Bellwork

- Complete Newton's Second Law worksheet using equation: F=ma

Note that Newton's Second Law can be written as:

- F=ma
- a=F/m
- m=F/a

Simply plug in the missing value into using of the equations above.

MERITS FOR COMPLETED WORKSHEET (do your own work, please!).

BellWork Review

What makes an object speed up or slow down?

What determines how much an object speeds up or slows down?

If a one kilogram object is pushed with 10 Newtons of force, what will it's acceleration be? (assuming no friction). Recall a=F/m (Newton's Second Law)

NEWTON'S THIRD LAW OF MOTION

Copy in your books the slides and/or sentences with this symbol

Forces and Interactions

Interaction

- is between one thing and another.
- requires a pair of forces acting on two objects.

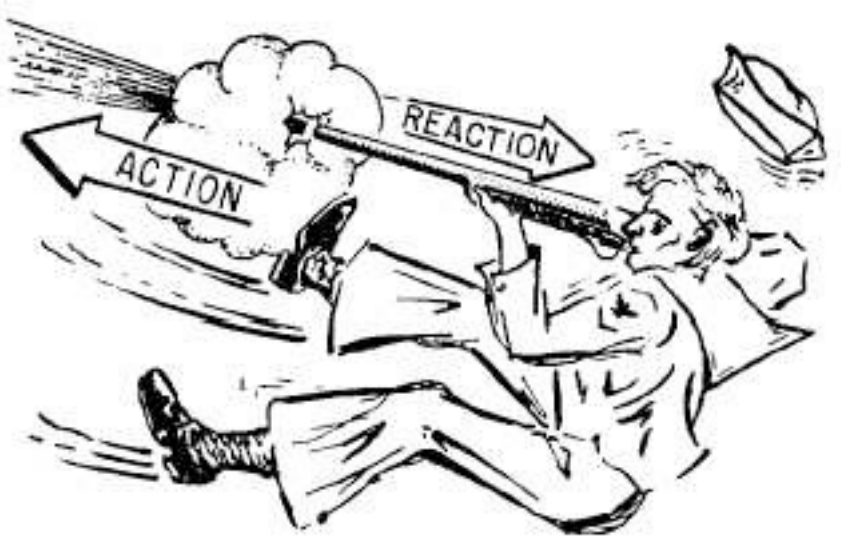
Example: interaction of hand and wall pushing on each other

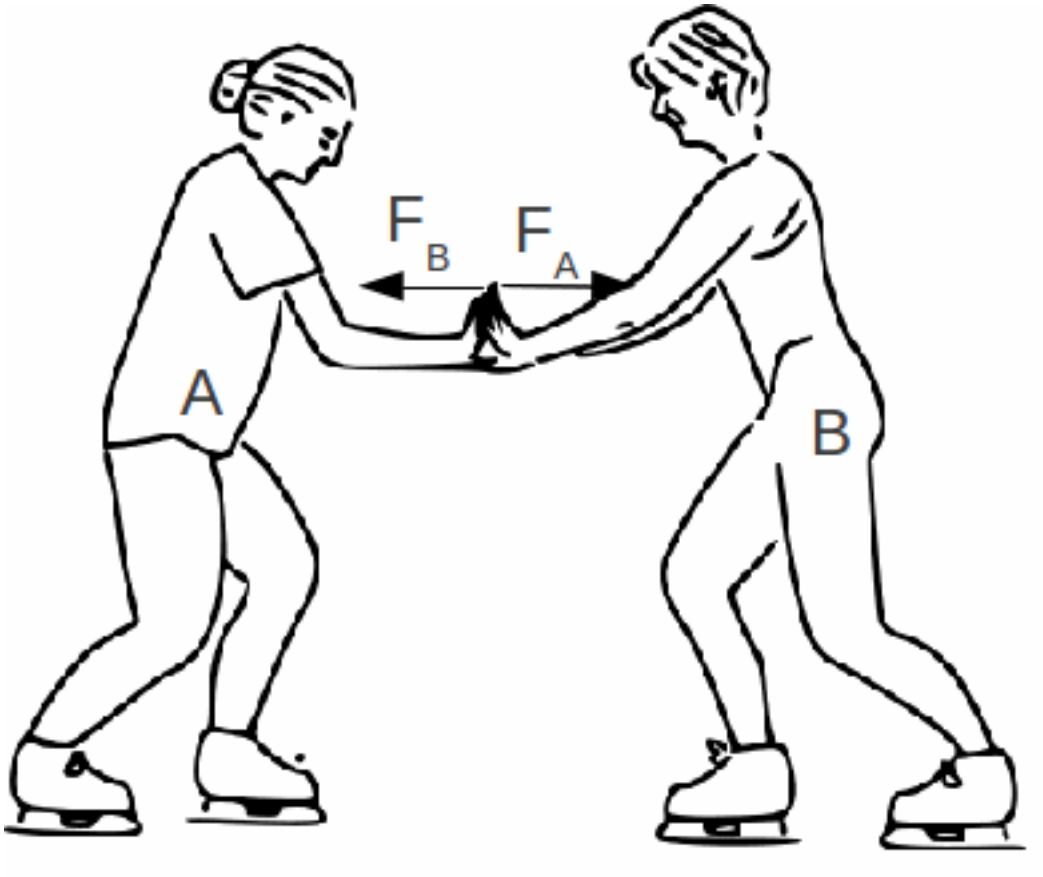
Force pair—you push on wall; wall pushes on you.

Newton's Third Law of Motion

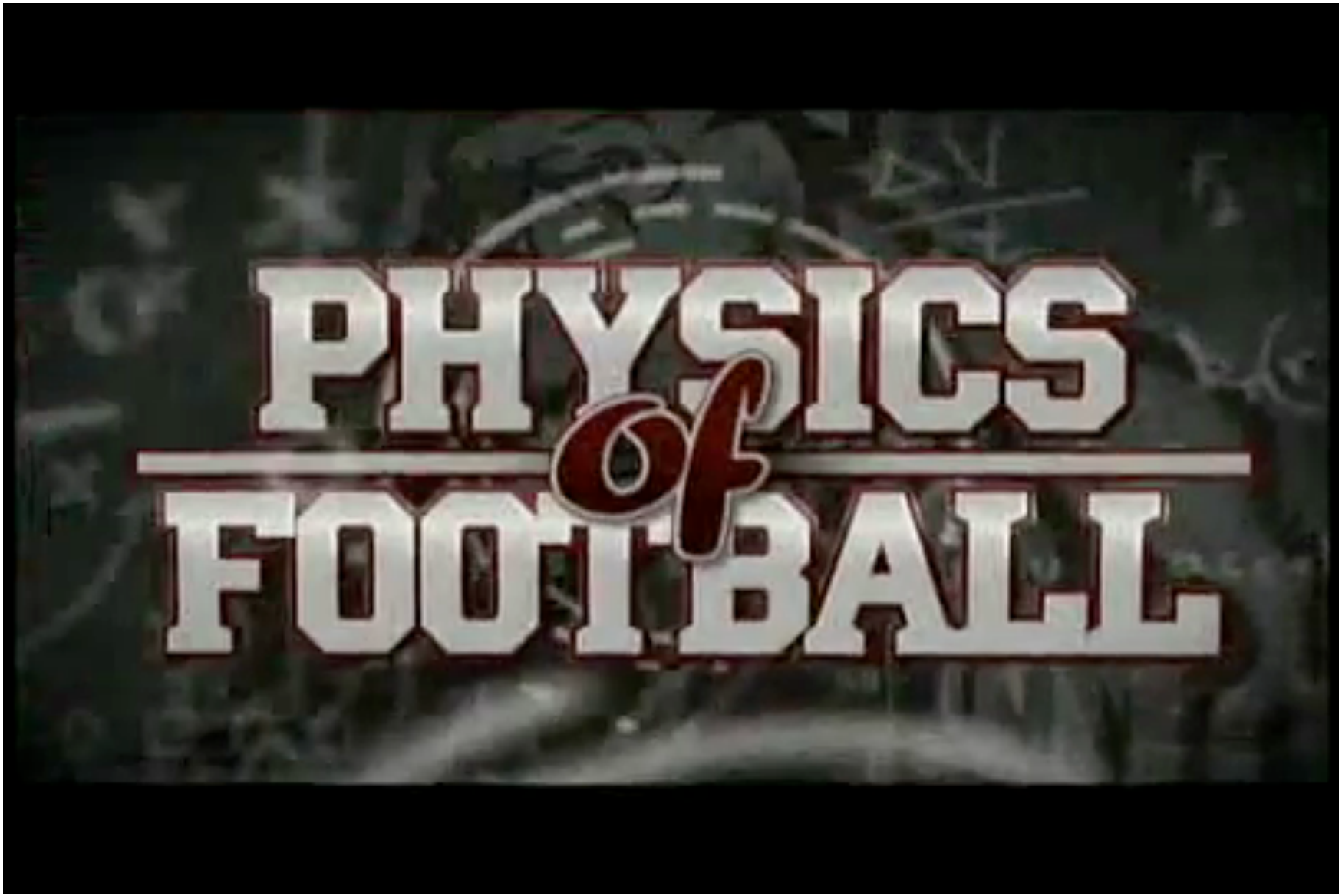
To every action there is always an equal and opposite reaction.

The third law states that all forces exist in pairs. The forces of two bodies on each other are always equal and are directed in opposite directions.





The forces two people pushing on each other will ALWAYS be the same. Here, $F_A=F_B$.



Newton's Third Law of Motion
Concept Check

A soccer player kicks a ball with 1500 N of force. The ball exerts a reaction force against the player's foot of

A. somewhat less than 1500 N.
B. 1500 N.
C. somewhat more than 1500 N.
D. None of the above.

Newton's Third Law of Motion
CHECK YOUR ANSWER

A soccer player kicks a ball with 1500 N of force. The ball exerts a reaction force against the player's foot of

A. somewhat less than 1500 N.

B. **1500 N.**

C. somewhat more than 1500 N.

D. None of the above.

Newton's Third Law of Motion

Action and reaction forces:

- neither force exists without the other.
- are equal in strength and opposite in direction.
- always act on *different* objects.

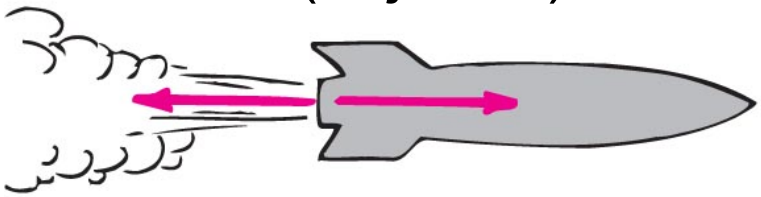
Newton's Third Law of Motion

Simple rule to identify action and reaction

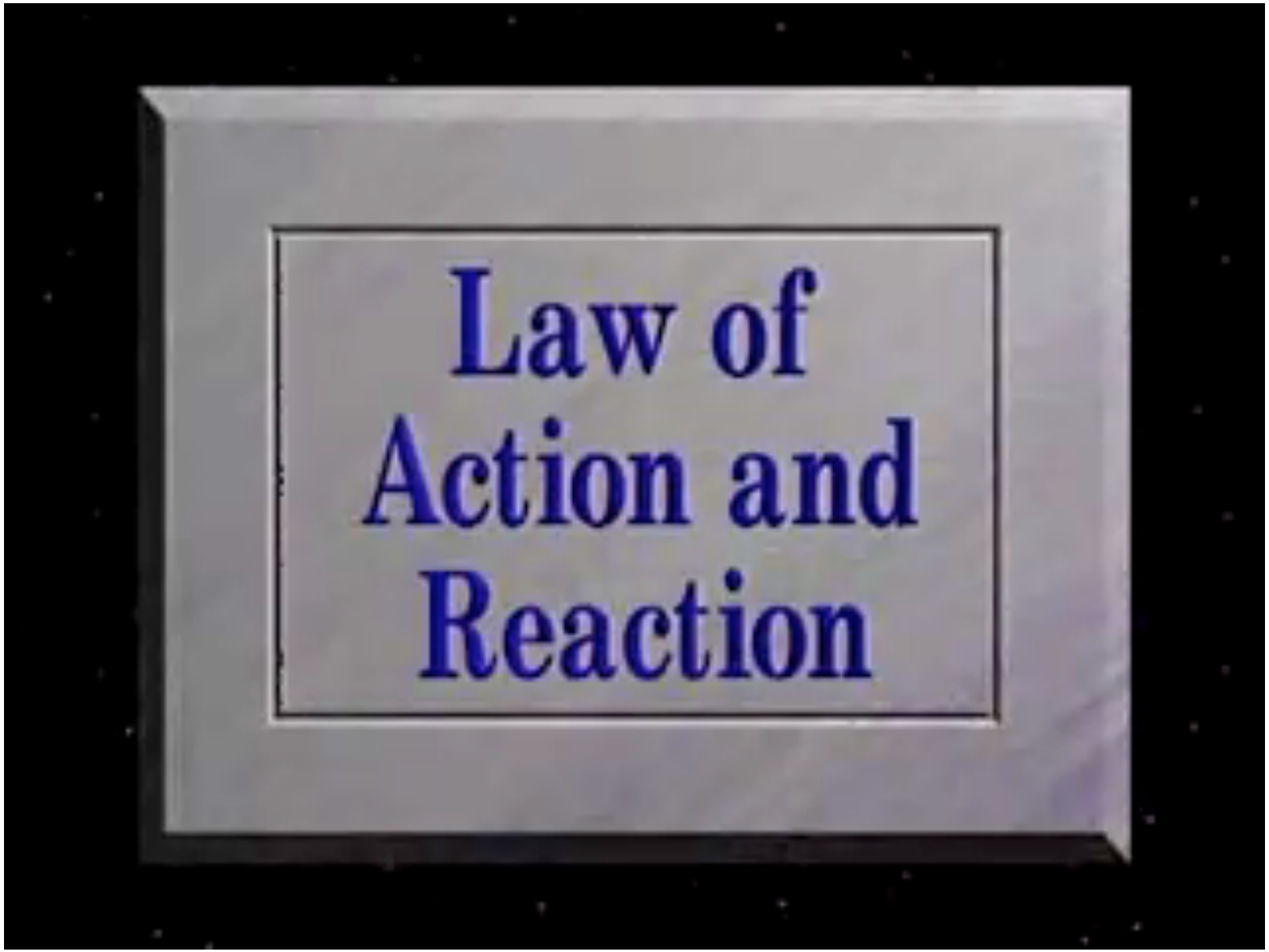
- Identify the interaction—one thing interacts with another
  - Action: Object A exerts a force on object B.
  - Reaction: Object B exerts a force on object A.

Example: Action—rocket (object A) exerts force on gas (object B).

Reaction—gas (object B) exerts force on rocket (object A).



Action: rocket pushes on gas Reaction: gas pushes on rocket



Newton's Third Law of Motion
CHECK YOUR NEIGHBOR

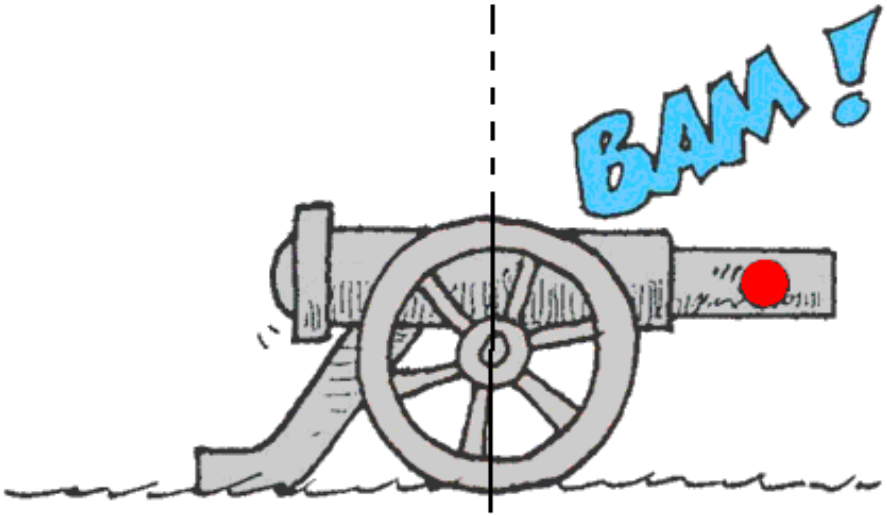
When a cannon is fired, the accelerations of the cannon and cannonball are different because the

A. forces don't occur at the same time.

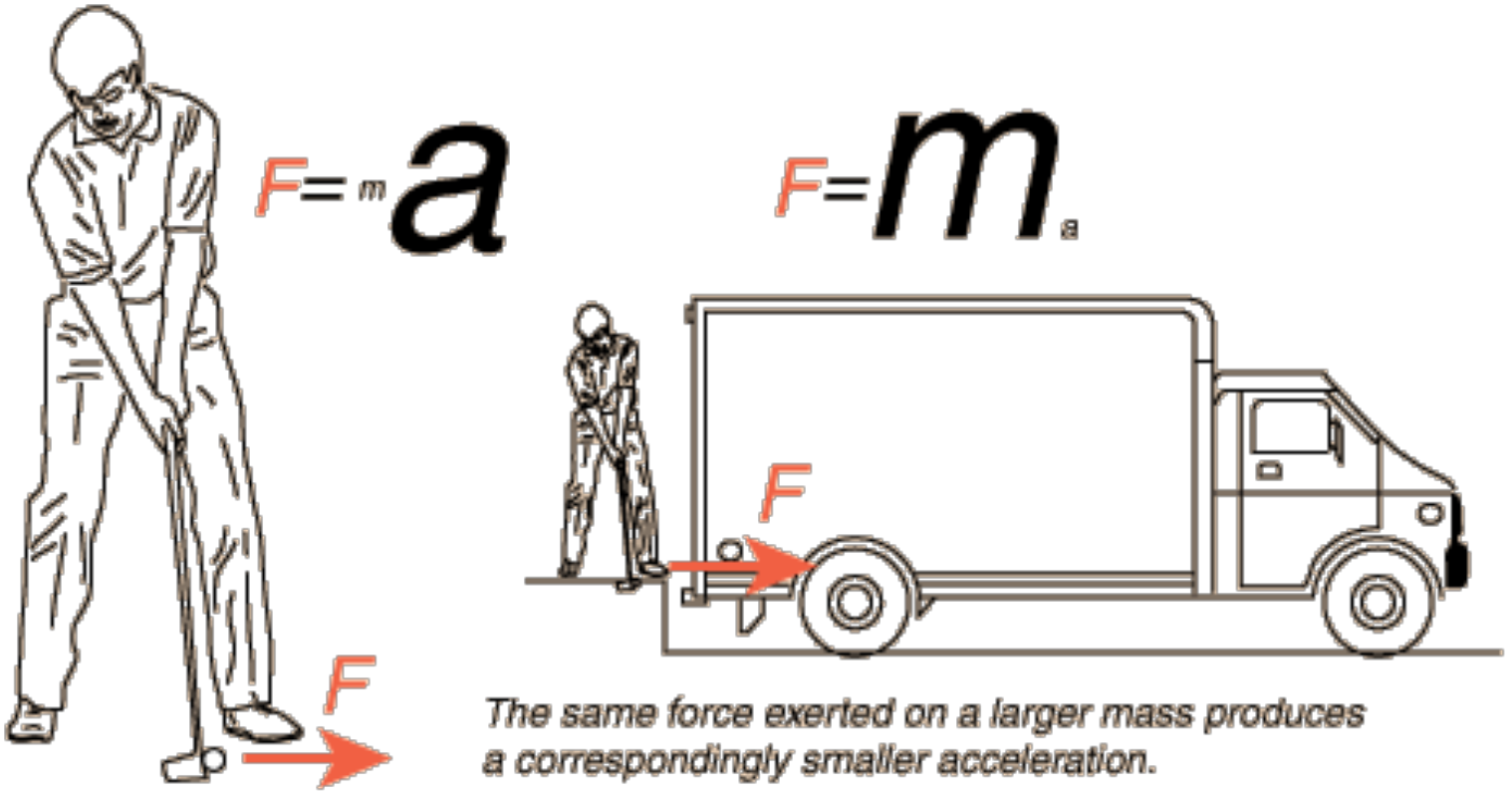
B. forces, although theoretically the same, in practice are not.

C. masses are different.

D. ratios of force to mass are the same.



Recall Newton's Second Law...



The same force exerted on a larger mass produces a correspondingly smaller acceleration.

Newton's Third Law of Motion
CHECK YOUR ANSWER

When a cannon is fired, the accelerations of the cannon and cannonball are different because

C. the masses are different.

Action and Reaction on Different Masses

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

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

- The same force exerted on a small mass produces a large acceleration.
- The same force exerted on a large mass produces a small acceleration.

Newton's Third Law
CHECK YOUR NEIGHBOR

Consider a high-speed bus colliding head-on with an innocent bug. The force of impact splatters the unfortunate bug over the windshield.
Which is greater, the force on the bug or the force on the bus?

A. Bug
B. Bus
C. Both are the same.
D. Cannot say

Newton's Third Law
CHECK YOUR ANSWER

Consider a high-speed bus colliding head-on with an innocent bug. The force of impact splatters the unfortunate bug over the windshield.
Which is greater, the force on the bug or the force on the bus?

A. Bug
B. Bus
C. **Both are the same.**
D. Cannot say

Comment:

Although the forces are equal in magnitude, the effects are very different. Do you know why?

Newton's Third Law
CHECK YOUR NEIGHBOR

A bird flies by

A. flapping its wings.
B. pushing air down so that the air pushes it upward.
C. hovering in midair.
D. inhaling and exhaling air.

Newton's Third Law
CHECK YOUR ANSWER

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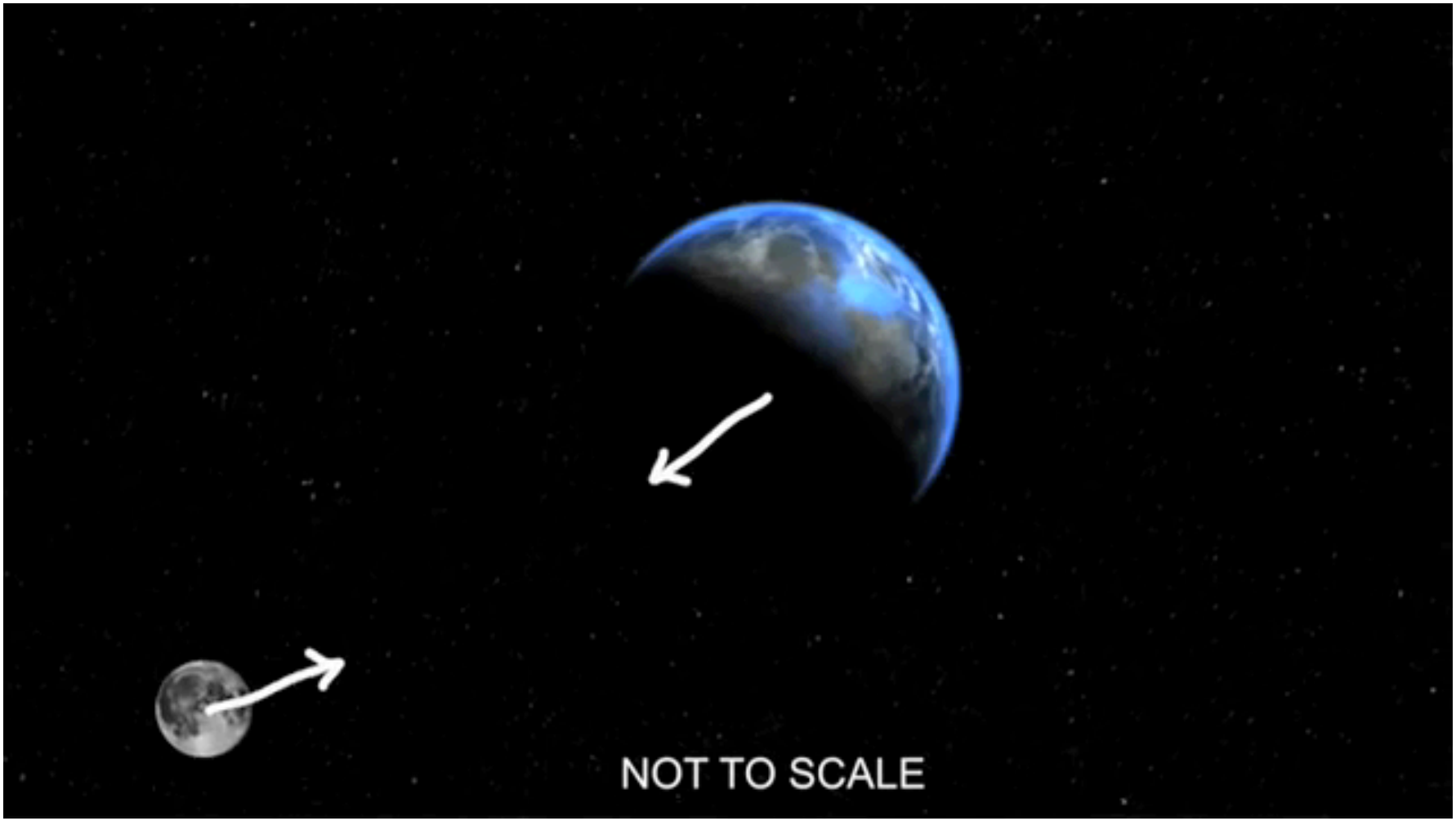
Hands On Demos

Newton's Third Law

Rocket Bus	Describe what happened	Why does the cork go further than the bus? (hint: F = m.a)
Do the Twist	Describe what happened	Why does the chair go in the opposite direction to your arms? (hint: Newton's 3rd Law)
Backwards Ho!	Describe what happened	Why or why didn't you move?
Balloon Races	Describe what happened	Draw a diagram to show the action and reaction in this demonstration.



Newton's Third Law of Motion
CHECK YOUR NEIGHBOR

When you step off a curb, Earth pulls you downward. The reaction to this force is

A. a slight air resistance.
B. nonexistent in this case.
C. you pulling Earth upward.
D. None of the above.

Newton's Third Law of Motion
CHECK YOUR ANSWER

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Newton's Third Law of Motion
CHECK YOUR NEIGHBOR

When you step off a curb, Earth pulls you downward and you pull the force upward. Why do you not sense Earth moving upward toward you?

A. Earth is fixed, so it cannot move.
B. Earth can move, but other objects on it prevent it from moving.
C. It moves, but a very small amount that you cannot see.
D. None of the above.

Newton's Third Law of Motion
CHECK YOUR ANSWER

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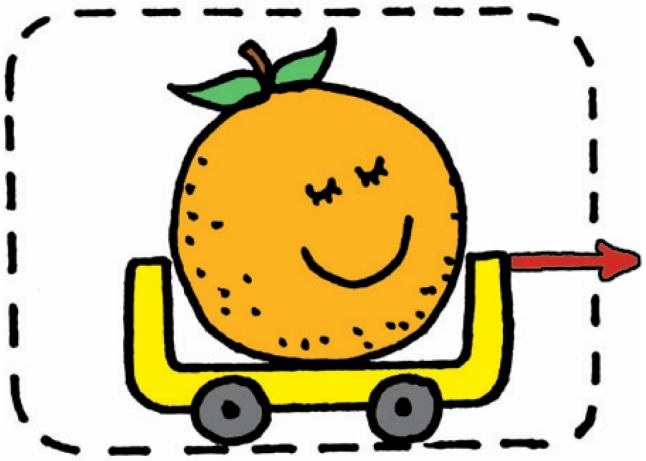
D. None of the above.

Explanation:
You exert a force on Earth that is equal to the force it exerts on you. But you move more than the Earth does, because its mass is so great compared to your mass that it moves very little and you do not notice it.

Newton's Third Law of Motion

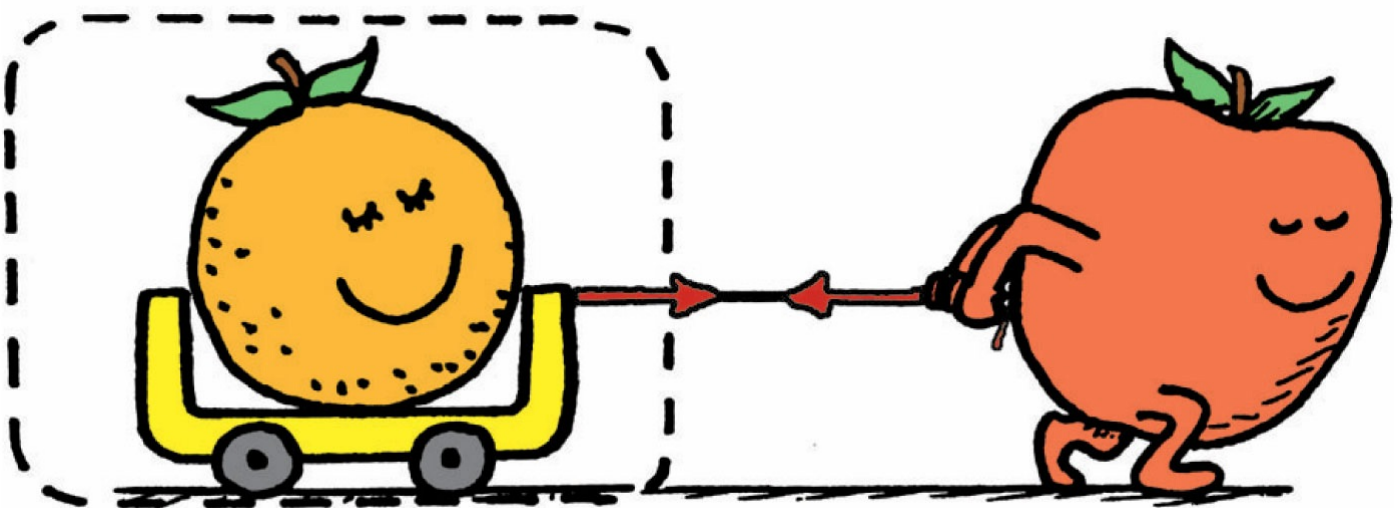
Defining Your System

- Consider a single enclosed orange.
  - Applied external force causes the orange to accelerate in accord with Newton's second law.
  - Action and reaction pair of forces is not shown.



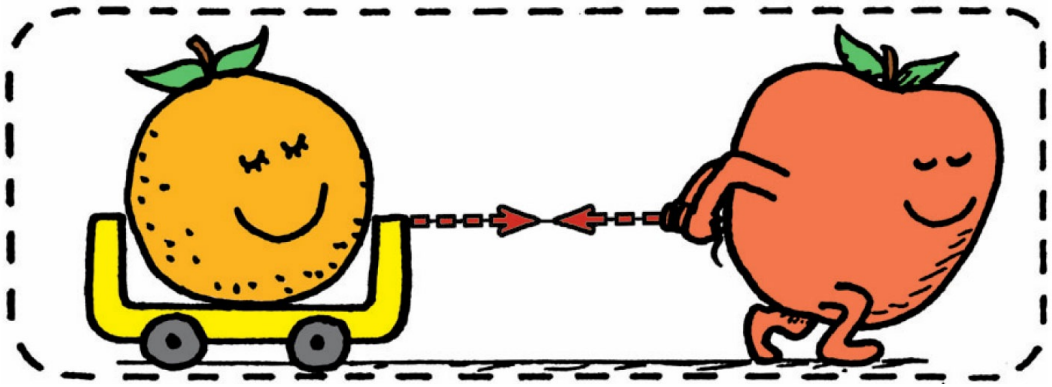
Newton's Third Law of Motion

- Consider the orange and the apple pulling on it.
  - Action and reaction do not cancel (because they act on different things).
  - External force by apple accelerates the orange.



Newton's Third Law of Motion

- Consider a system comprised of both the orange and the apple
  - The apple is no longer external to the system.
  - Force pair is internal to system, which doesn't cause acceleration.
  - Action and reaction within the system cancel.
  - With no external forces, there is no acceleration of system.

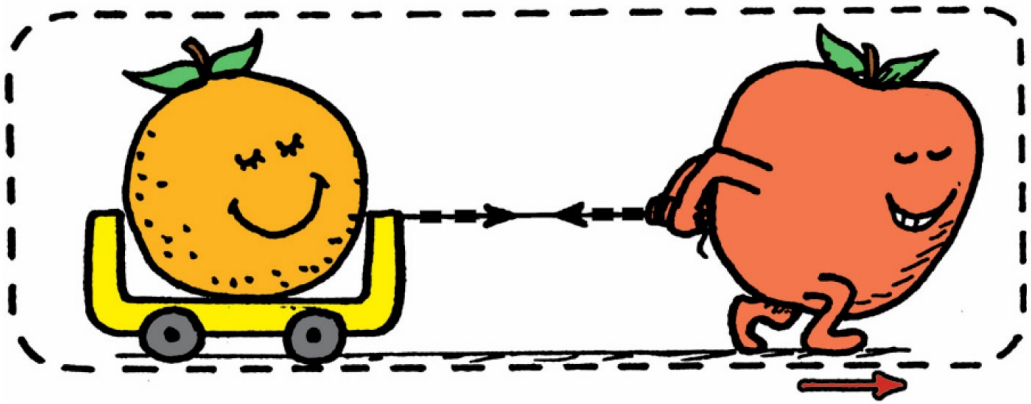


Newton's Third Law of Motion

- Consider the same system, but with external force of friction on it.
  - Same internal action and reaction forces (between the orange and apple) cancel.
  - A second pair of action-reaction forces (between the apple's feet and the floor) exists.

Newton's Third Law of Motion

- One of these acts by the system (apple on the floor) and the other acts on the system (floor on the apple).
- External frictional force of floor pushes on the system, which accelerates.
- Second pair of action and reaction forces do not cancel.



Summary of Newton's Three Laws of Motion

- Newton's first law of motion (the law of inertia)
  - An object at rest tends to remain at rest; an object in motion tends to remain in motion at constant speed along a straight-line path.
- Newton's second law of motion (the law of acceleration)
  - When a net force acts on an object, the object will accelerate. The acceleration is directly proportional to the net force and inversely proportional to the mass.
- Newton's third law of motion (the law of action and reaction)
  - Whenever one object exerts a force on a second object, the second object exerts an equal and opposite force on the first.