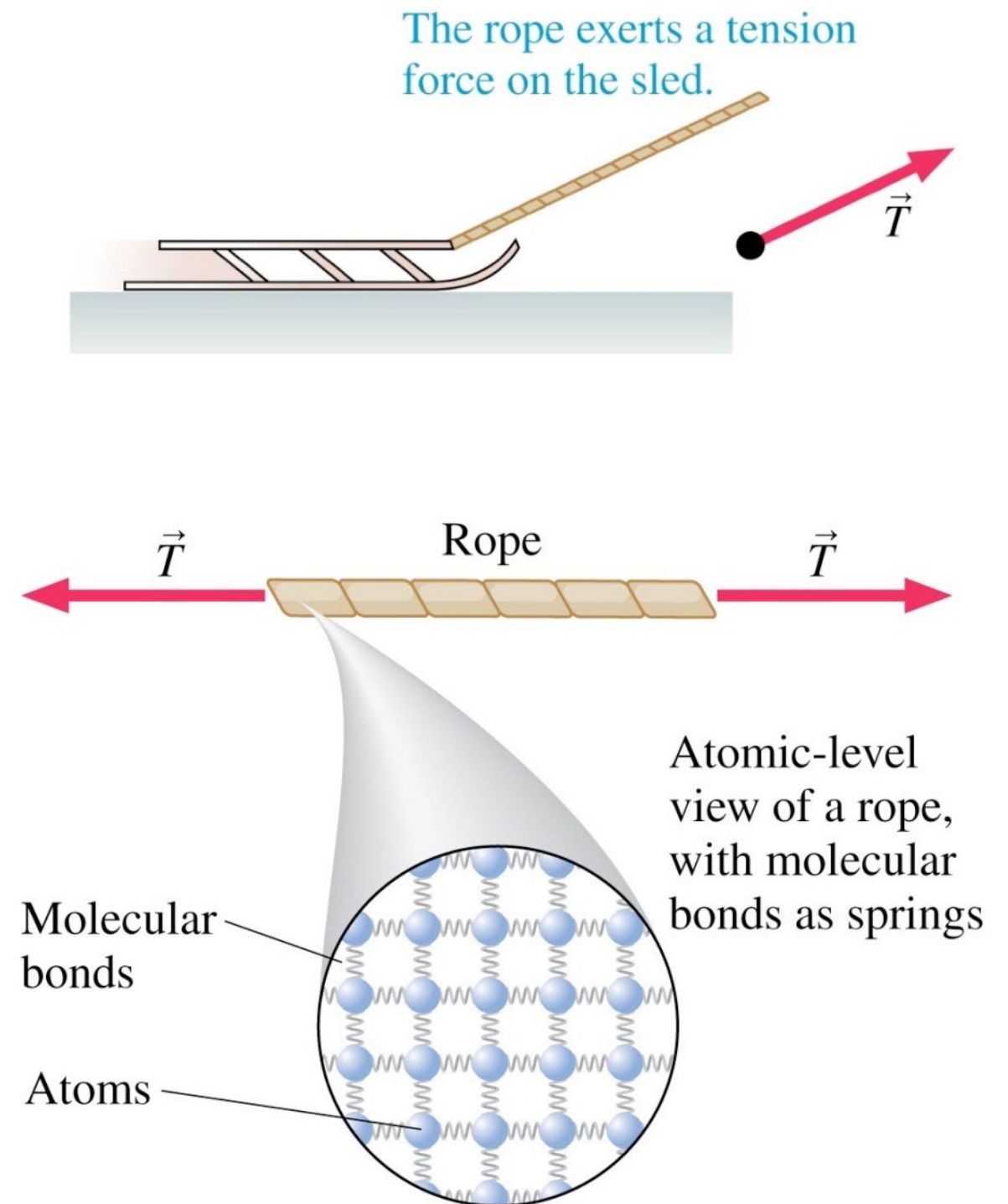
Spring Force

- 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**.

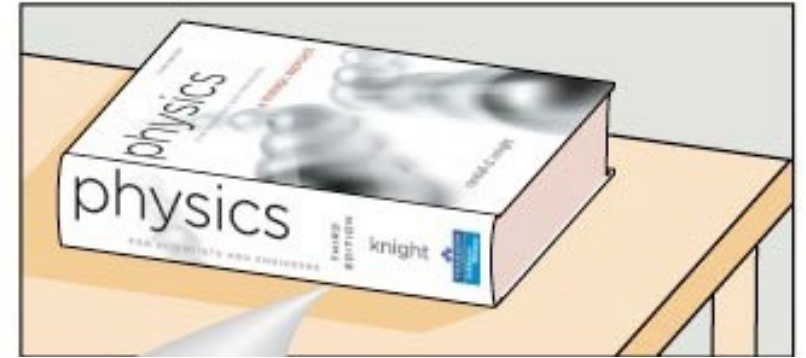


Tension Force

- 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.

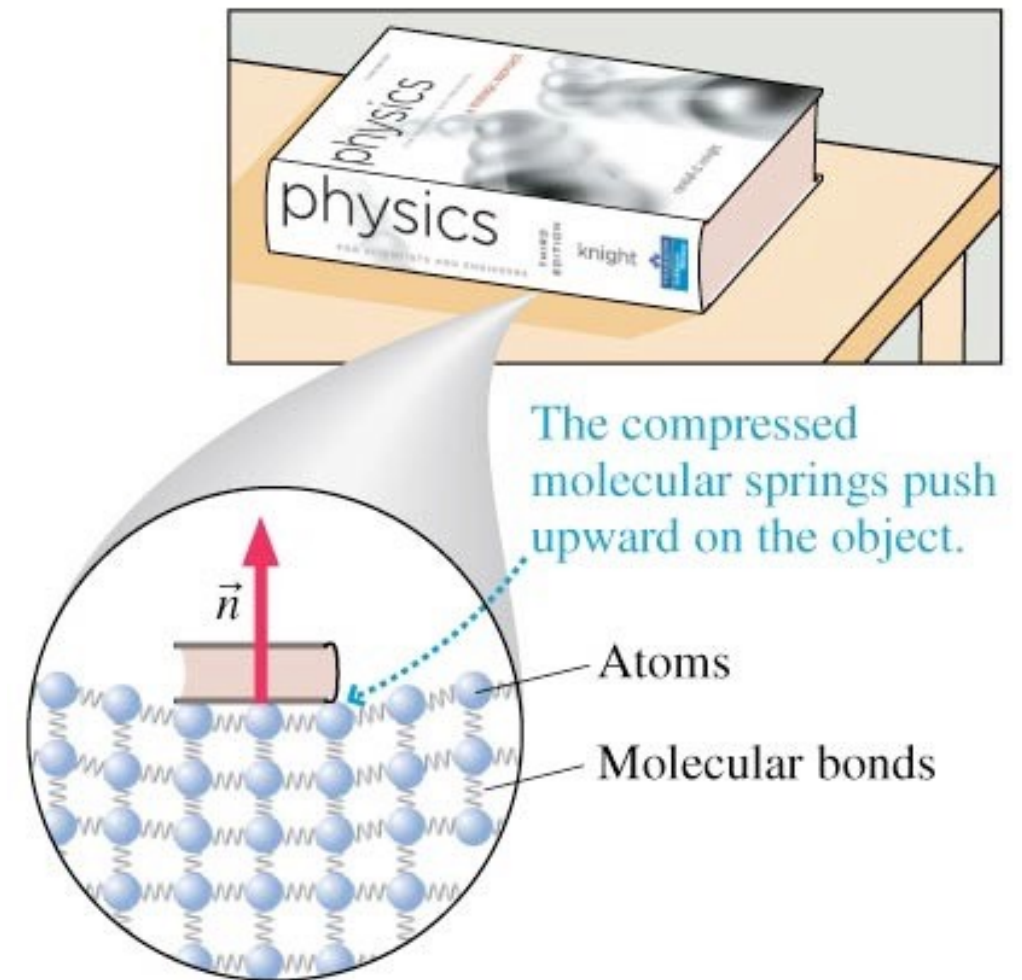


If gravity is pulling down on this book, why does it not fall downward?

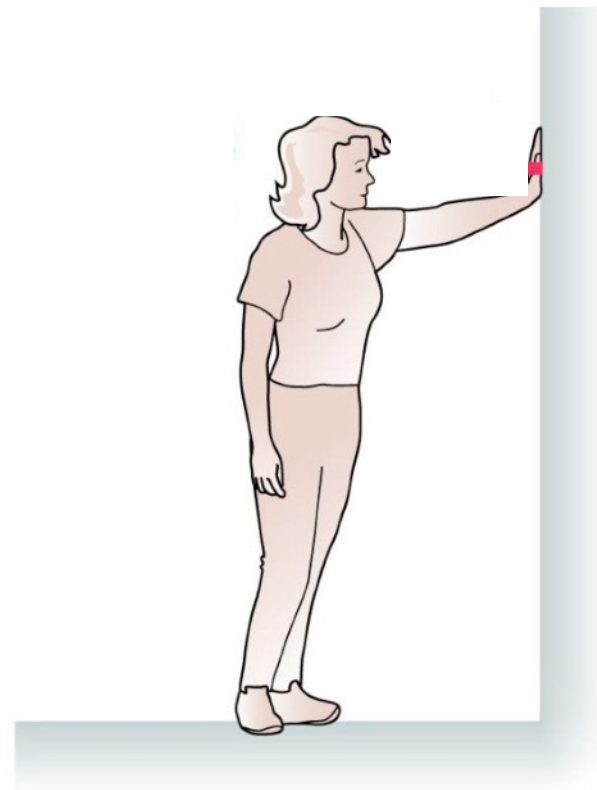


Normal Force

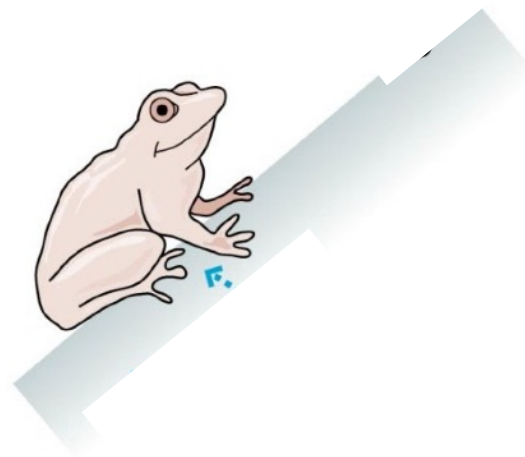
- When an object sits on a table, the table surface exerts an upward contact force on the object.
- This pushing force is directed *perpendicular* to the surface, and thus is called the **normal force**.
- A table is made of *atoms* joined together by *molecular bonds* which can be modeled as springs.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



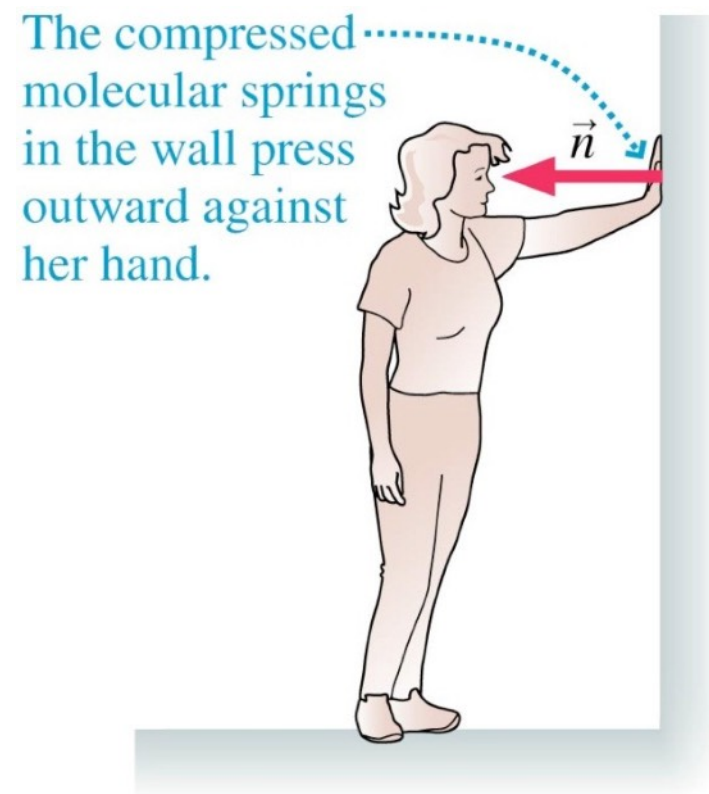
Examples of Normal Forces



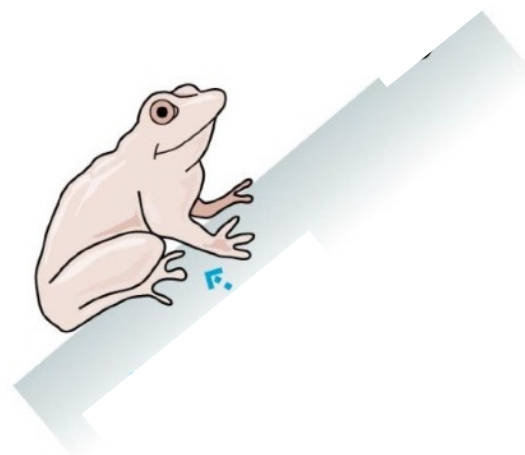
Which direction does the normal force point?



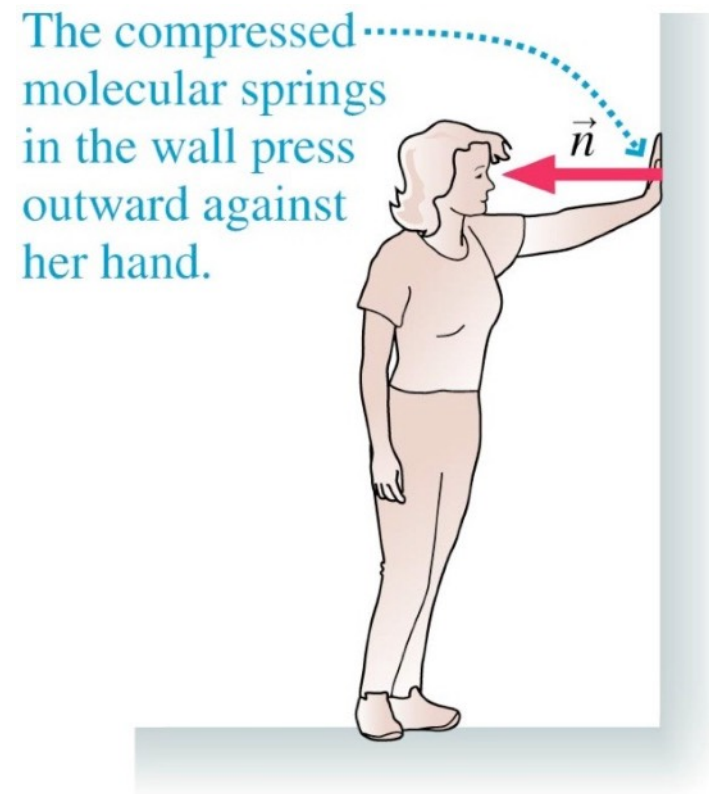
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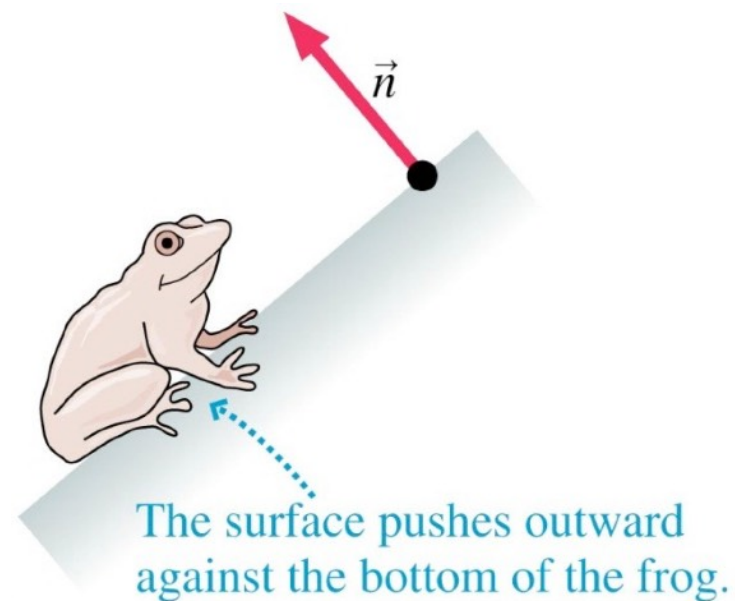
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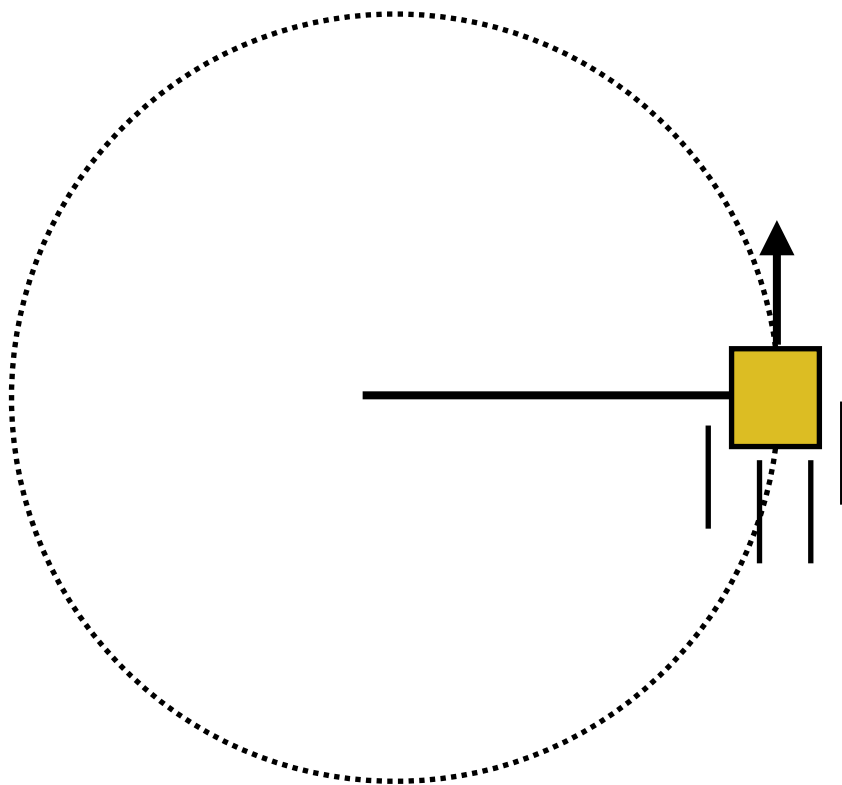
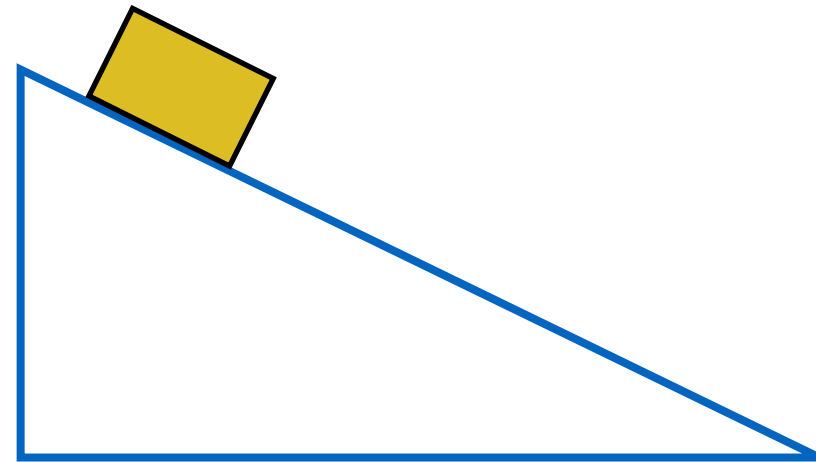
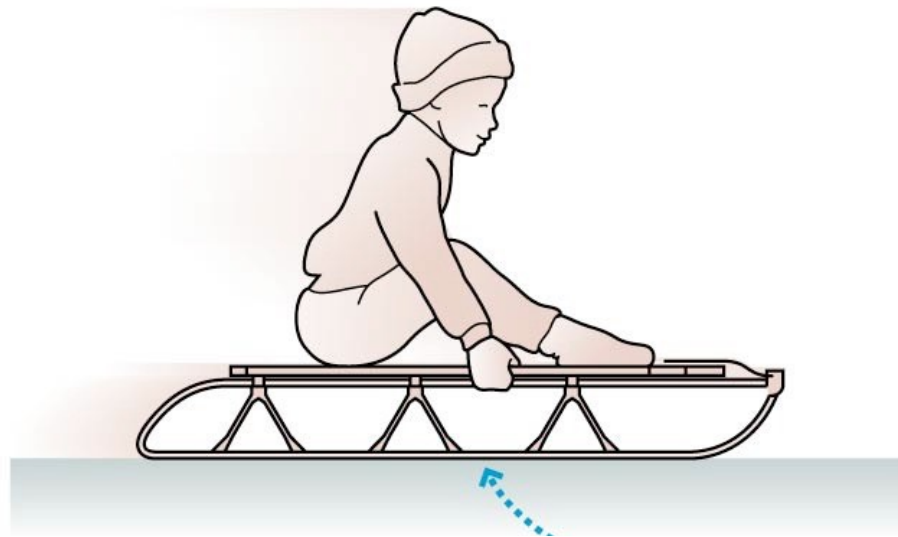
Examples of Normal Forces



Which direction does the normal force point?



Kinetic Friction



Which way does friction point?

Quiz

A bobsledder pushes her sled across horizontal snow to get it going, then jumps in. After she jumps in, the sled gradually slows to a halt. What forces act on the sled just after she's jumped in?

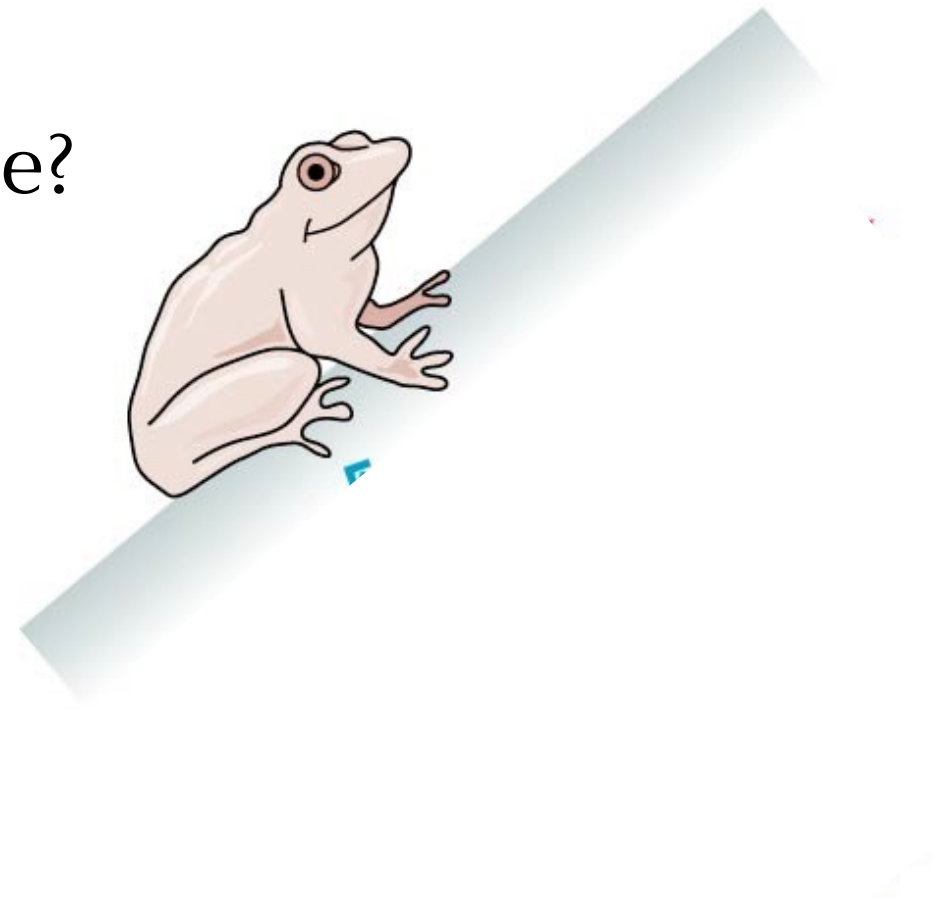
- a) Gravity and kinetic friction.
- b) Gravity and a normal force.
- c) Gravity and the force of the push.
- d) Gravity, a normal force, and kinetic friction.
- e) Gravity, a normal force, kinetic friction, and the force of the push.

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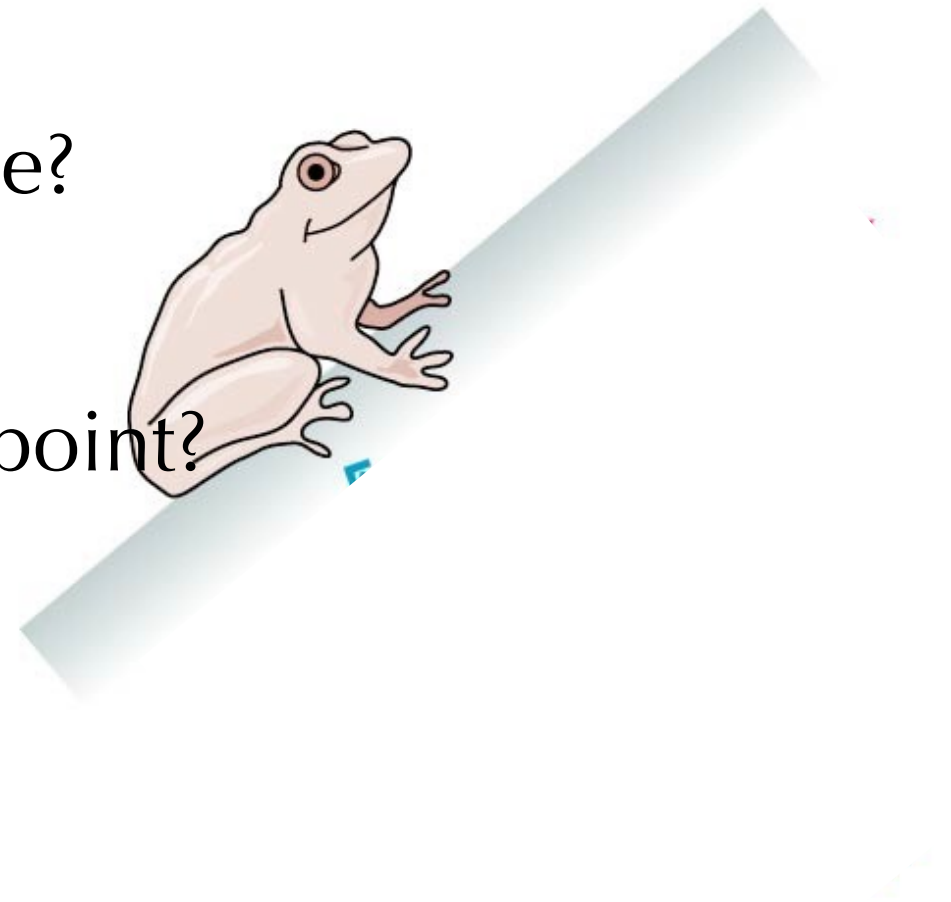
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Why doesn't this frog fall down the incline?



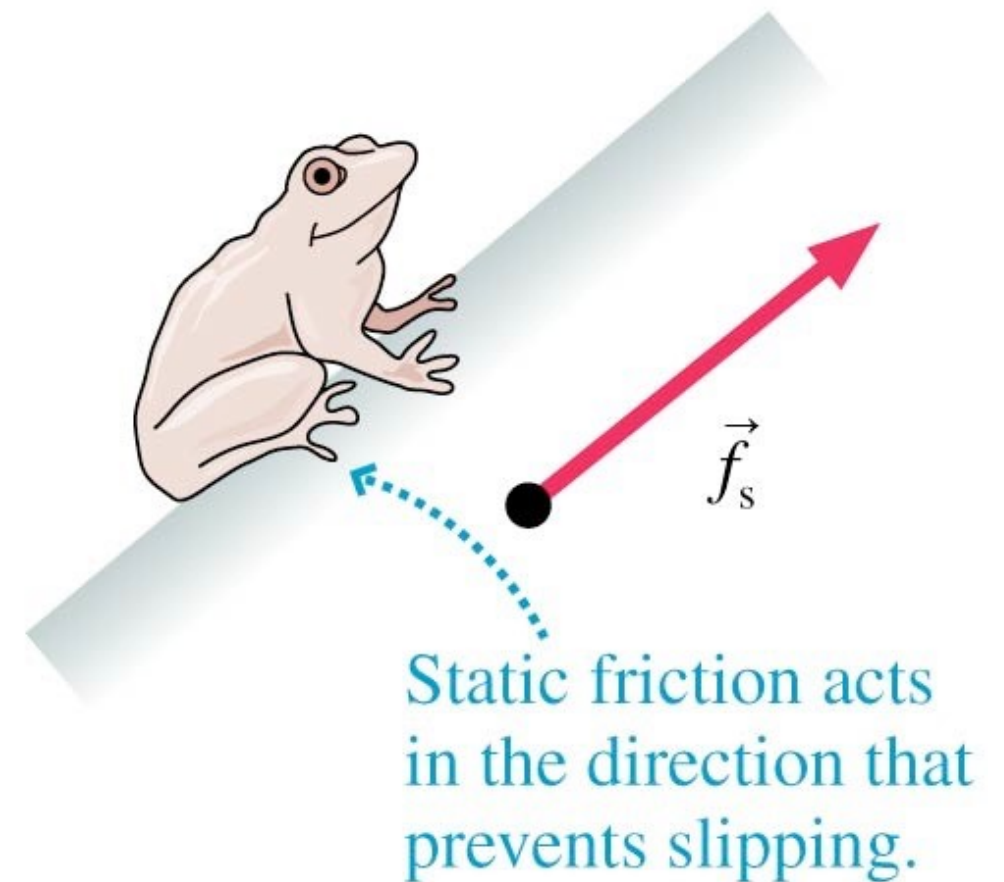
Why doesn't this frog fall down the incline?

Which direction does the frictional force point?



Static Friction

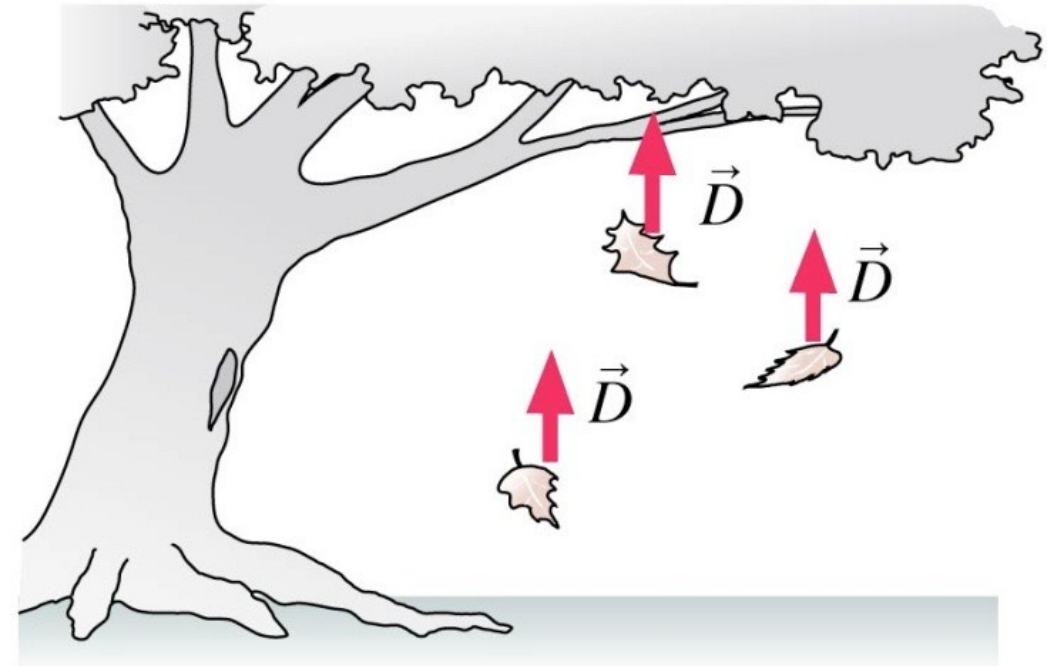
- **Static friction** is the contact force that keeps an object “stuck” on a surface, and prevents relative motion.
- The static friction force is directed *tangent* to the surface.
- Static friction points opposite the direction in which the object *would* move if there were no static friction.



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.**

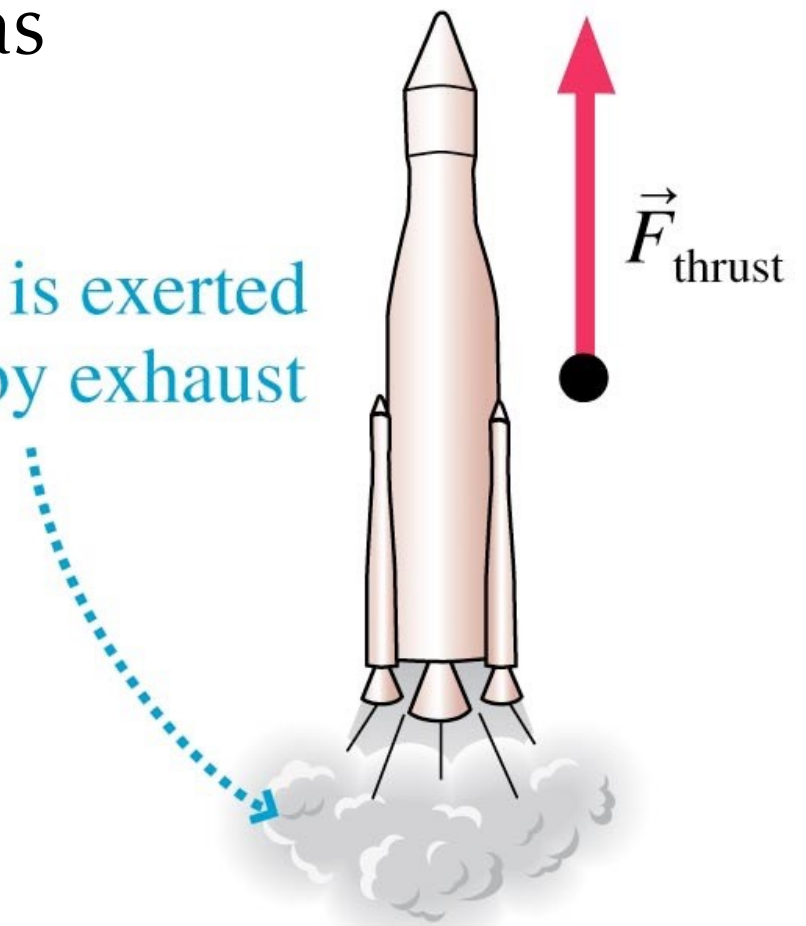
Air resistance is a significant force on falling leaves. It points opposite the direction of motion.



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.

Thrust force is exerted on a rocket by exhaust gases.

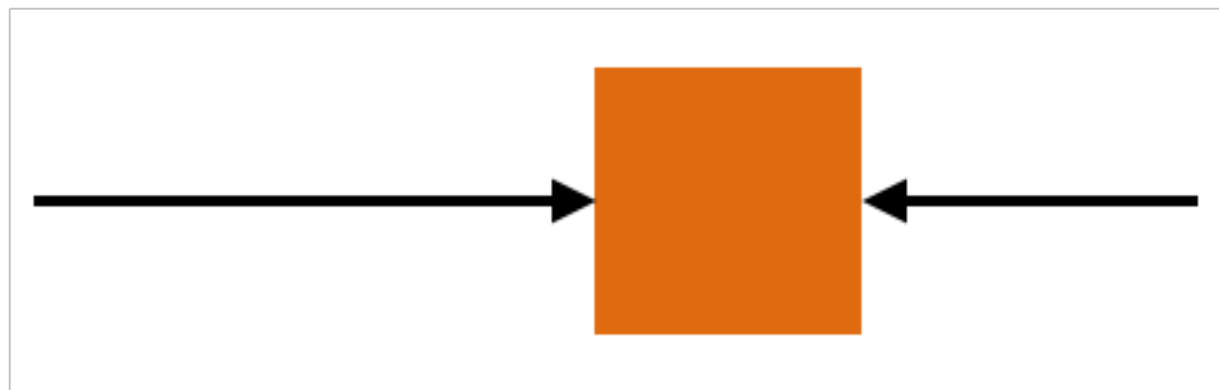
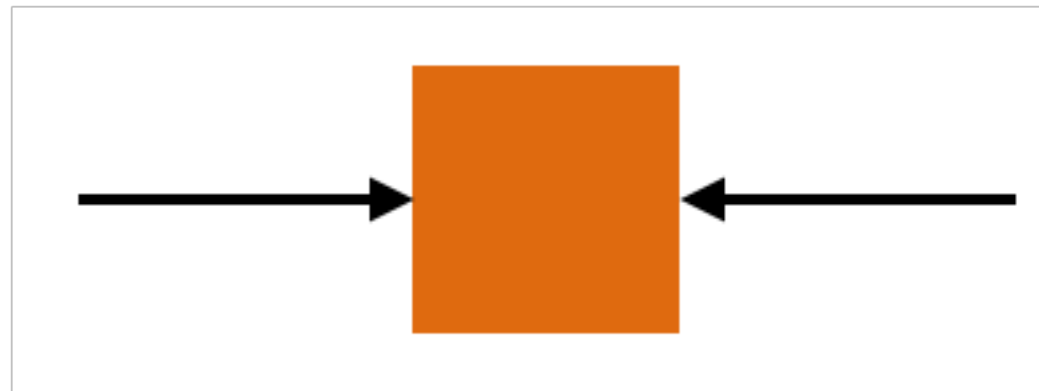


Symbols for forces

Force	Notation
General force	\vec{F}
Gravitational force	\vec{F}_G
Spring force	\vec{F}_{sp}
Tension	\vec{T}
Normal force	\vec{n}
Static friction	\vec{f}_s
Kinetic friction	\vec{f}_k
Drag	\vec{D}
Thrust	\vec{F}_{thrust}

Use Newton's 1st law to explain?

Use Newton's 2nd law to explain?



Newton's First Law

What is it?

Newton's First Law

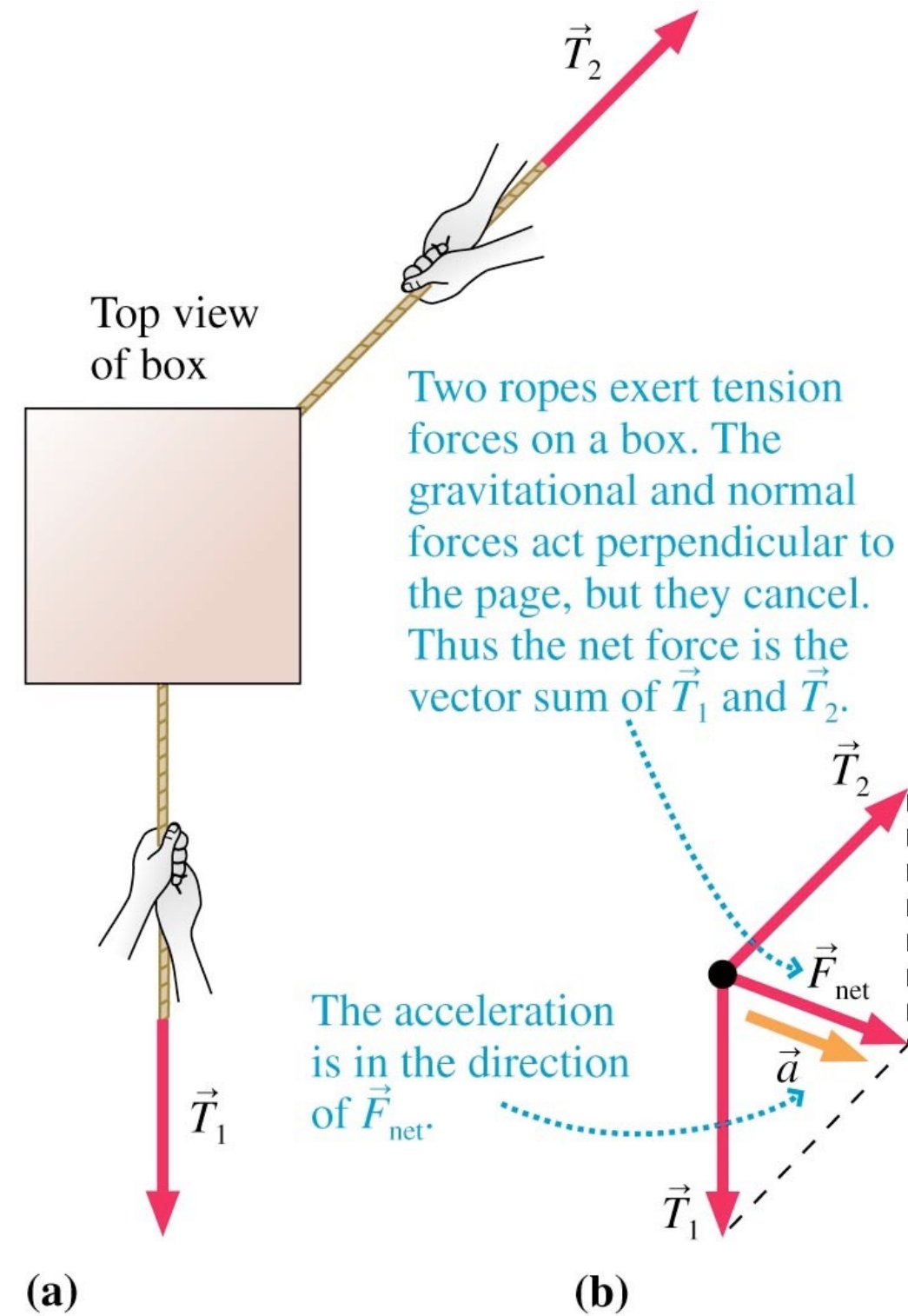
What is it?

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*.

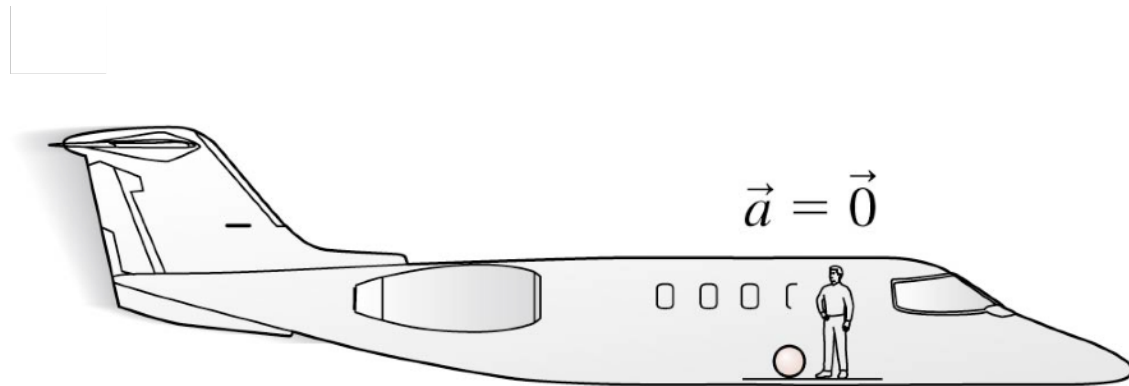
Newton's Second Law

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

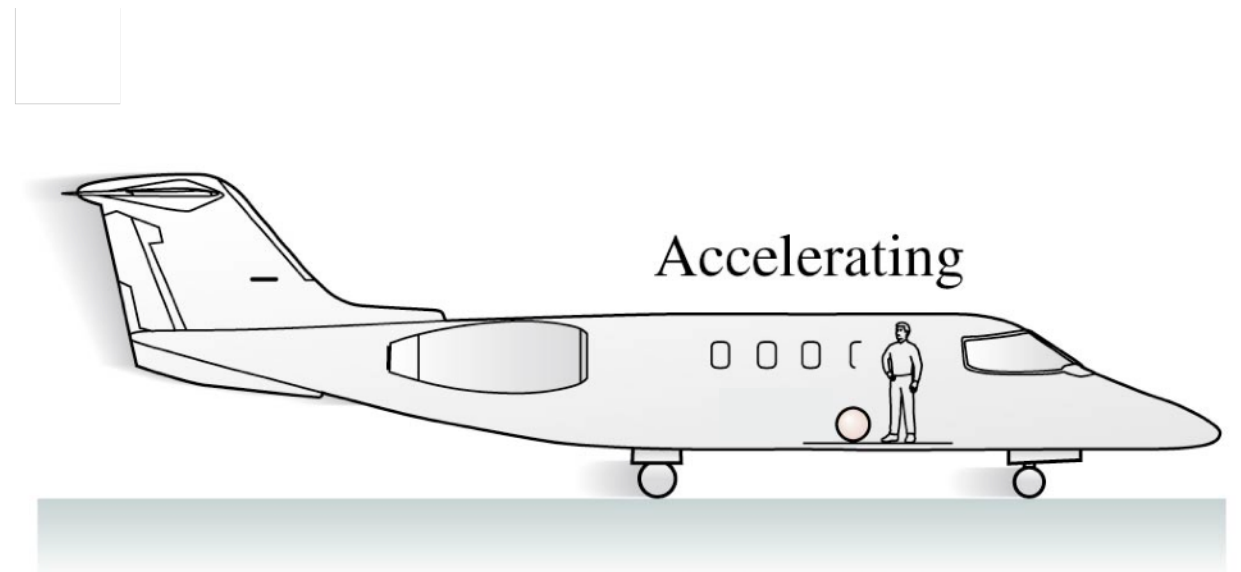


Inertial Reference Frames

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

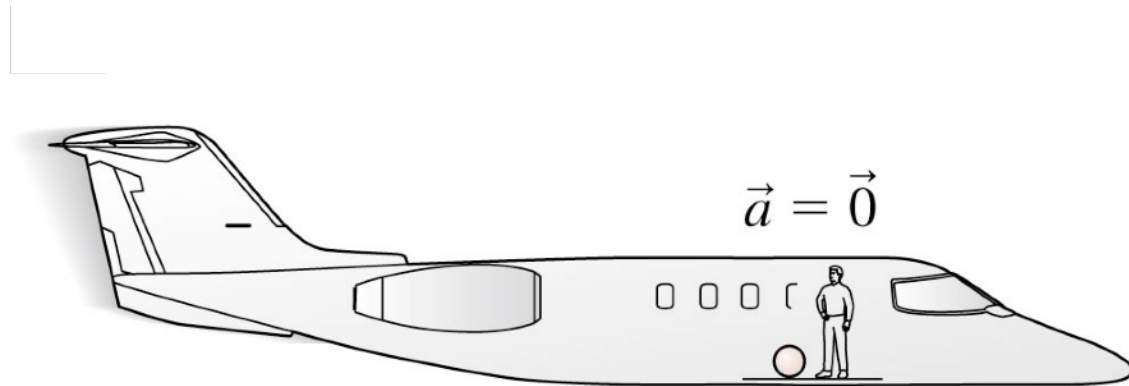


Describe the motion of the ball when the plane is accelerating.

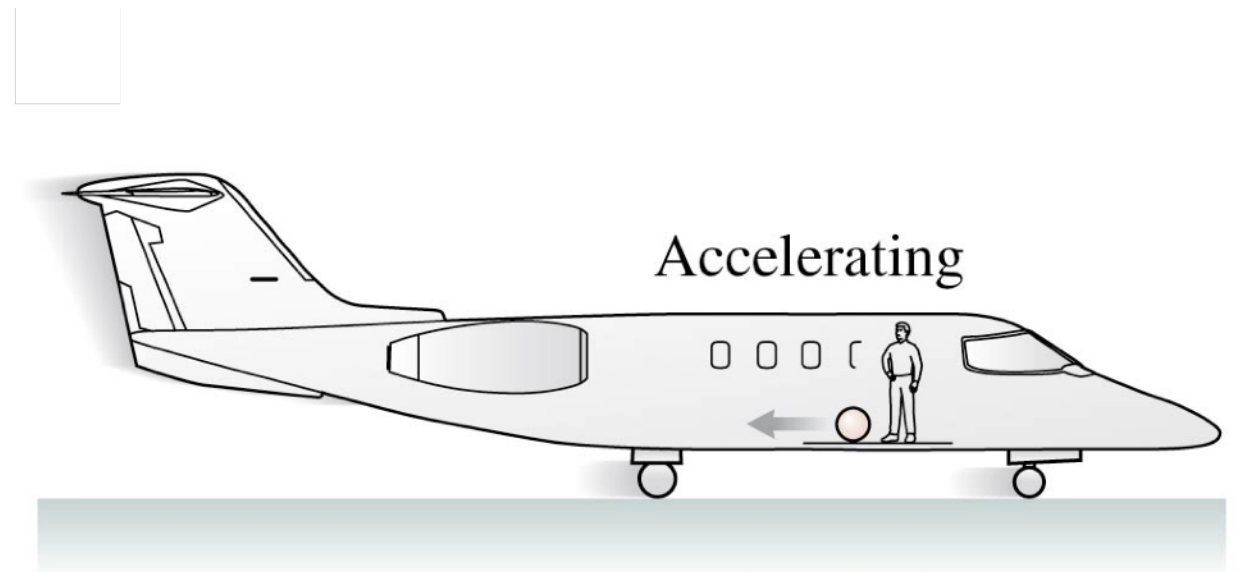


Inertial Reference Frames

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.



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.



Example

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

