Question #32

A mosquito runs head-on into a truck. Splat! Which is true during the collision?

A. The mosquito exerts more force on the truck than the truck exerts on the mosquito.
B. The mosquito exerts the same force on the truck as the truck exerts on the mosquito.
C. The truck exerts more force on the mosquito than the mosquito exerts on the truck.
D. The truck exerts a force on the mosquito but the mosquito does not exert a force on the truck.
E. The mosquito exerts a force on the truck but the truck does not exert a force on the mosquito.

Quiz

A mosquito runs head-on into a truck. Splat! Which is true during the collision?

A. The mosquito exerts more force on the truck than the truck exerts on the mosquito.

B. The mosquito exerts the same force on the truck as the truck exerts on the mosquito.

C. The truck exerts more force on the mosquito than the mosquito exerts on the truck.

D. The truck exerts a force on the mosquito but the mosquito does not exert a force on the truck.

E. The mosquito exerts a force on the truck but the truck does not exert a force on the mosquito.

First Law

Second Law

Third Law

Question #33

a) Faster cart feels more force
b) .
c) Slower cart feels more force.
d) Both experience same force.

First Law

Second Law

Third Law

Question #33

a) Faster cart feels more force
b) .
c) Slower cart feels more force.
d) Both experience same force.

Question #34

a) Heavier cart feels more force
b) Both experience same force.
c) Lighter cart feels more force.

First Law

Second Law

Third Law

Question #33

a) Faster cart feels more force
b) .
c) Slower cart feels more force.
d) Both experience same force.

Question #34

a) Heavier cart feels more force
b) Both experience same force.
c) Lighter cart feels more force.

Question #35

a) Heavier cart in motion feels more force
b) Lighter cart at rest feels more force.
c) Both experience same force.

First Law

Second Law

Third Law

Question #36

A mosquito runs head-on into a truck. Which is true during the collision?

A. The truck accelerates but the mosquito does not.
B. The magnitude of the mosquito's acceleration is larger than that of the truck.
C. The magnitude of the mosquito's acceleration is the same as that of the truck.
D. The magnitude of the truck's acceleration is larger than that of the mosquito.
E. The mosquito accelerates but the truck does not.

Quiz

A mosquito runs head-on into a truck. Which is true during the collision?

A. The truck accelerates but the mosquito does not.
B. The magnitude of the mosquito's acceleration is larger than that of the truck.
C. The magnitude of the mosquito's acceleration is the same as that of the truck.
D. The magnitude of the truck's acceleration is larger than that of the mosquito.
E. The mosquito accelerates but the truck does not.

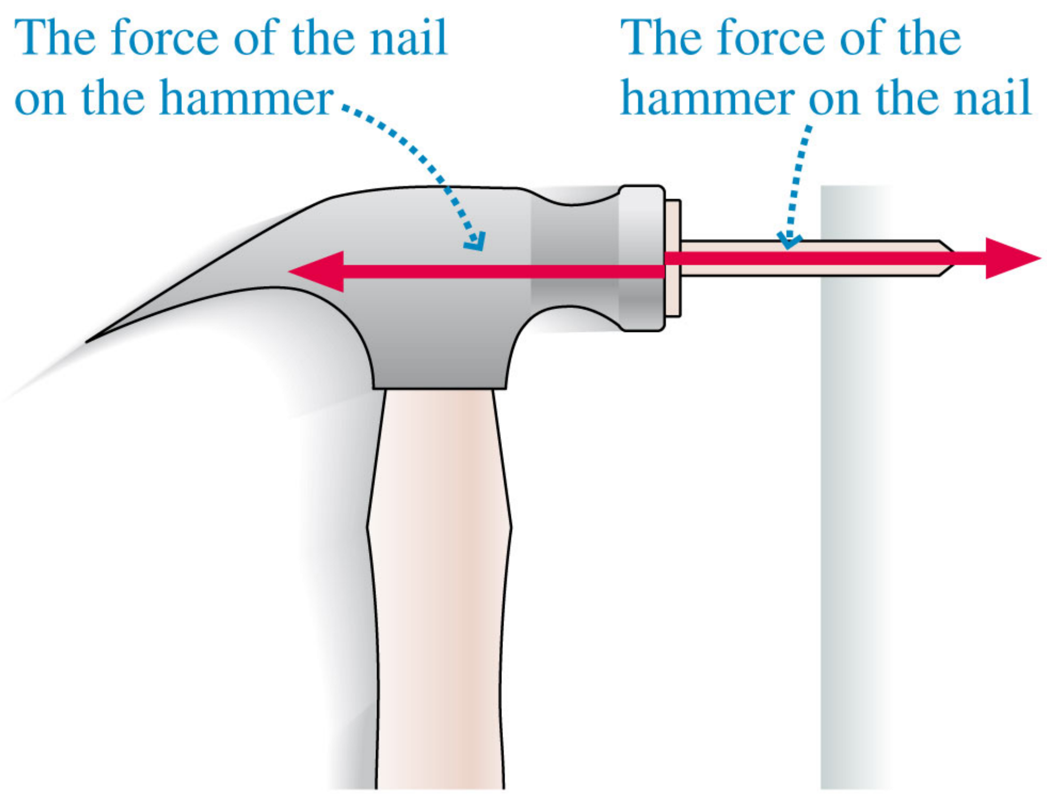
Same for both

$$a = \frac{F}{m}$$

Huge difference

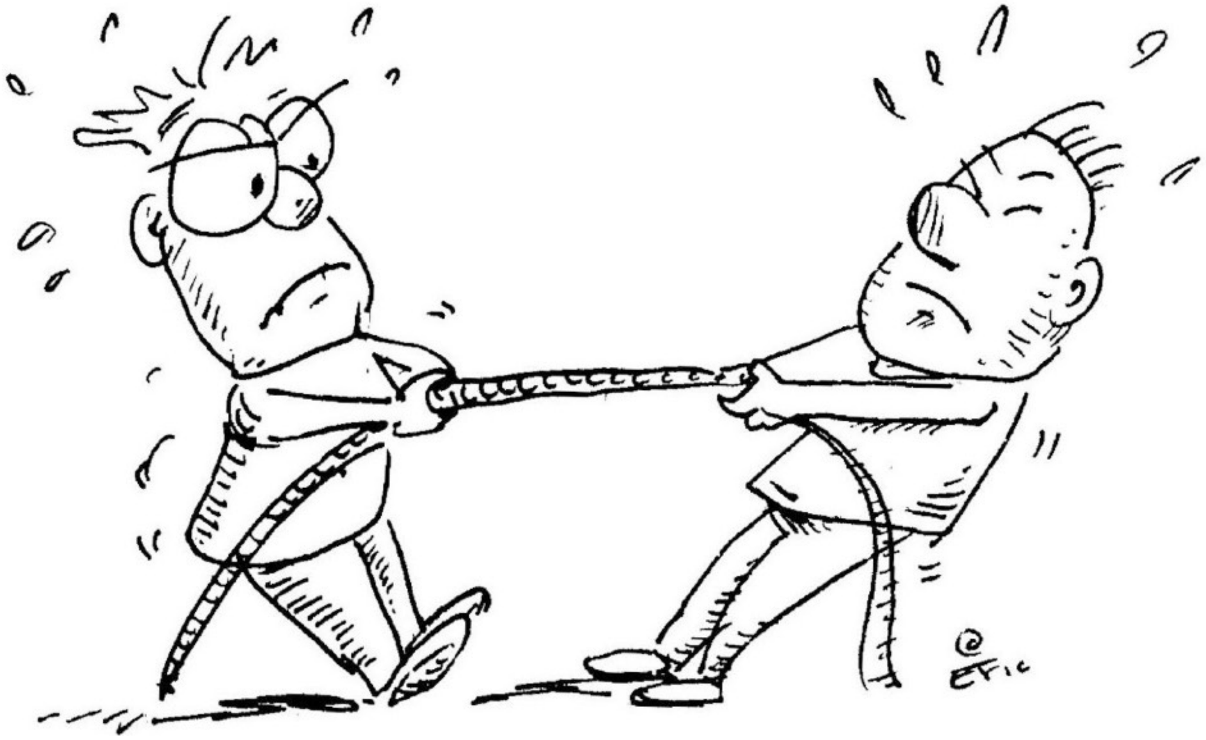
Don't confuse cause and effect! The same force can have very different effects.

Interacting objects



- When a hammer hits a nail, it exerts a forward force on the nail
- At the same time, the nail exerts a backward force on the hammer.

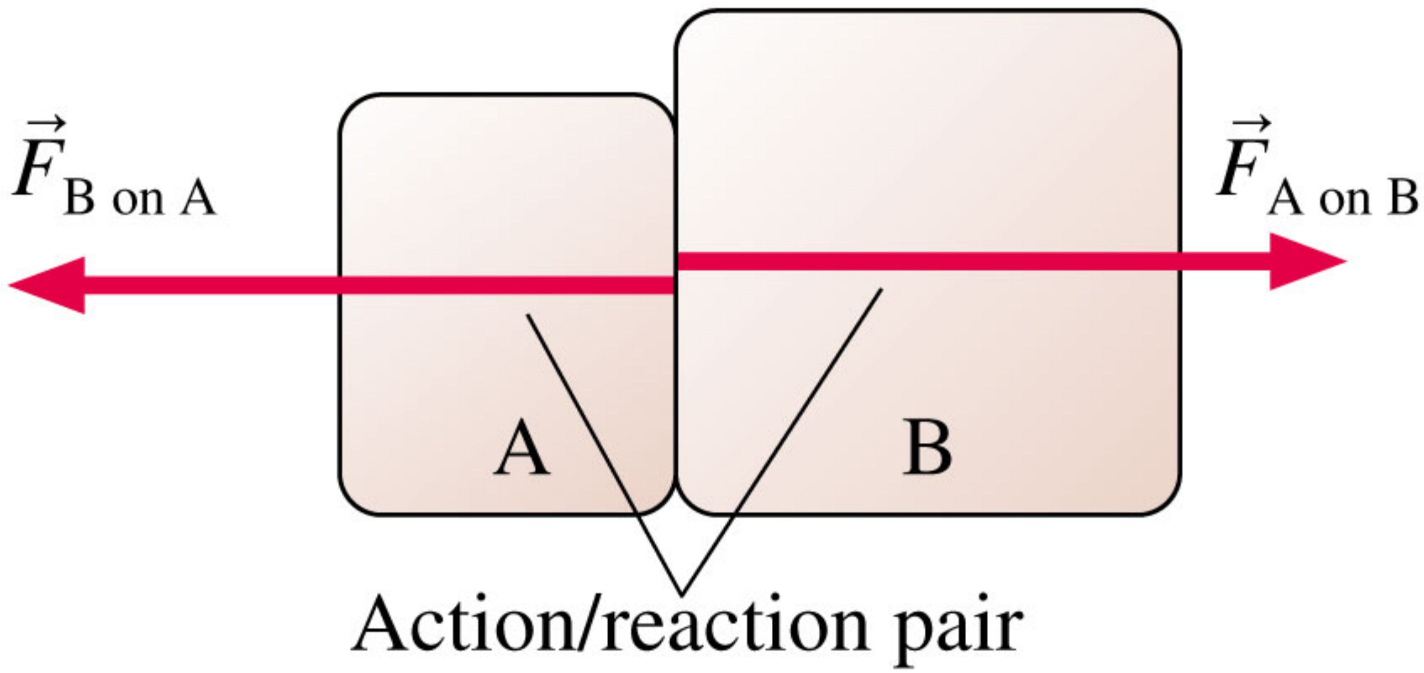
Interacting objects



Action/Reaction pairs

Interacting objects

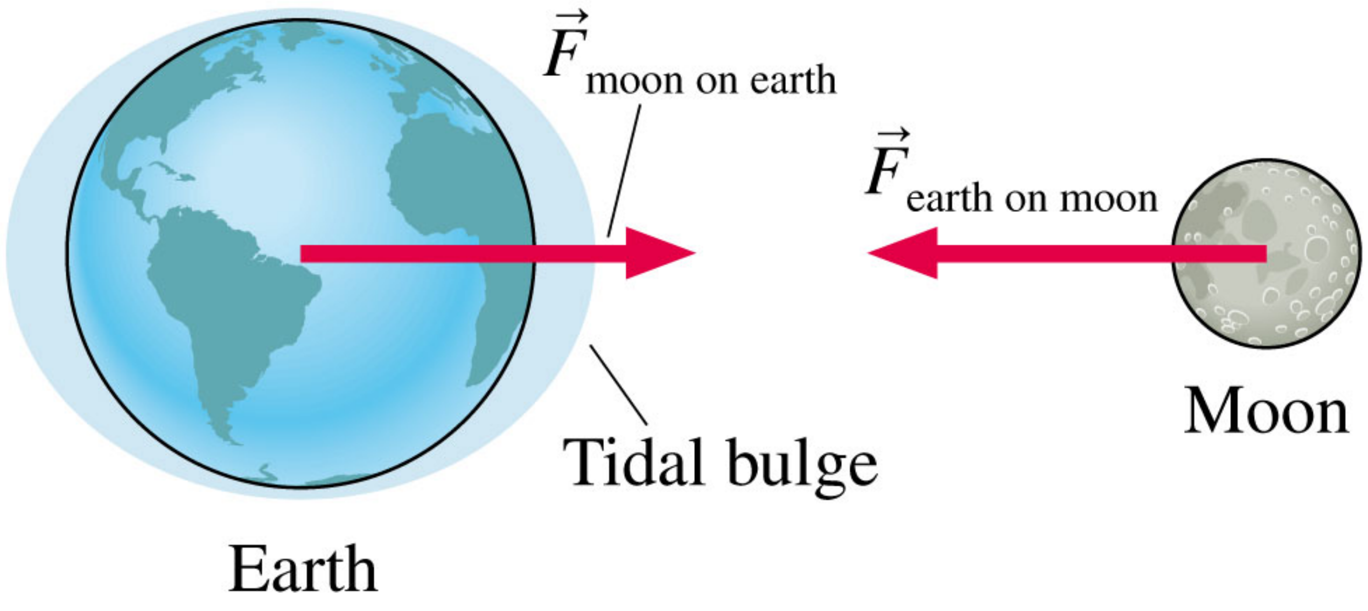
If object A exerts a force on object B, then object B exerts a force on object A.



Interacting objects

Long-range forces, such as gravity, also come in pairs.

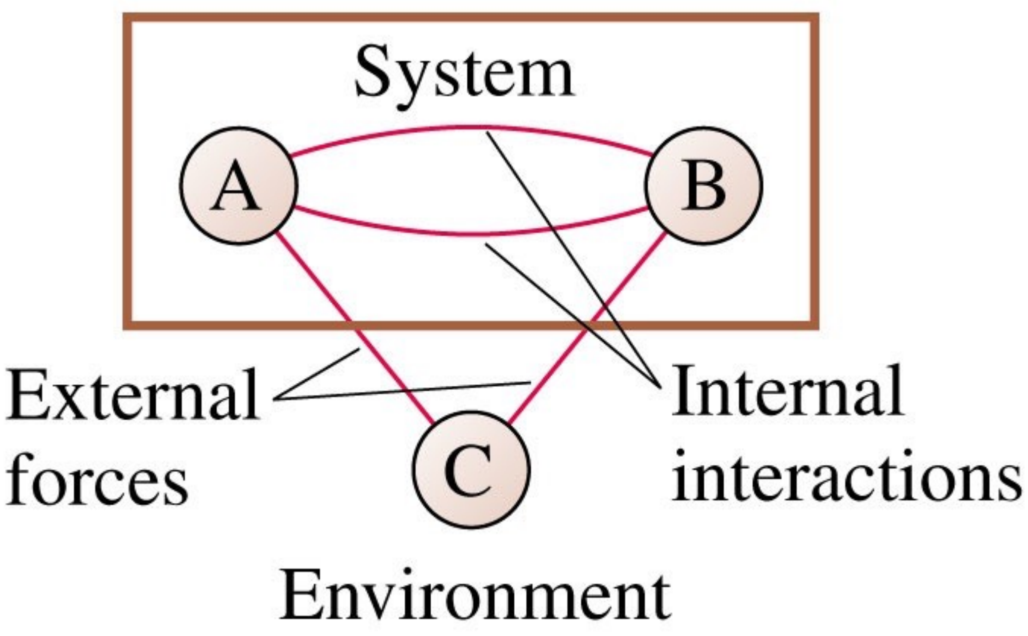
- If you release a ball, it falls because the earth's gravity exerts a downward force $\vec{F}_{\text{earth on ball}}$
- At the same time, the ball pulls upward on the earth with a force $\vec{F}_{\text{ball on earth}}$



Interaction diagram

The objects in the system are enclosed in a box.

Interactions are represented by lines connecting the objects



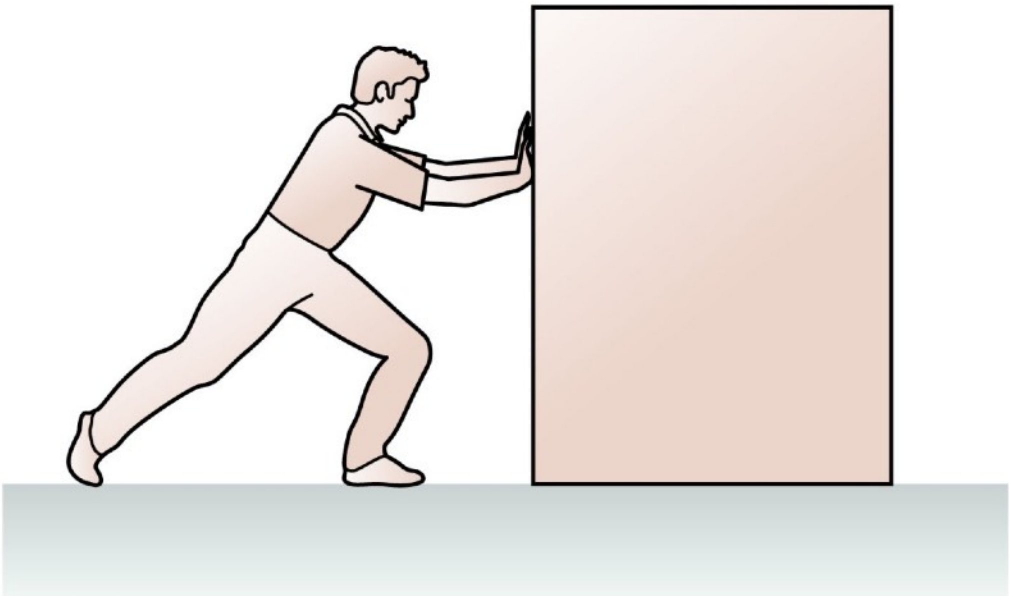
This is an *interaction diagram*.

System: those objects whose motion we want to analyze.

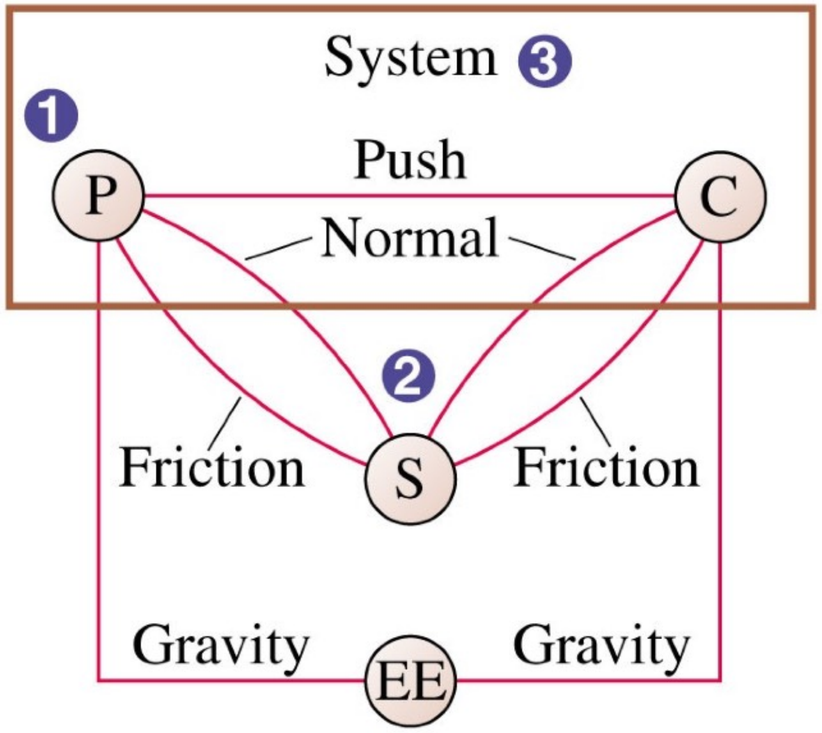
Environment: objects external to the system.

Example: Pushing a crate

Identify all interactions and draw free body diagrams for the person and the box.

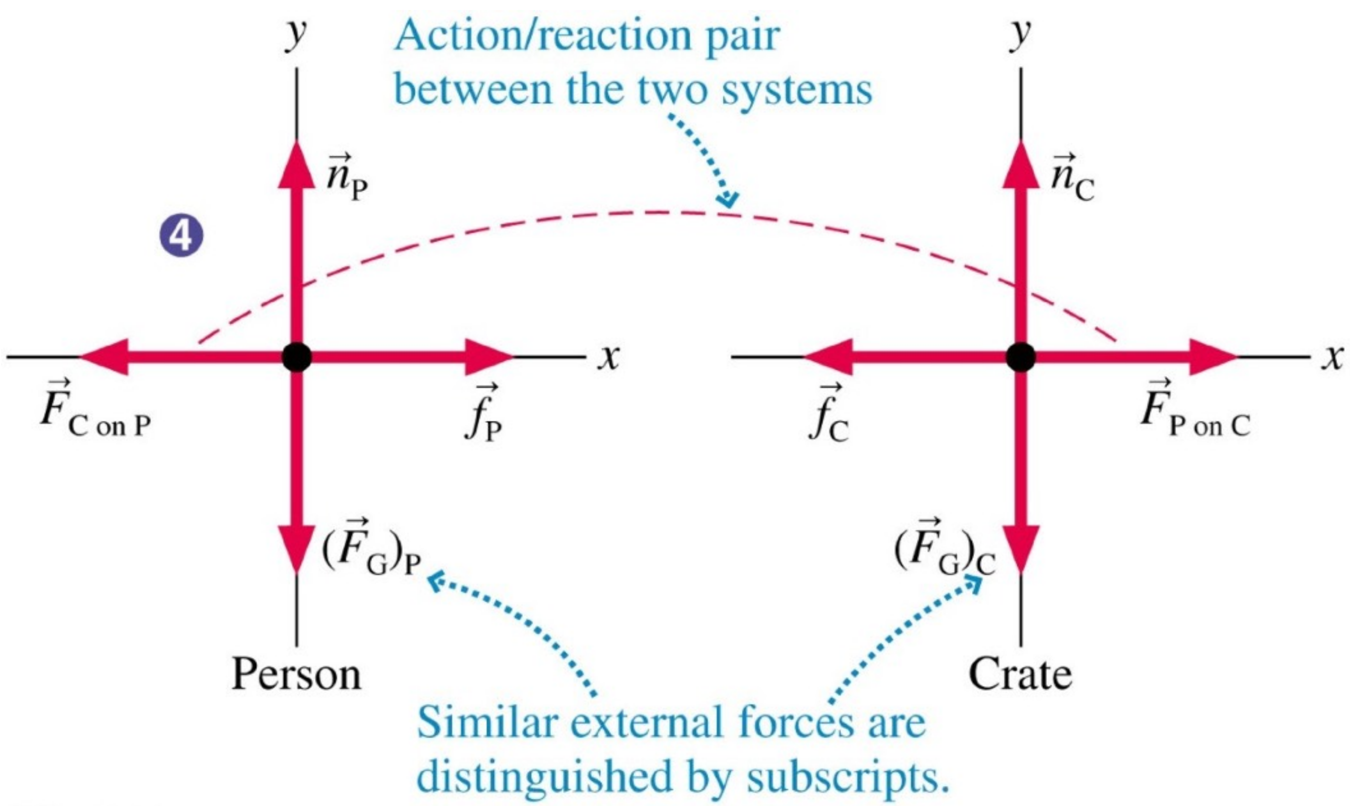


Example: Pushing a crate



P = Person
C = Crate
S = Surface
EE = Entire Earth

Pushing a crate: The free-body diagrams

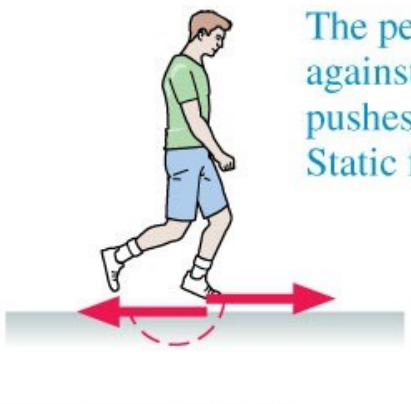


You could now use the completed free-body diagrams and apply Newton's second law to each object.

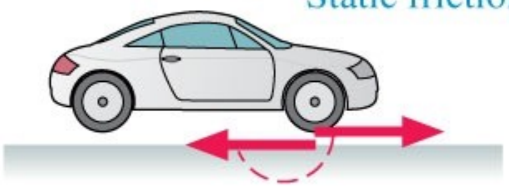
Propulsion

What causes this sprinter
to accelerate?

Examples of Propulsion



The person pushes backward against the earth. The earth pushes forward on the person. Static friction.



The car pushes backward against the earth. The earth pushes forward on the car. Static friction.

The rocket pushes the hot gases backward. The gases push the rocket forward. Thrust force.

Newton's third law

Every force occurs as one member of an action/ reaction pair of forces

$$\vec{F}_{\text{A on B}} = -\vec{F}_{\text{B on A}}$$

"For every action there is an equal but opposite reaction."

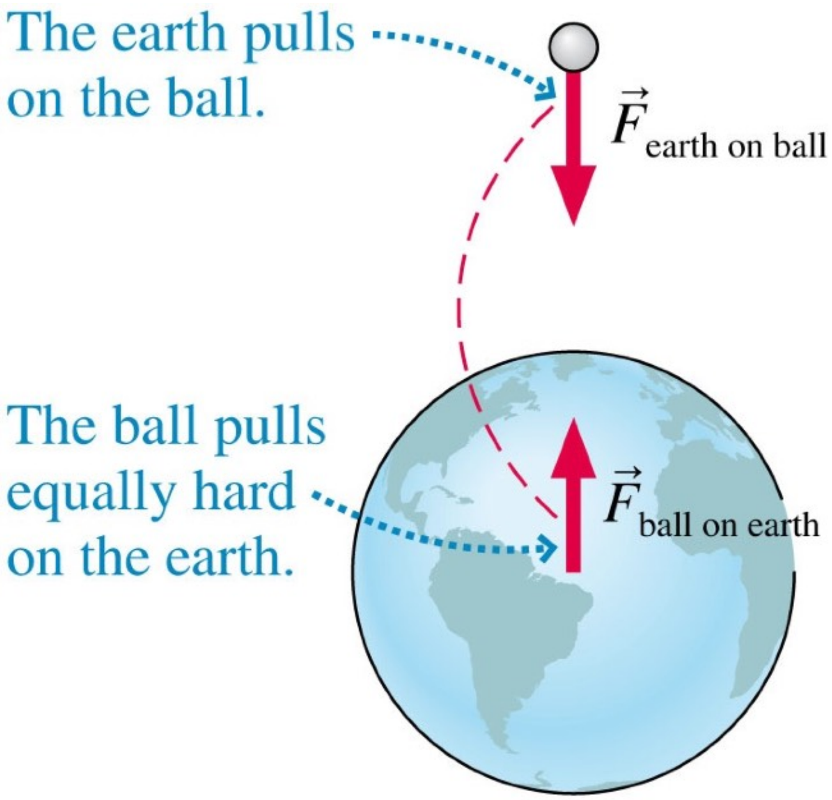
Reasoning with Newton's Third Law

<u>acceleration of ball</u>

$$\vec{F}_{\text{earth on ball}} = (\vec{F}_G)_B = -m_B g\hat{j}$$

<u>acceleration of earth</u>

$$\vec{a}_E = \frac{\vec{F}_{\text{ball on earth}}}{m_E} = \frac{m_B g\hat{j}}{m_E} = \left(\frac{m_B}{m_E}\right) g\hat{j}$$

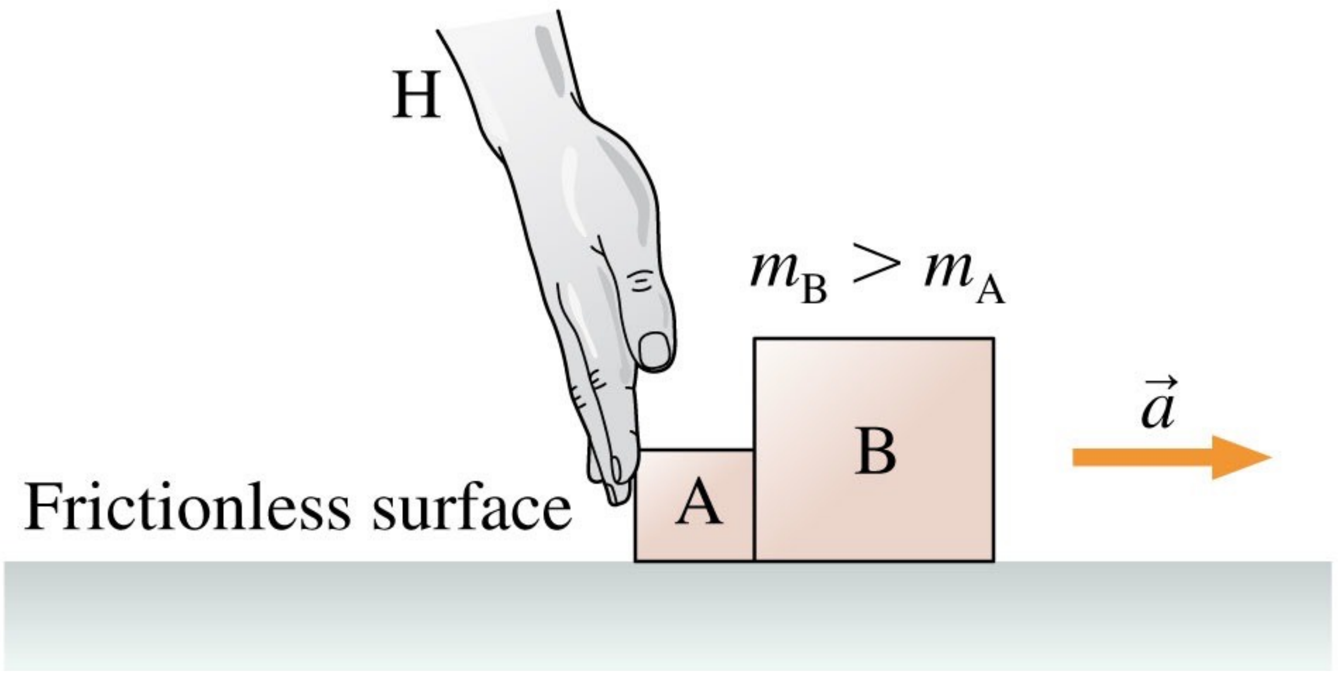


- If the ball has a mass of 1 kg, the earth accelerates upward at 2×10^{-24} m/s^2.

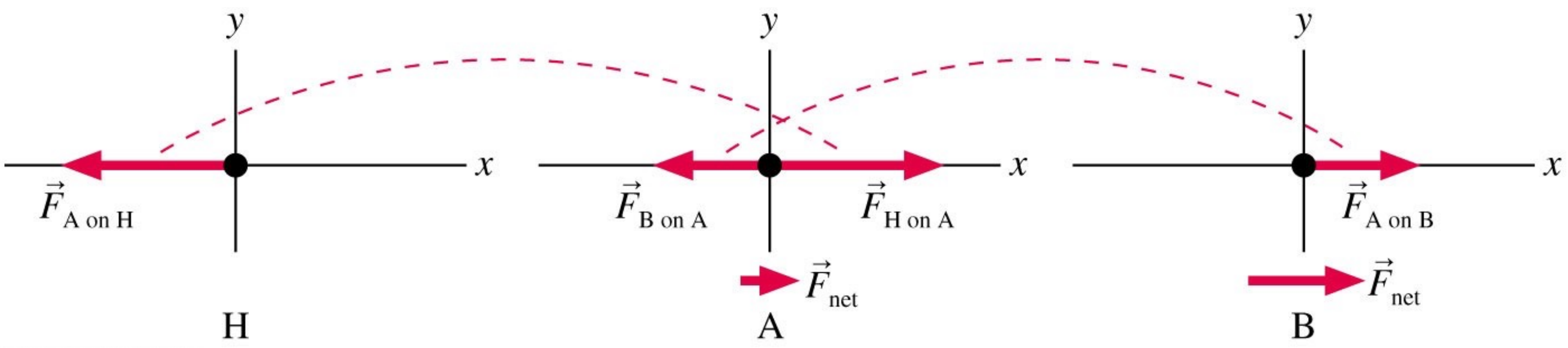
Example

The hand shown pushes boxes A and B to the right across a frictionless table. The mass of B is larger than the mass of A.

a. Draw a free-body diagram of A, B, and the hand H, showing only horizontal forces. Connect action/reaction pairs with dashed lines.
b. Rank in order, from largest to smallest, the horizontal forces.



The free-body diagrams



Draw the free body diagram for both blocks.

Identify the action/reaction pairs.

How hard can you pull before the top block slides off?