Physics 121: Force

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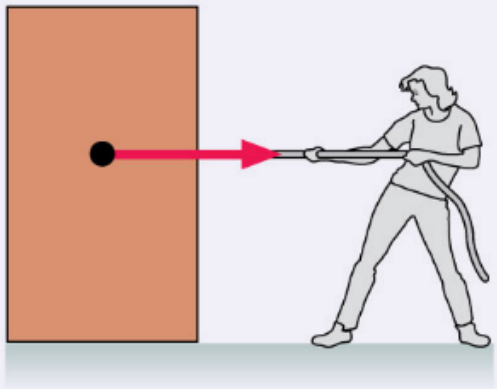
Reminder

- Go over the test
- Next HW is due next Thursday (28th of September). Covers chapter 5 on Forces.

What is a force?

The fundamental concept of **mechanics** is force.

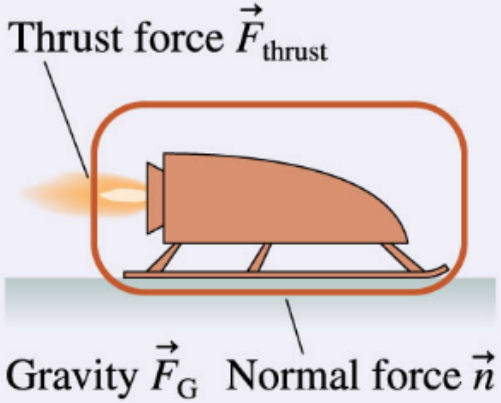
- A force is a push or a pull.
- A force acts on an object.
- A force requires an agent.
- A force is a vector.



How do we identify forces?

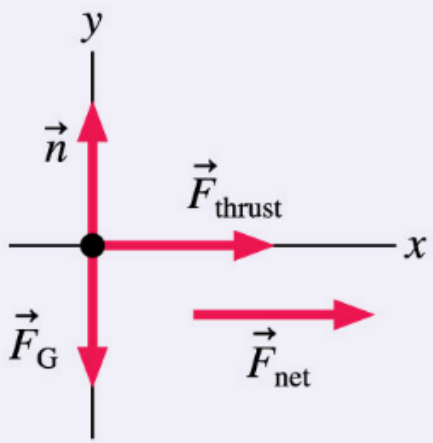
A force can be a contact force or a long-range force.

- Contact forces occur at points where the environment touches the object.
- Contact forces disappear the instant contact is lost. Forces have no memory.
- Long-range forces include gravity and magnetism.



How do we show forces?

Forces can be displayed on a free-body diagram. You'll draw all forces—both pushes and pulls—as vectors with their tails on the particle. A well-drawn free-body diagram is an essential step in solving problems, as you'll see in the next chapter.



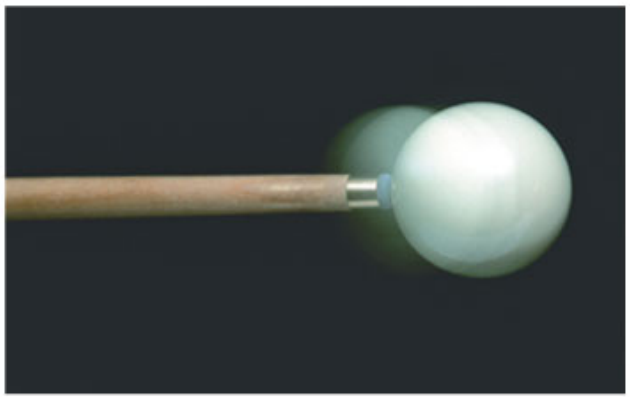
Force

- A force is a *push* or *pull*.

- A force acts on an **object**, the thing that pushed and pulls act on.
- The object has a force *exerted* on it. The boxer exerted a force on the punching bag.

Force

- A force is exerted on something by an **agent**.
- If you throw or kick an object your hand or foot is the agent exerting the force on the object.



- A force is a vector (all vector rules we have learned apply).
- To quantify the force (push or pull) you need both magnitude and direction.

Force

- Forces come in two types. The first type is a **contact force**.
- Contact forces need to touch a object to exert a force on it.

- The second type is a **long-range force** in which the agent doesn't tough the object. Examples?

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- The second type is a **long-range force** in which the agent doesn't tough the object. Examples?
- Gravity or magnetism are examples of long-range forces.

Force

- How do you think we represent forces visually?

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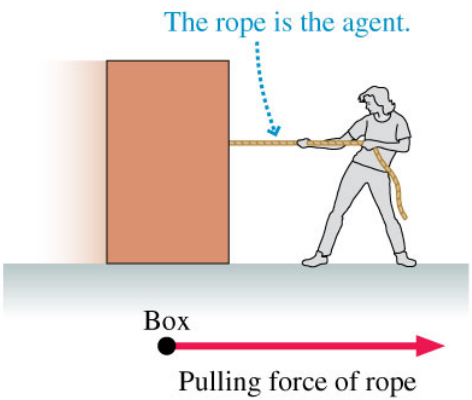

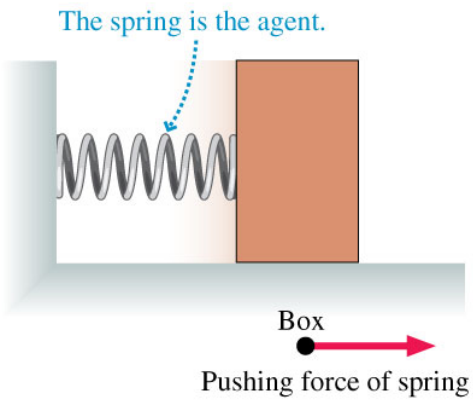

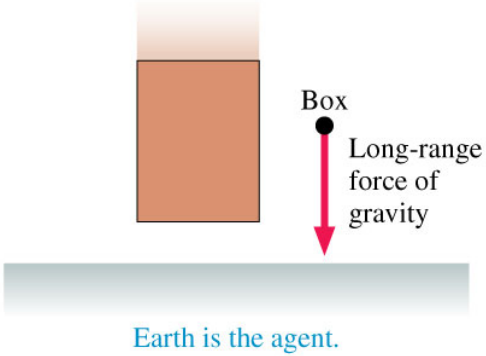

Force

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- There is a force on me from the ground. These two forces must cancel out. Thus you must be able to add forces to come up with a *resulting force*.
- The resulting force is called the **net force**.

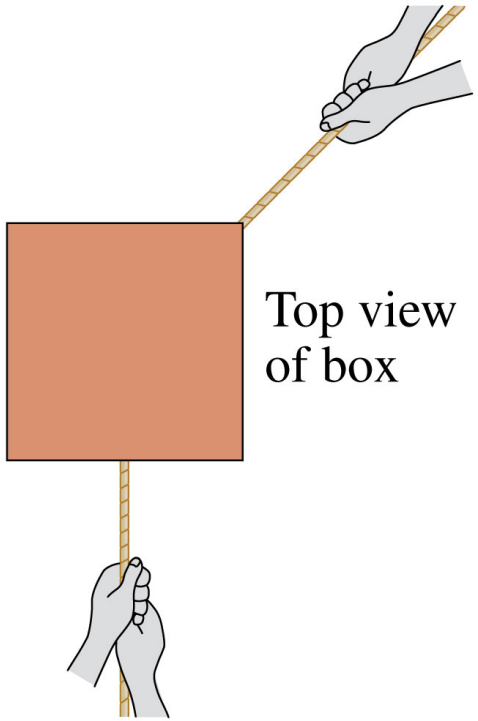
$$\vec{F}_{net} \equiv \sum_{i=1}^{N} \vec{F}_i = \vec{F}_1 + \vec{F}_2 + \ldots + \vec{F}_N$$

NOTICE THAT THIS IS VECTOR ADDITION.

Quick Check

There are two forces pulling on this box. Draw the force vectors on the box to find the net force on the box. Assume the forces are the same magnitude.

(a)



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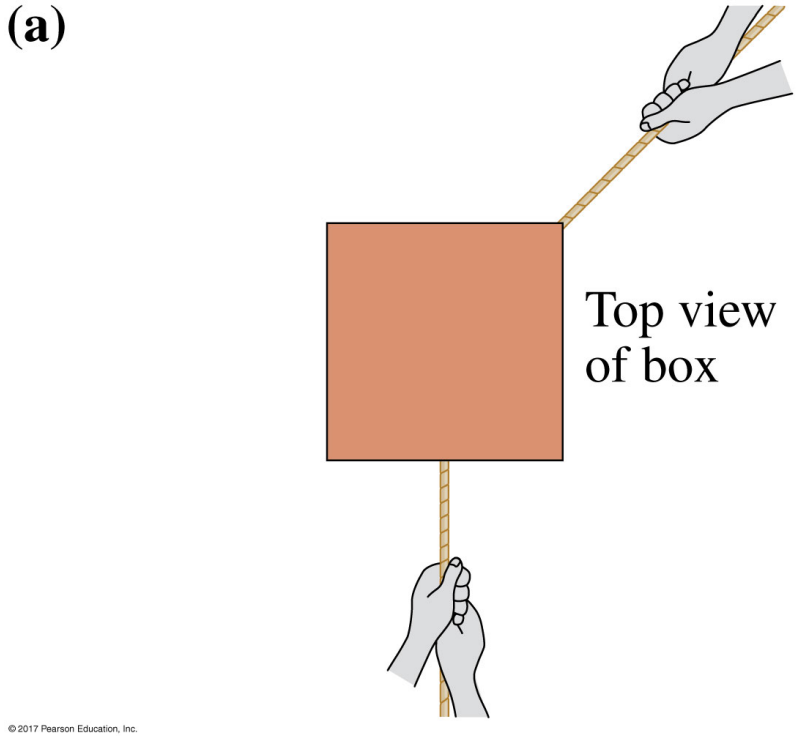
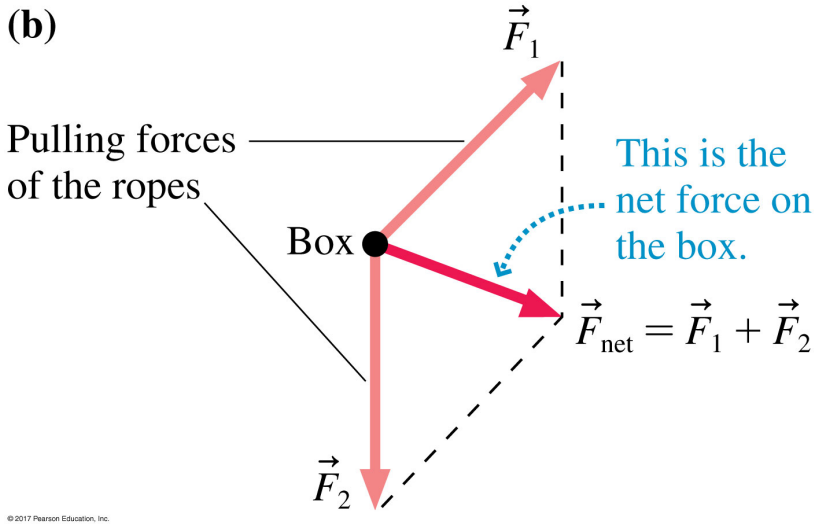
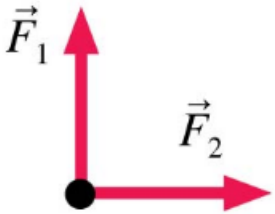
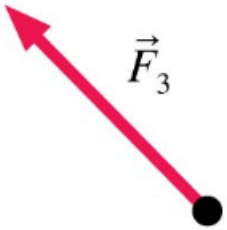




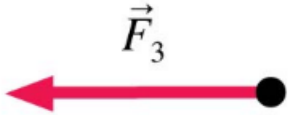
The net force on an object points to the left. Two of three forces are shown. Which is the missing third force?



Two of the three forces exerted on an object



A.



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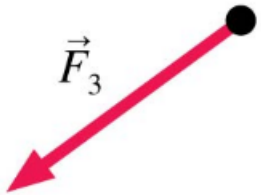
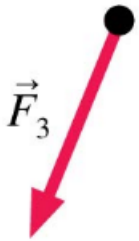


C.



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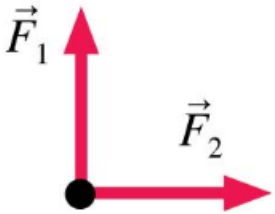

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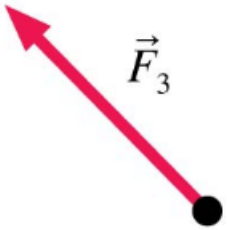

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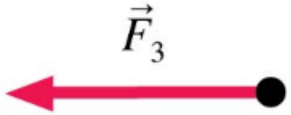

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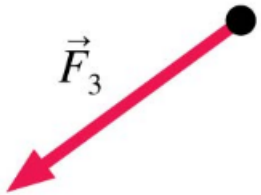
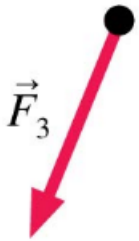


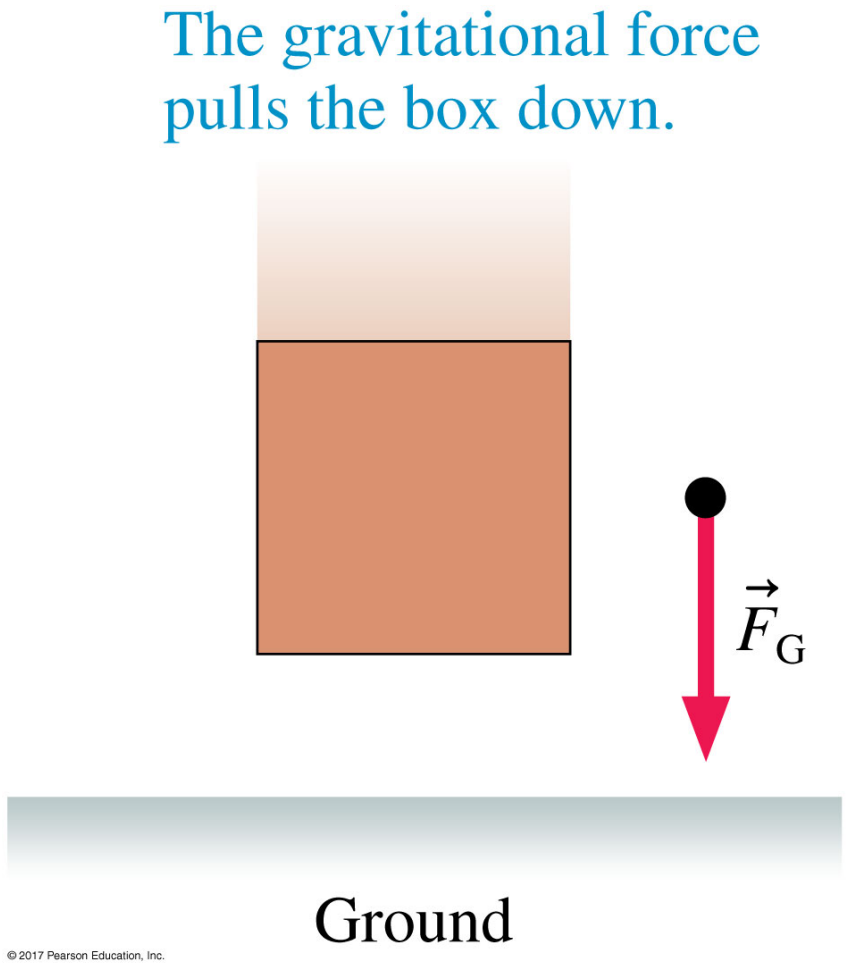
C. ✓



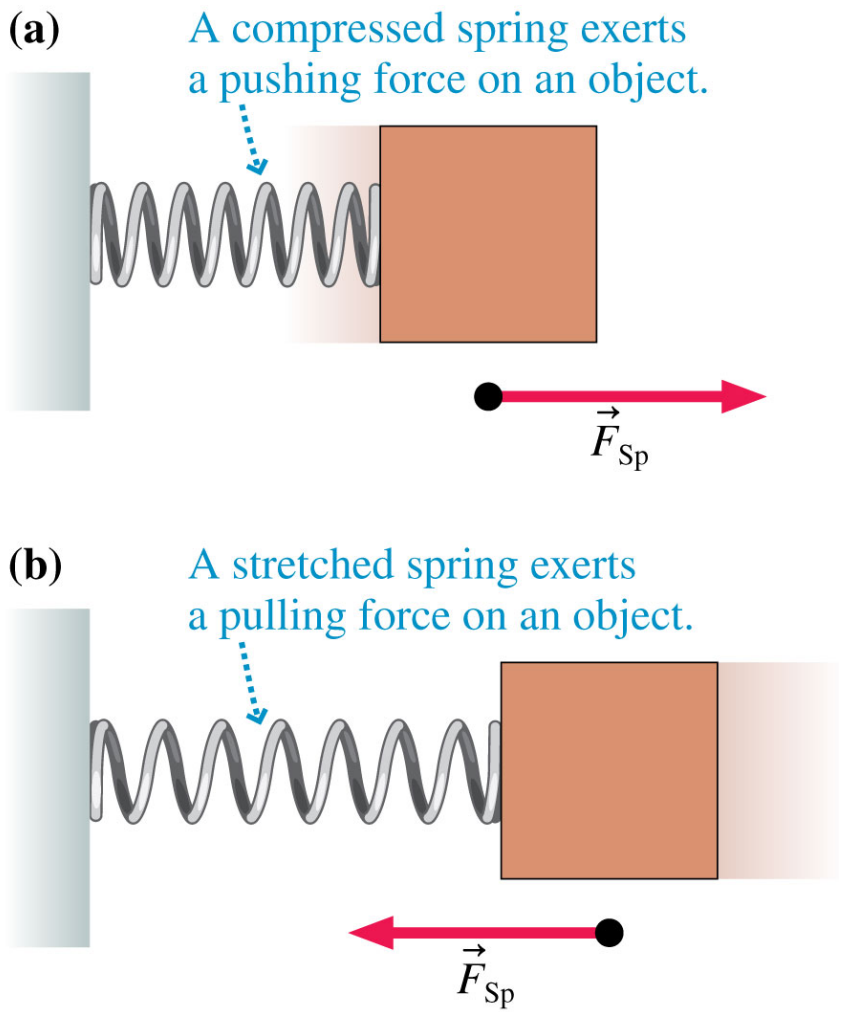
D.

Types 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.



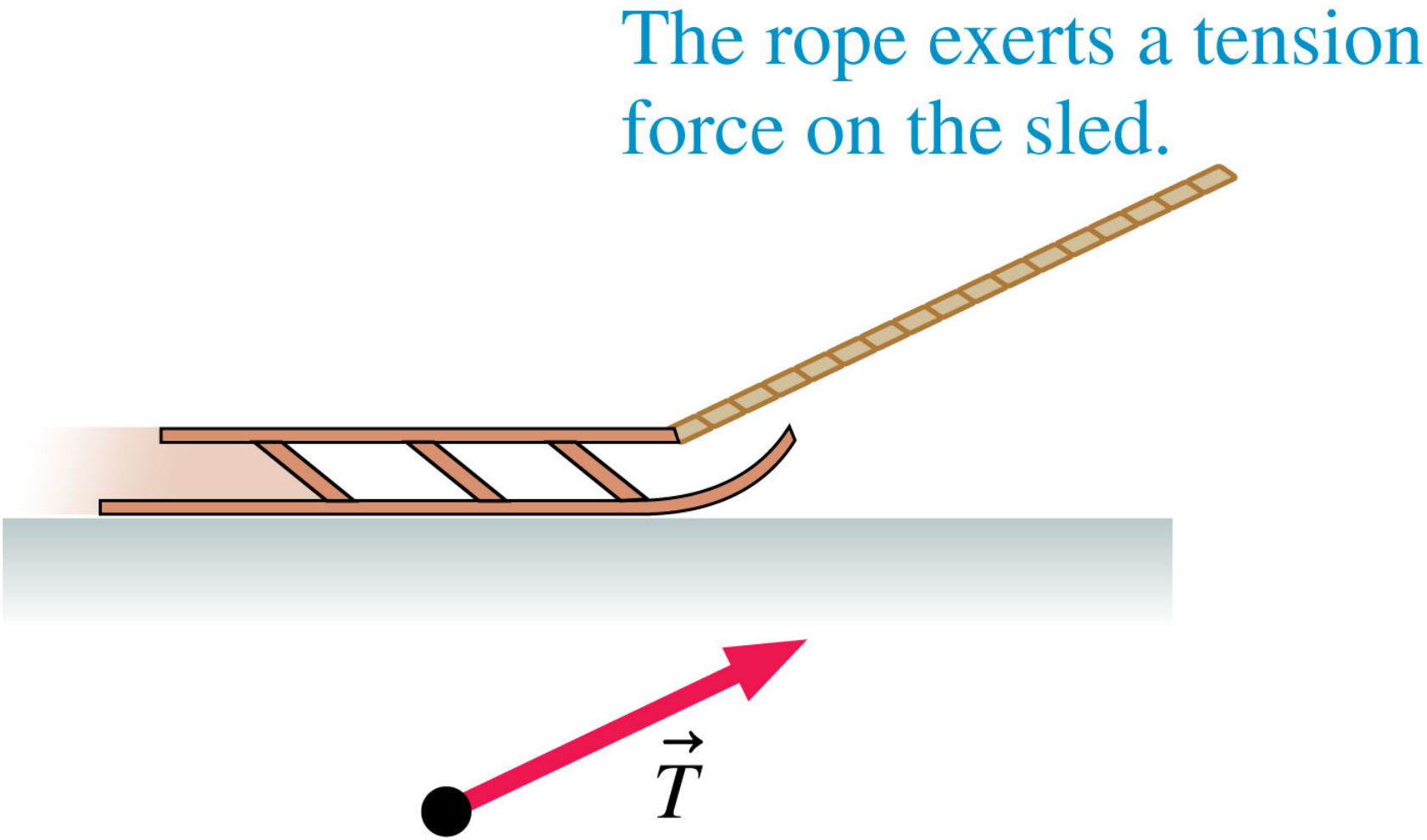
Types of Forces - Spring Force



- 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**.

Types of Forces - Tension

- 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.



Types of Forces

What exactly is happening when you pull on a rope attached to an object? How does the force you exert transfer through the rope?

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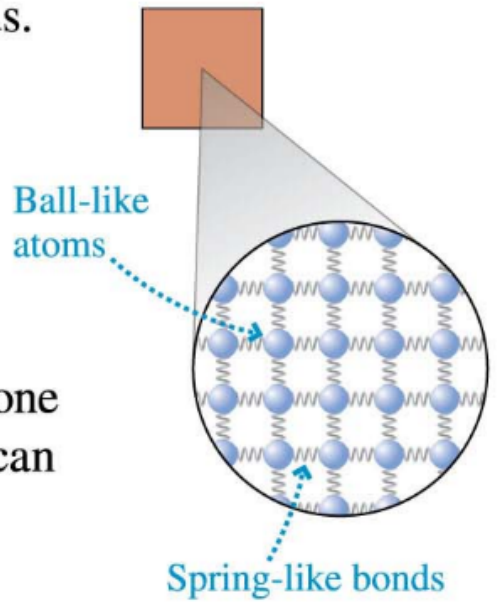
MODEL 5.1

Ball-and-spring model of solids

Solids consist of atoms held together by molecular bonds.

- Represent the solid as **an array of balls connected by springs.**
- Pulling on or pushing on a solid causes the bonds to be stretched or compressed. **Stretched or compressed bonds exert spring forces.**
- There are an immense number of bonds. The force of one bond is very tiny, but the combined force of all bonds can be very large.
- Limitations: Model fails for liquids and gases.



Quick Check

A steel beam hangs from a cable as a crane lifts the beam. What forces act on the beam?

A. Gravity.
B. Gravity and tension in the cable.
C. Gravity and a force of motion.
D. Gravity and tension and a force of motion.

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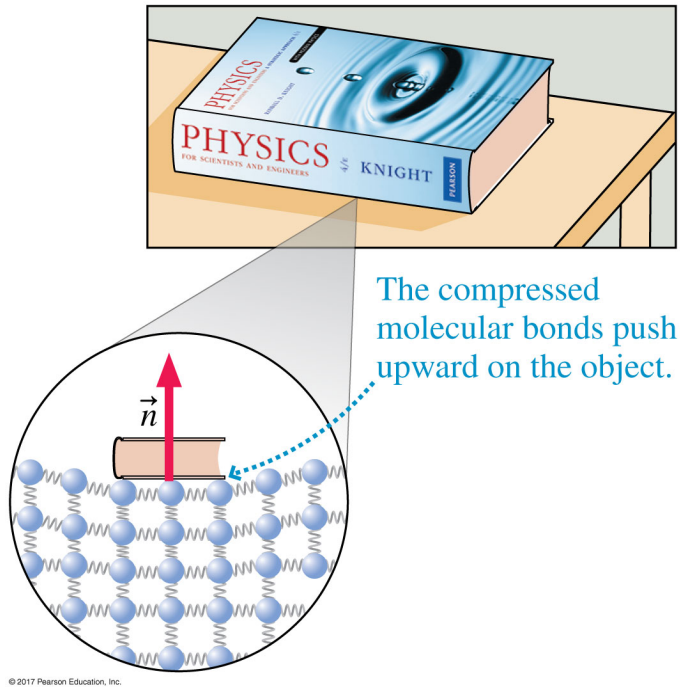
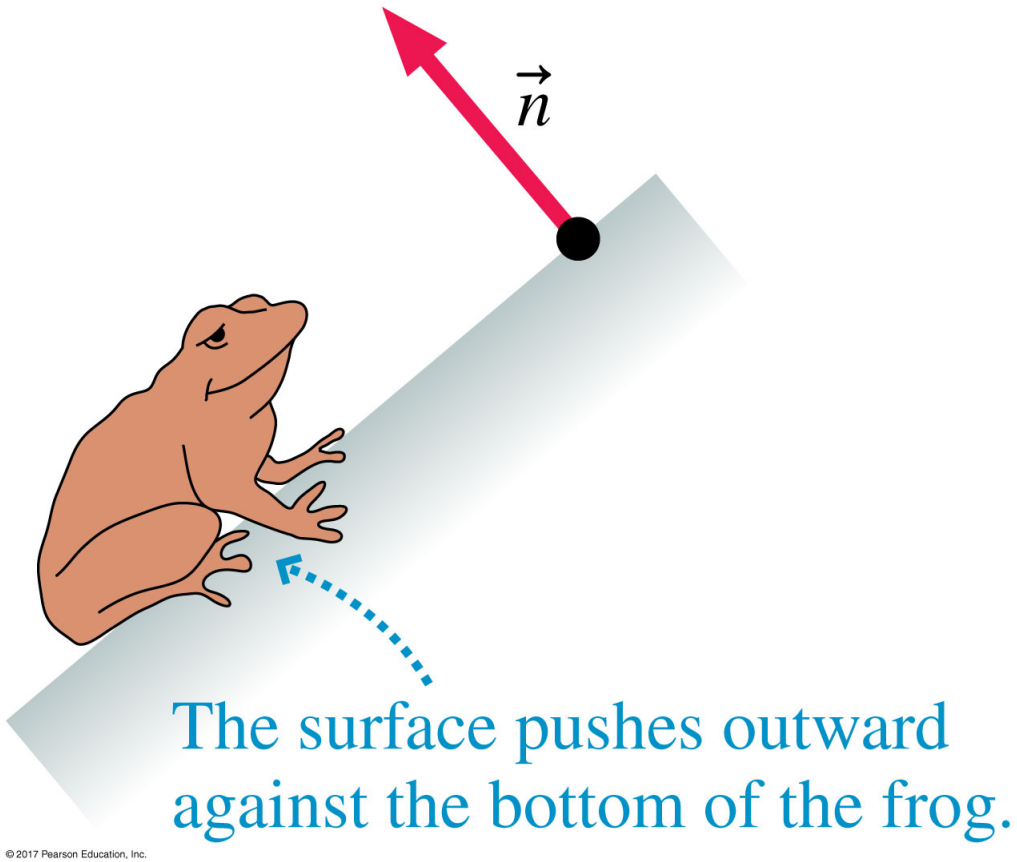
Types of Forces - Normal Force

- 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.



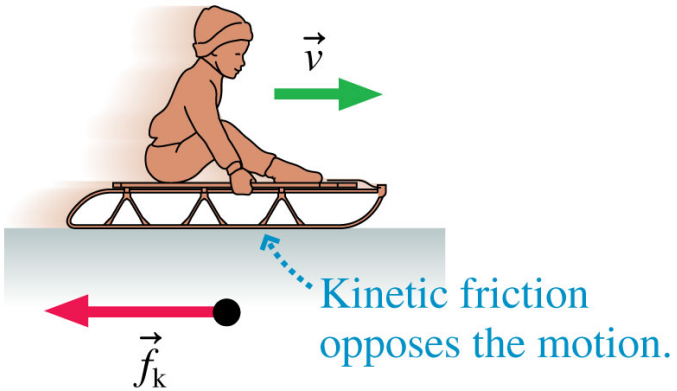
Types of Forces - Normal Force

- The normal force is perpendicular to the surface regardless the angle it makes with the object.
- Suppose a frog sits on an inclined surface. The surface exerts a tilted normal force on the frog.



Types of Forces - Kinetic Friction

- When an object slides along a surface, the surface can exert a contact force which opposes the motion.
- This is called sliding friction or **kinetic friction**.
- The kinetic friction force is directed *tangent to the surface*, and *opposite to the velocity* of the object relative to the surface.



Quick Check

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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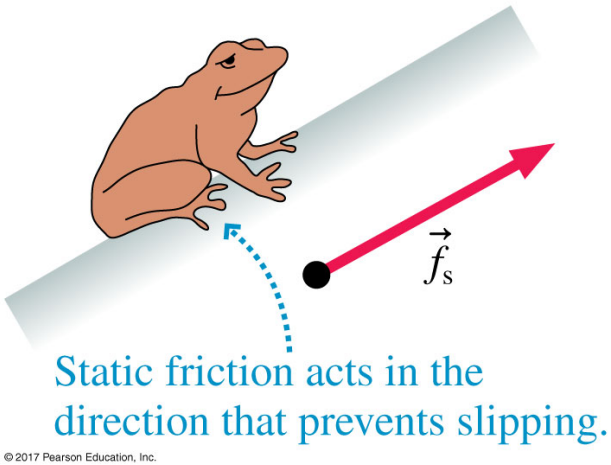
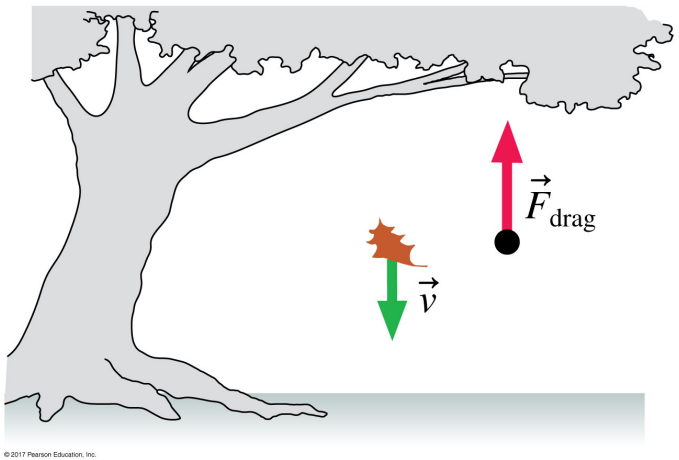
Types of Forces - Static Friction

- **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.



Types of Forces - Drag

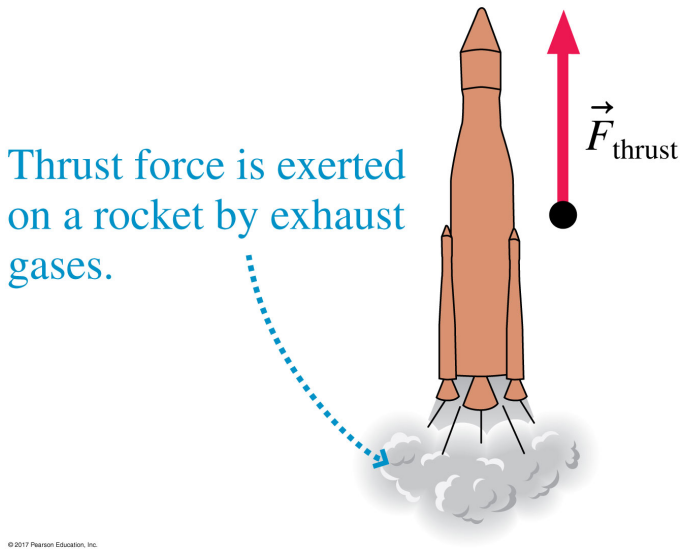
Air resistance points opposite the direction of motion.



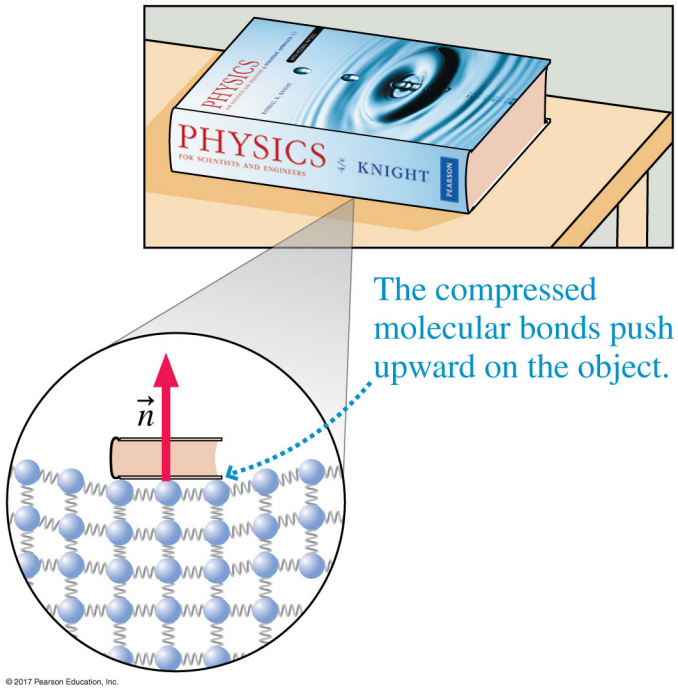
- Kinetic friction is a resistive force, which opposes or resists motion.
- Resistive forces are also experienced by objects moving through fluids.
- The resistive force of a fluid is called **drag**.
- Drag points opposite the direction of motion.
- For heavy and compact objects in air, drag force is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

Types of Forces - 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 (We'll talk more about this in the future).
- The direction of thrust is opposite the direction in which the exhaust gas is expelled.



Types of Forces - Electric and Magnetic



- Electric and Magnetic forces exert long-range forces (like gravity).
- We aren't going to study these forces in the class, but you will in physics II.
- Bonds between particles in materials are due to these forces and thus the normal force, friction are really a types of electric and magnetic forces.

Types of 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	$\vec{F}_{\mathrm{drag}}$
Thrust	$\vec{F}_{\mathrm{thrust}}$

Identifying Forces

TACTICS BOX 5.2

Identifying forces

1. **Identify the object of interest.** This is the object you wish to study.
2. **Draw a picture of the situation.** Show the object of interest and all other objects—such as ropes, springs, or surfaces—that touch it.
3. **Draw a closed curve around the object.** Only the object of interest is inside the curve; everything else is outside.
4. **Locate every point on the boundary of this curve where other objects touch the object of interest.** These are the points where *contact forces* are exerted on the object.
5. **Name and label each contact force acting on the object.** There is at least one force at each point of contact; there may be more than one. When necessary, use subscripts to distinguish forces of the same type.
6. **Name and label each long-range force acting on the object.** For now, the only long-range force is the gravitational force.

Exercises 3–8

Identifying Forces

EXAMPLE 5.1 | **Forces on a bungee jumper**

A bungee jumper has leapt off a bridge and is nearing the bottom of her fall. What forces are being exerted on the jumper?

VISUALIZE

Identifying Forces

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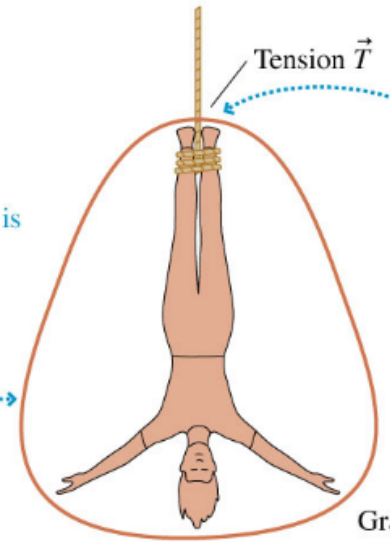

1. Identify the object of interest. Here the object is the bungee jumper.
2. Draw a picture of the situation.
3. Draw a closed curve around the object.
4. Locate the points where other objects touch the object of interest. Here the only point of contact is where the cord attaches to her ankles.
5. Name and label each contact force. The force exerted by the cord is a tension force.
6. Name and label long-range forces. Gravity is the only one.

Identifying Forces

EXAMPLE 5.2 | **Forces on a skier**

A skier is being towed up a snow-covered hill by a tow rope. What forces are being exerted on the skier?

VISUALIZE

Identifying Forces

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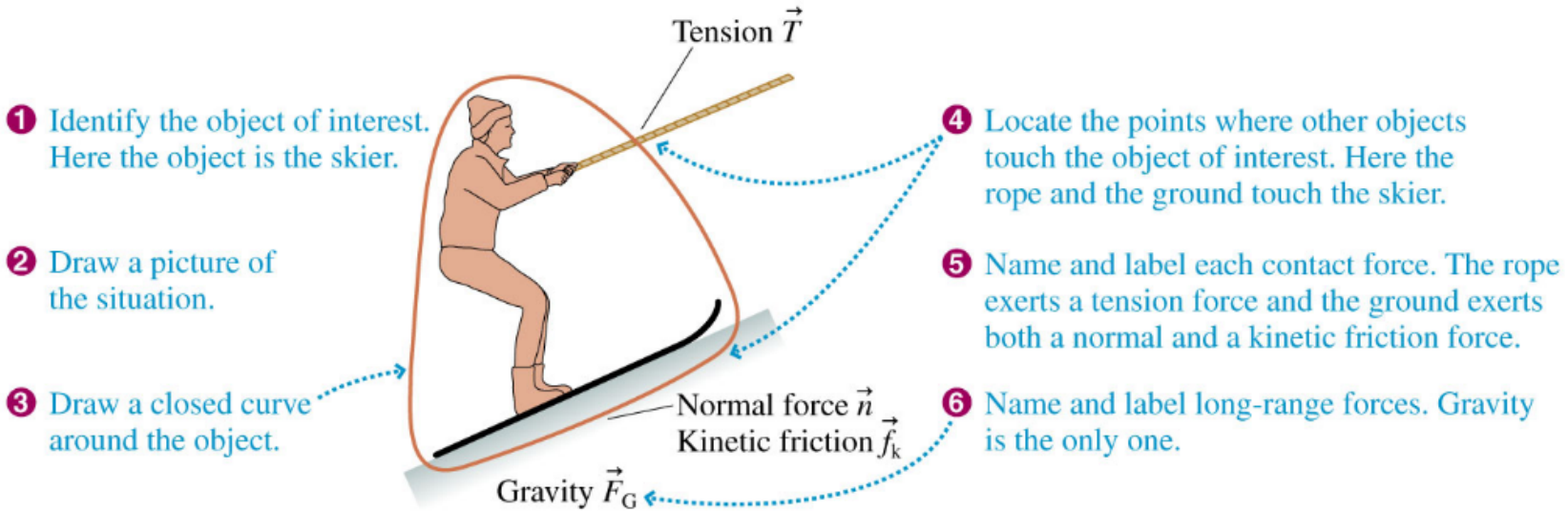

Identifying Forces

EXAMPLE 5.3 | **Forces on a rocket**

A rocket is being launched to place a new satellite in orbit. Air resistance is not negligible. What forces are being exerted on the rocket?

VISUALIZE This drawing is much more like the sketch you would make when identifying forces as part of solving a problem.

Identifying Forces

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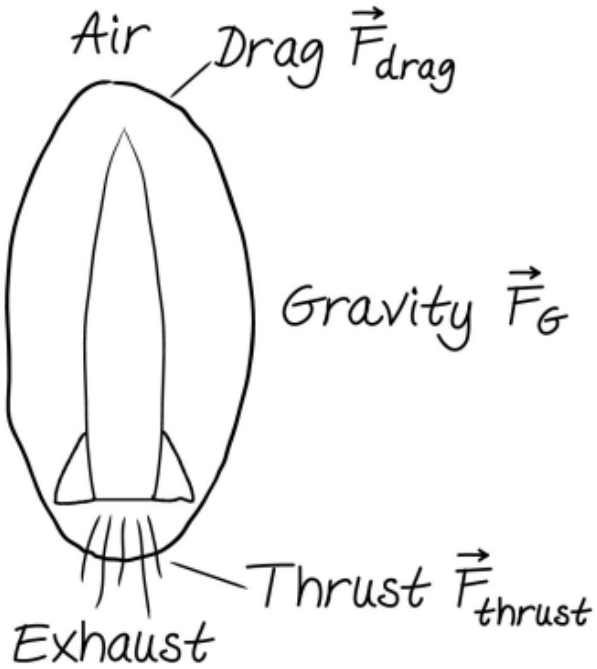

Picture References

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