Unit 8B: Forces
Newton's Laws of Motion

Indicator

PS-5.7: Explain the motion of objects on the basis of Newton's three laws of motion.

Objectives

1. State the meaning of Newton's laws of motion in your own words.
2. Apply Newton's laws of motion to real-life scenarios.
3. Construct cause-and-effect models/scenarios that demonstrate Newton's laws of motion.

What is a force?

- **Force**
  - A push or pull that one object exerts on another object

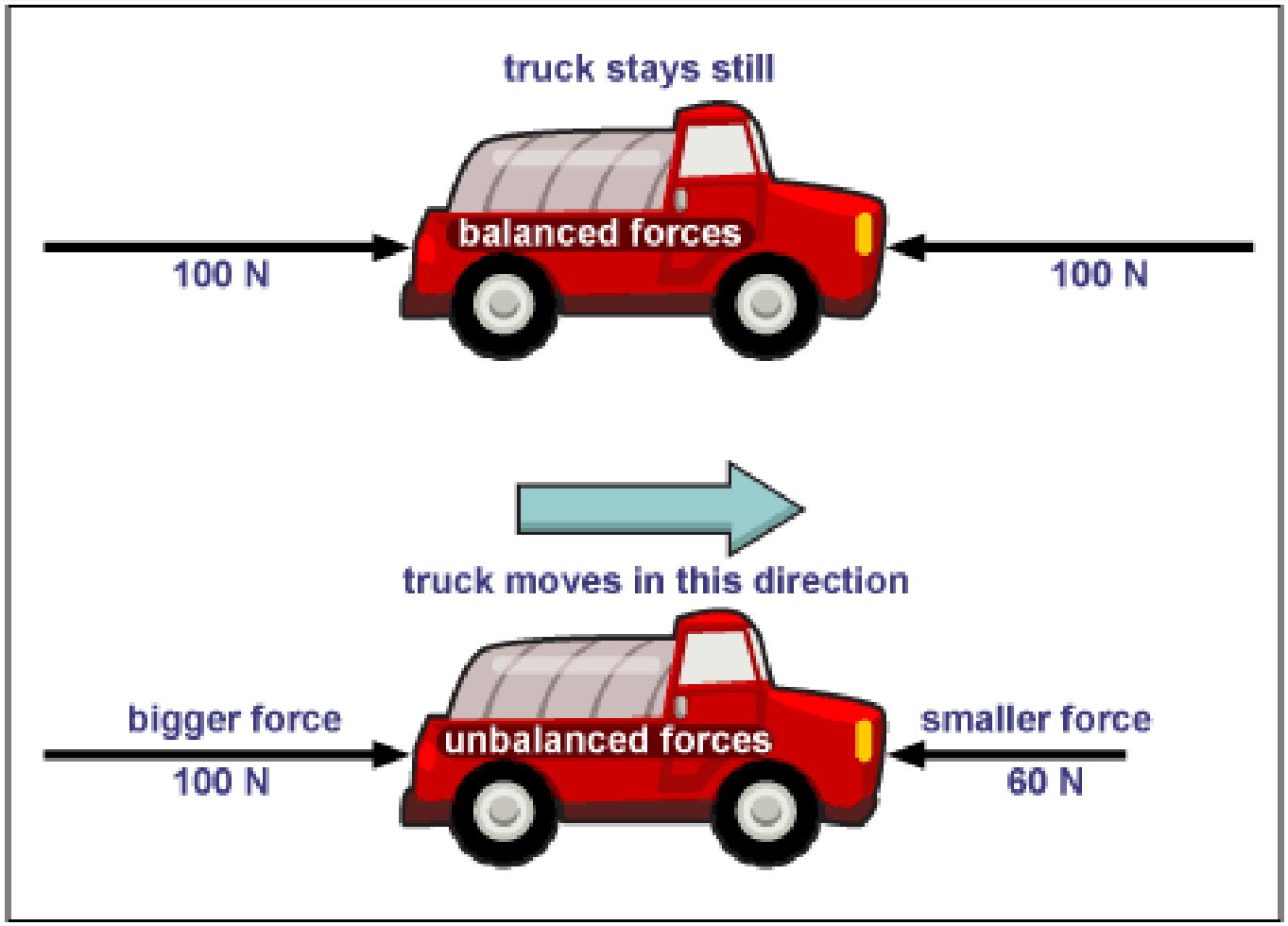
- **Units for Force**
  - Newtons (N)
  - A **newton** is the amount of force required to accelerate a 1 kilogram object at a rate of 1 meter/second/second
    - **1 newton = 1 kg m/s/s or 1 kg m/s^2**

Balanced Forces vs. Unbalanced Forces

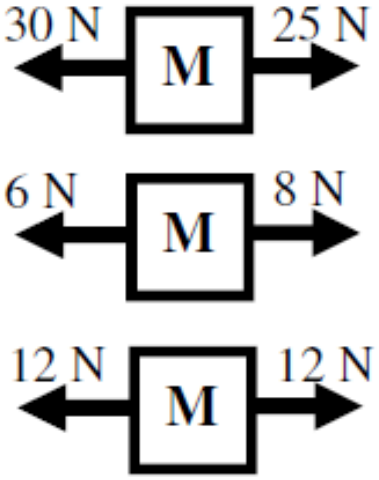
- **Balanced Forces**
  - Equal in size or magnitude
  - Opposite in direction
  - Balanced forces do NOT cause a change in motion

- **Unbalanced Forces**
  - Not equal in size and/or direction
  - Unbalanced forces cause a change in motion
  - An unbalanced force is called a **NET FORCE**

Balanced Forces vs. Unbalanced Forces



Check for Understanding



Label each example as balanced or unbalanced forces and explain the direction of acceleration (if any).

___ An person sitting on a chair?

___ 20 N left and 30 N right?

___ An object at constant speed?

___ An accelerating plane?

___ An object at rest?

____ If $\Delta v = 0$?

____ If $a \neq 0$?

____ If $a = 0$?

____ If $\Delta v \neq 0$?

____ A stopping car?

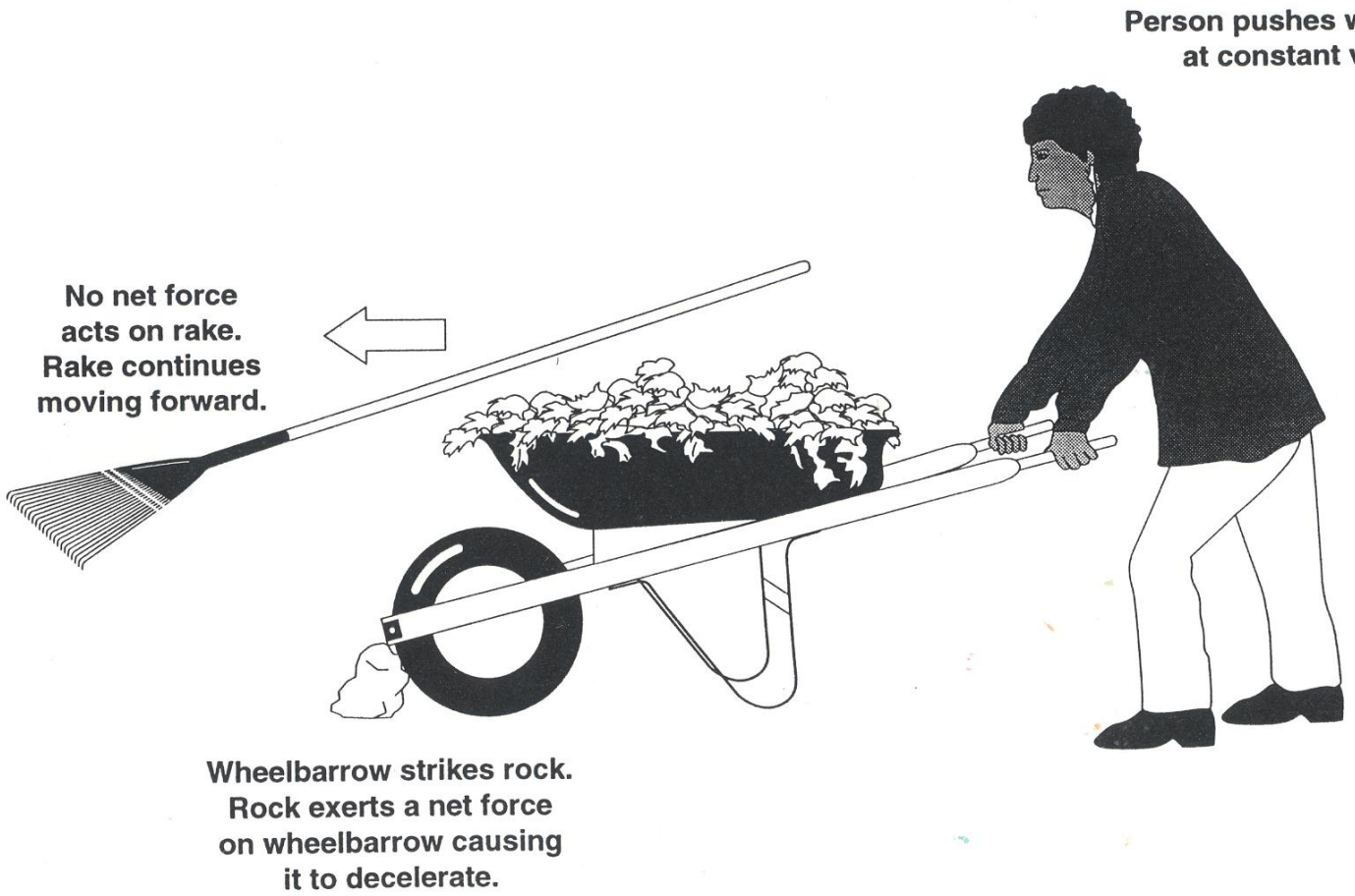
Newton's First Law of Motion

Newton's First Law of Motion

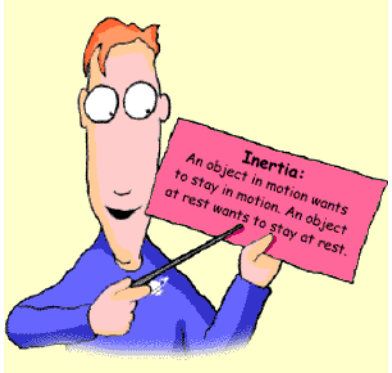
- *The velocity of an object will remain constant unless a net force acts on it.*

- **What does this really mean?**
  - If an object is moving, it will continue to move with the same speed in the same direction unless a net force acts on it.
  - If an object is at rest it will stay at rest unless a net force acts on it.
  - **Objects keep doing the same thing unless something causes them to change.**

NEWTON'S FIRST LAW



Newton's First Law of Motion

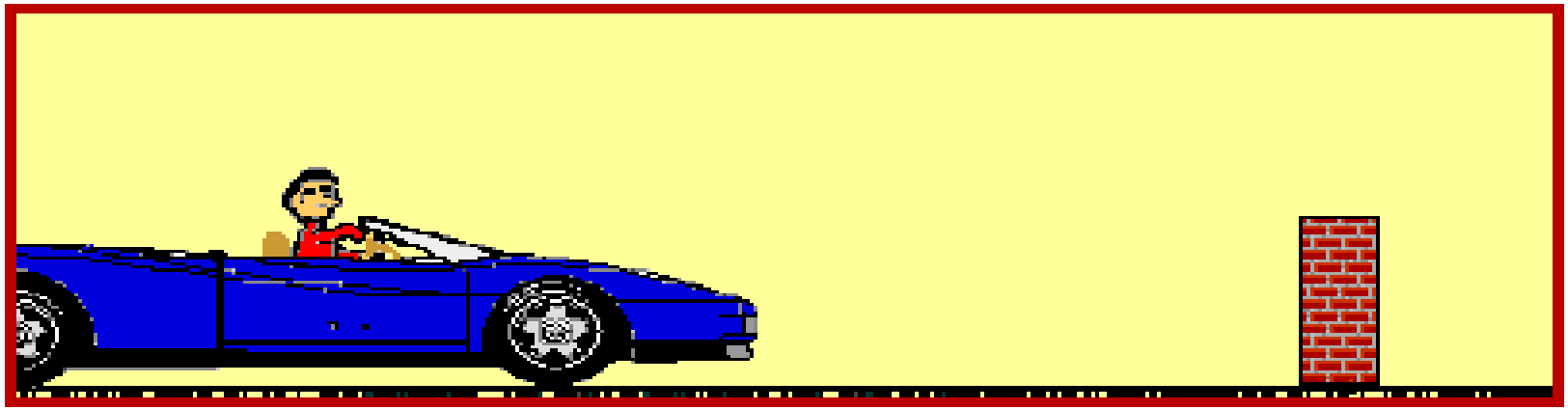


- ***Law of Inertia***

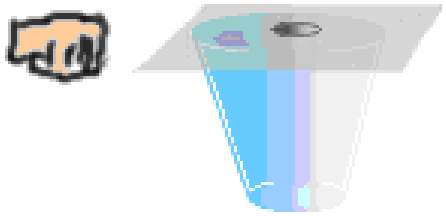
- **Inertia**
  - Tendency of an object an object to resist a change in motion
  - Inertia means that the object's motion will stay constant in terms of speed and direction
  - Depends on the **mass** of an object
  - Does NOT depend of the presence of gravity
    - **An object's inertia is the same on Earth and in space**

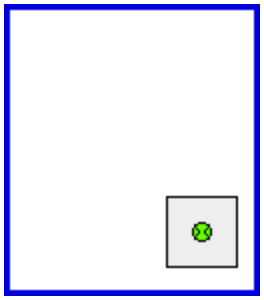
  - **Objects with a greater mass have greater inertia**
  - **Example**
    - **It is more difficult to change the motion of bowling ball than the motion of a golf ball**

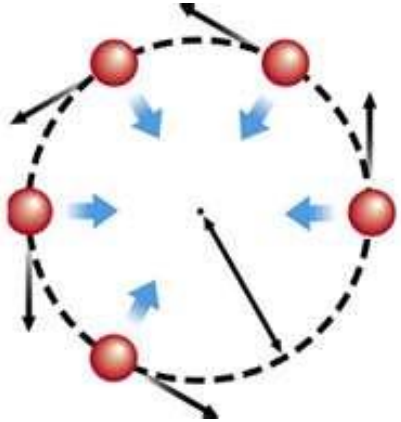
Inertia at Work

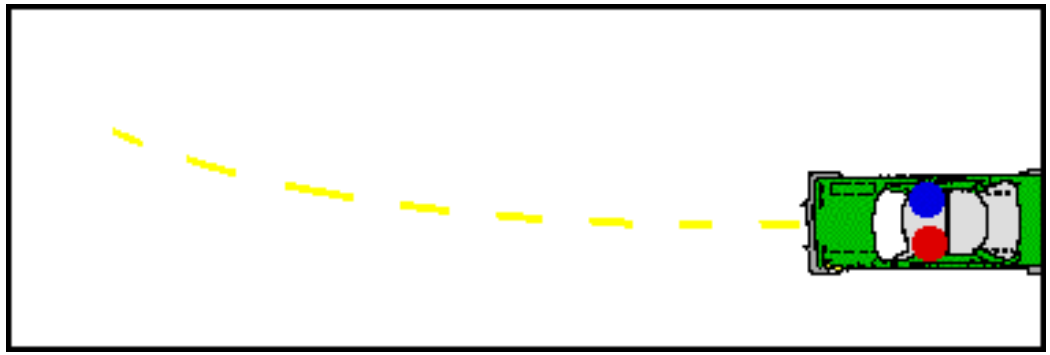


Examples of Newton's First Law of Motion









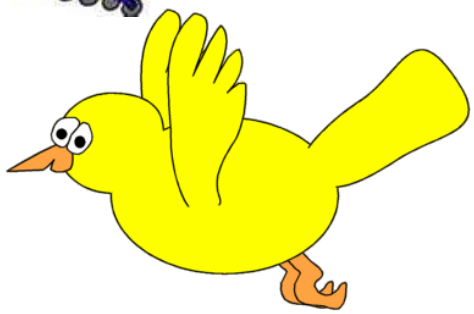
Check for Understanding

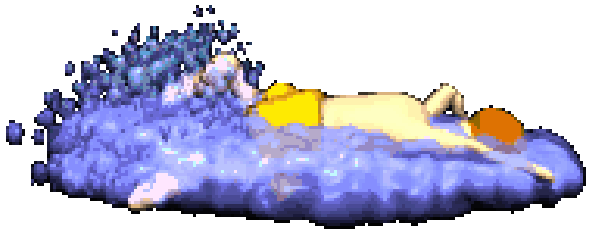
- Restate Newton's First Law of Motion in your own words.
- What is inertia?
- What are some examples of Newton's First Law of Motion?

What is the role of friction?

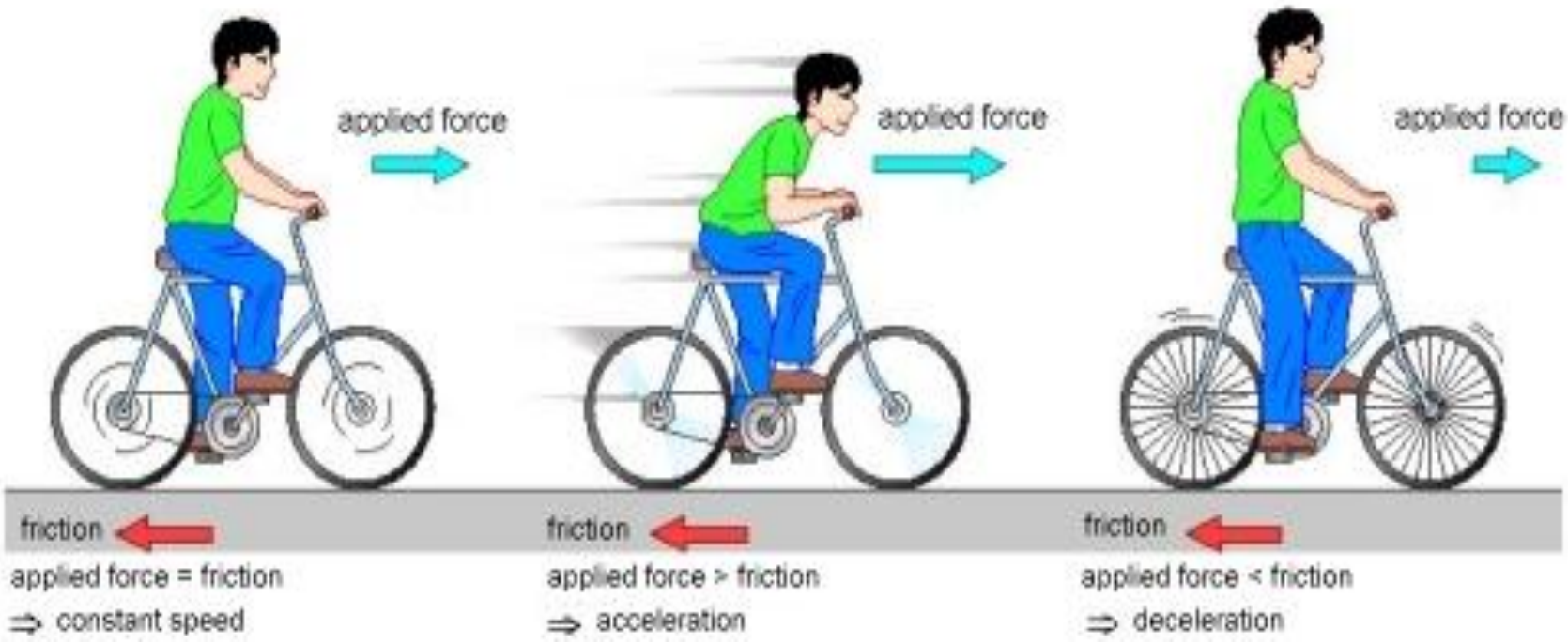
- **Friction**
  - Unbalanced force that opposes or slows down the motion of an object
  - Contact force caused when two objects are touching
  - Converts motion into heat

- **Types of Friction**
  - Static: two objects not moving
  - Sliding: two objects sliding past each other
  - Rolling: two objects rolling past each other
  - Fluid: viscous friction → gases or liquids





Newton's First Law and Friction



Net force = Zero
No change in motion

Net force ≠ Zero
Bike accelerates to the right

Net force ≠ Zero
Negative Acceleration

Check for Understanding

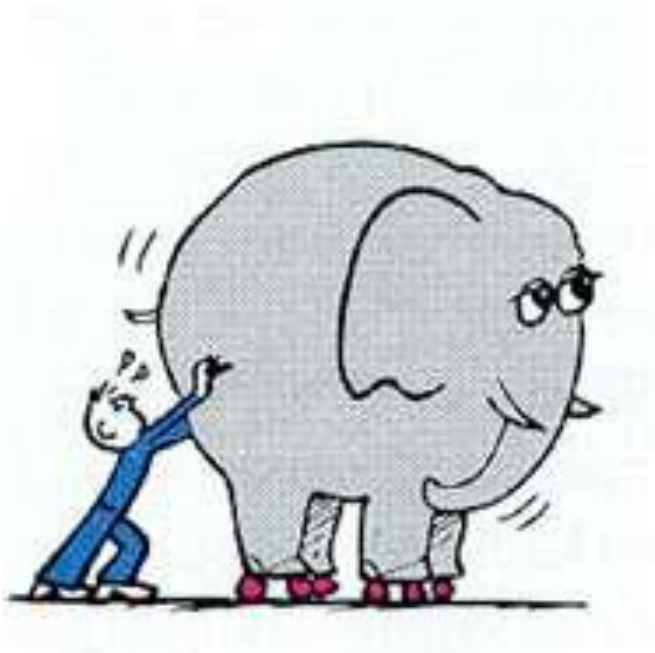
Which object has the greater inertia?

A train or a car?
A ping pong ball or a baseball?
A fast bowling ball or a slow bowling ball?
A 20 kg mass or a 10 kg mass?
A rock on the earth or a rock in space?

What is the role of friction in this diagram???

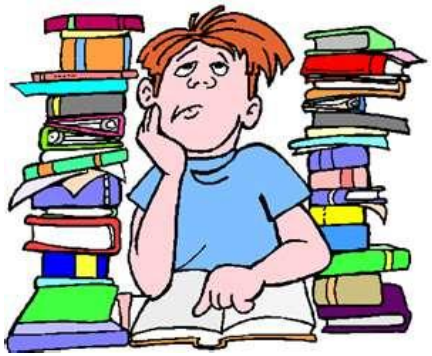
What types of friction are present?

Newton's Second Law of Motion



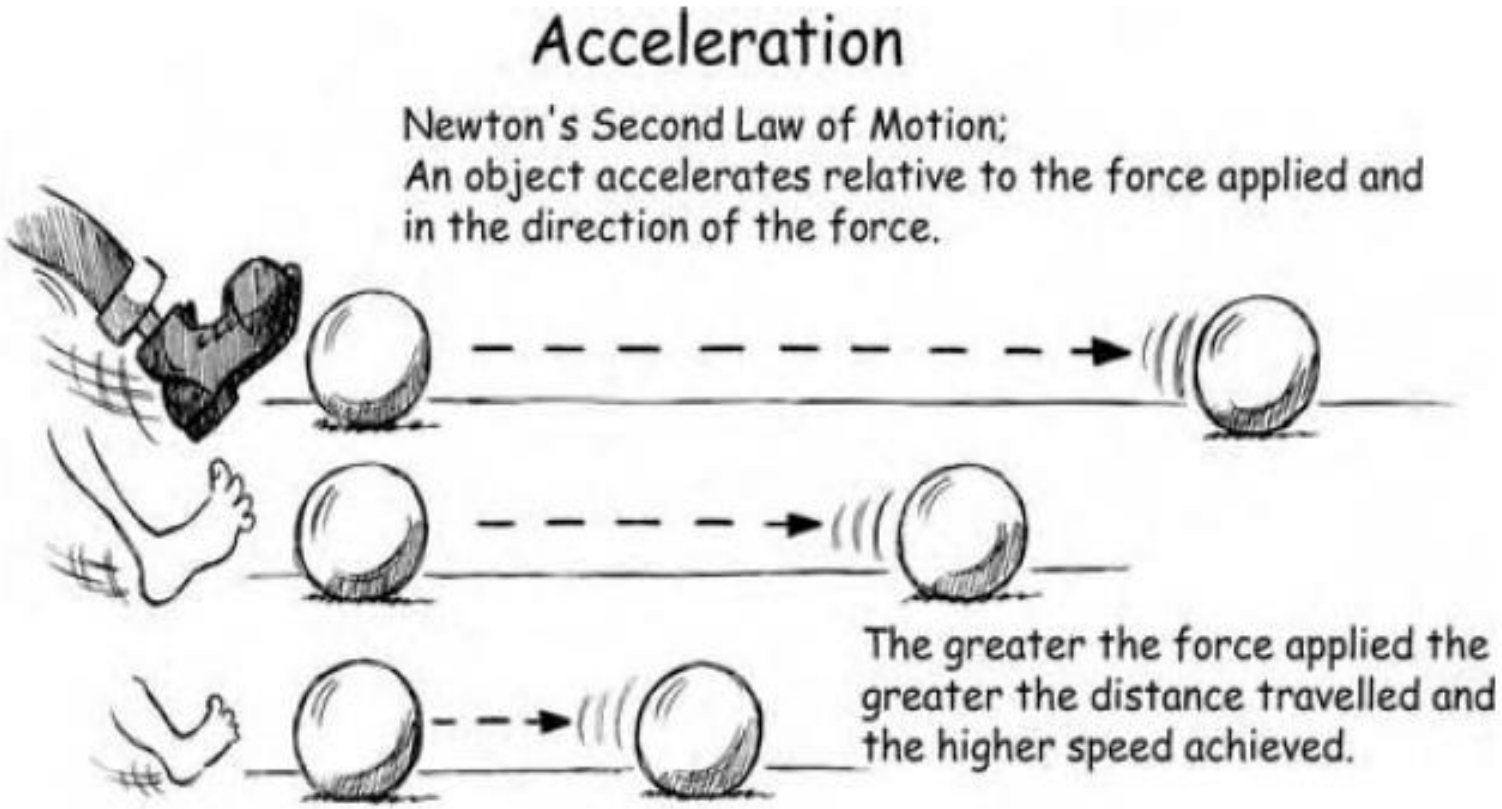
Newton's Second Law of Motion

- ***When a net force acts on an object the object will accelerate in the direction of the net force.***

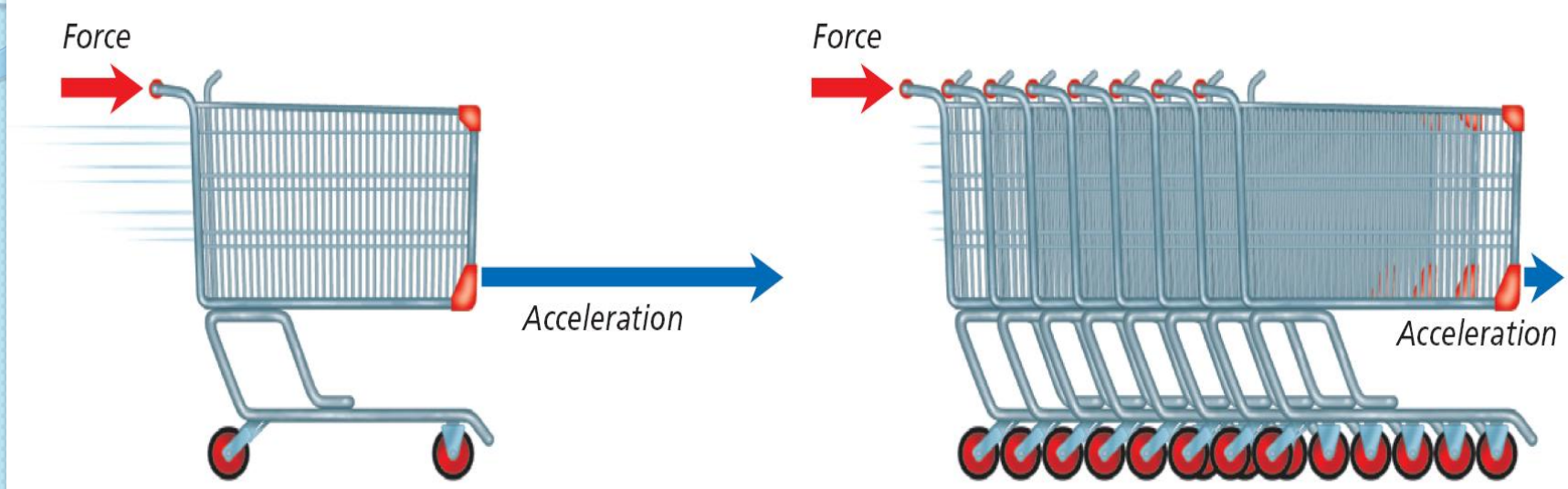


- What does this really mean?
  - If you push or pull an object it will accelerate in the direction of the force
    - Change in speed
    - Change in direction
  - The larger the net force → the faster the acceleration
  - The larger the mass → the smaller the acceleration.

Newton's Second Law of Motion



Newton's Second Law of Motion

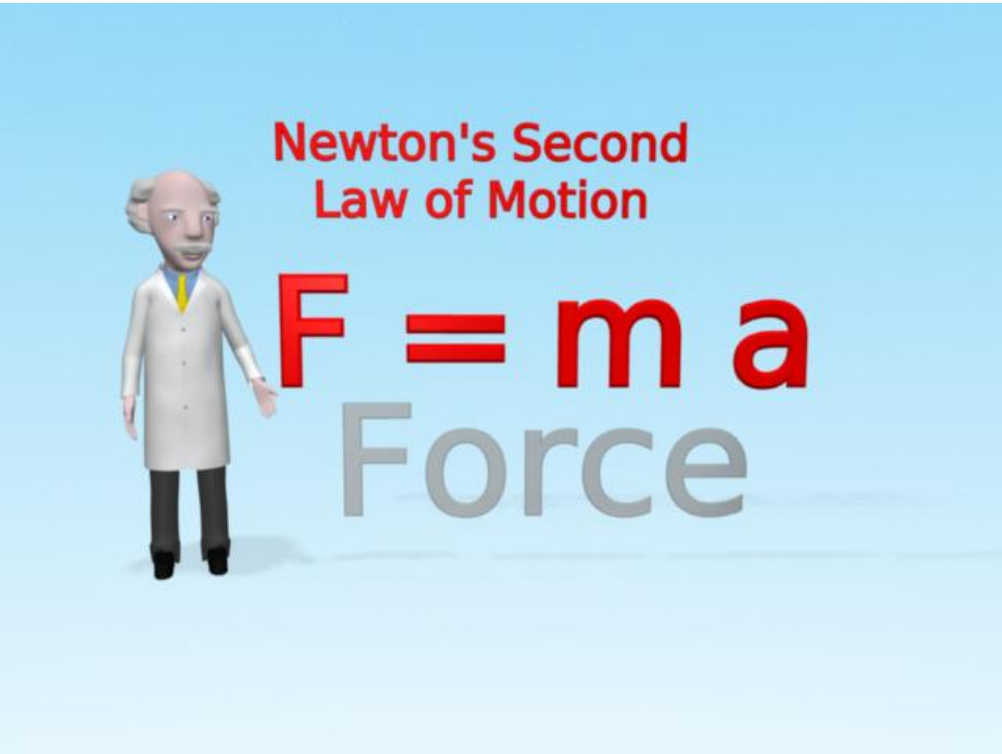


An object with a smaller mass has LESS INERTIA

Easier to accelerate a small mass

More difficult to accelerate a large mass that has more inertia

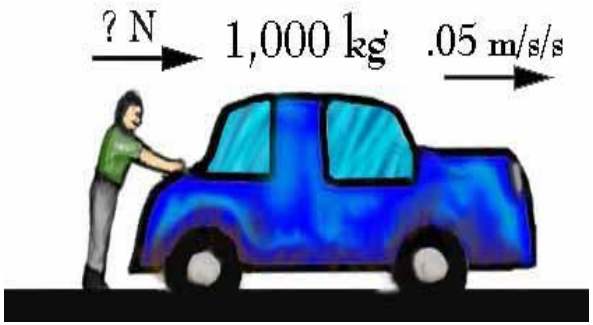
Equation for Newton's Second Law

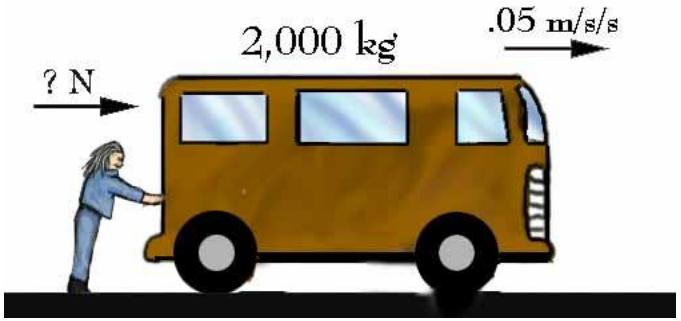


F = force (N)

m = mass (kg)

a = acceleration (m/s^2)





Check for Understanding

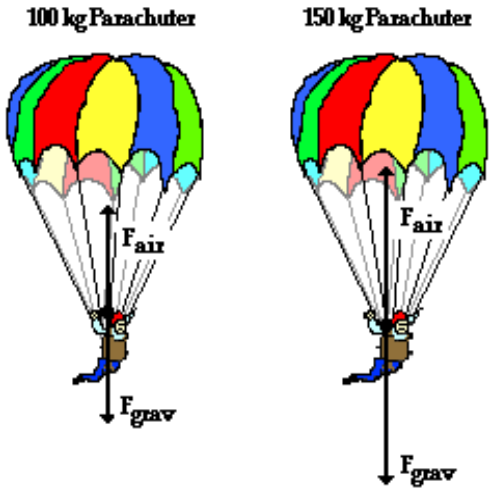
- Restate Newton's Second Law in your own words.

- Which would require a greater force to accelerate? WHY?
  - A hockey puck on ice or a hockey puck on uncut grass?
  - An empty suitcase or a suitcase full of bricks?

- If the mass of a rock is doubled, what happens to its acceleration if the force does NOT change?

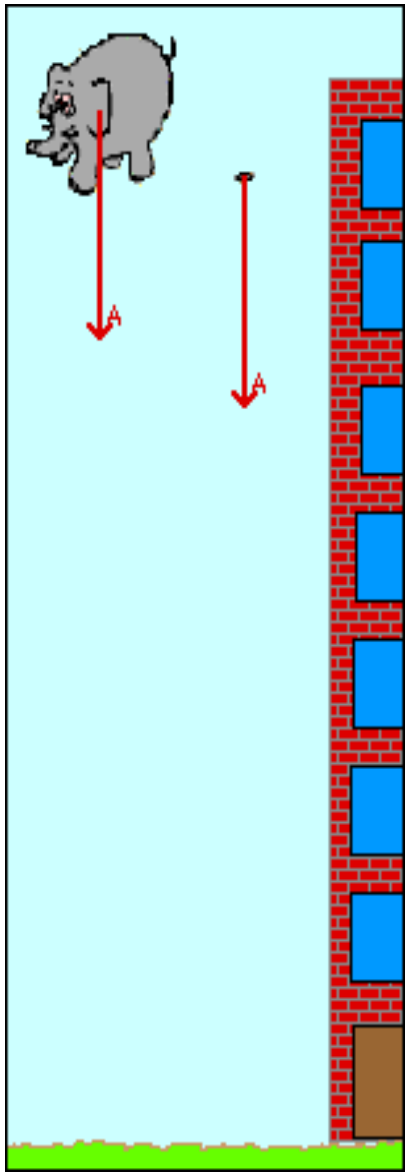
Newton's Second Law & Air Resistance

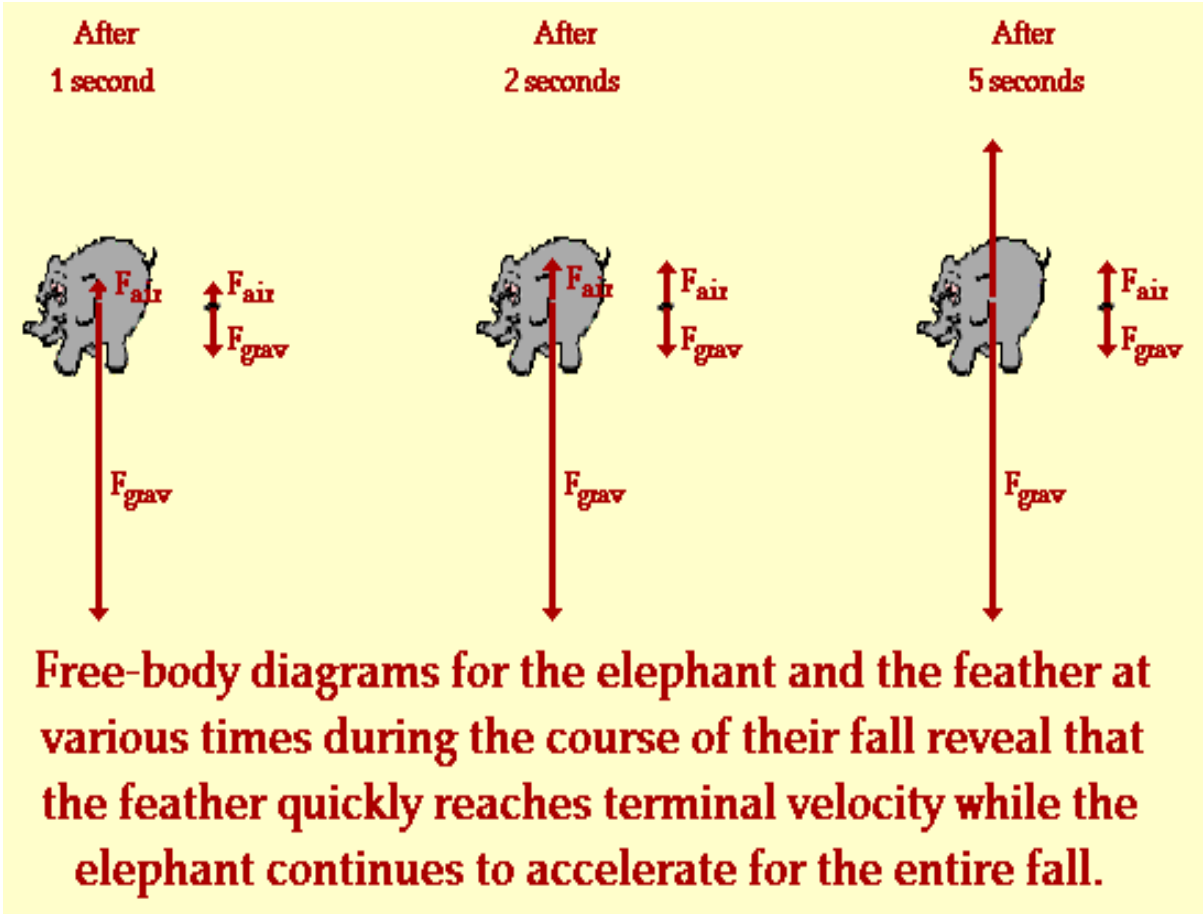
- **Air Resistance**
  - The force of air exerted on a falling object
  - Fluid Friction
  - The **air** pushes up as **gravity** pulls down
  - Depends on shape, size, and surface area of the falling object



- **Terminal Velocity**
  - The highest velocity an falling object will reach
  - An object reaches its terminal velocity when the force of air resistance = the force of gravity

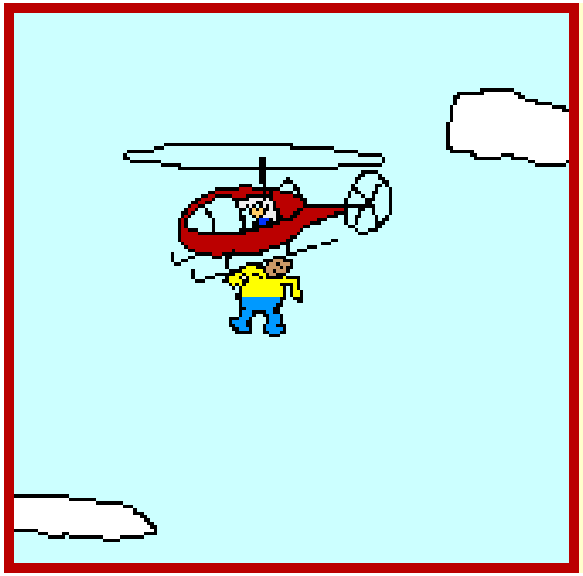
Air Resistance and Terminal Velocity

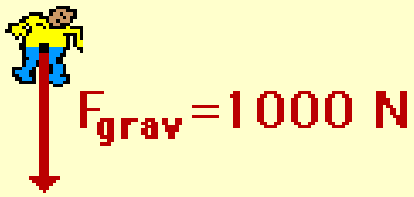




Free-body diagrams for the elephant and the feather at various times during the course of their fall reveal that the feather quickly reaches terminal velocity while the elephant continues to accelerate for the entire fall.

Air Resistance and Terminal Velocity





$$a = \frac{F_{net}}{m}$$

$$a = \frac{1000\ N}{100\ kg}$$

$$a = 10.0\ m/s^2\ (down)$$

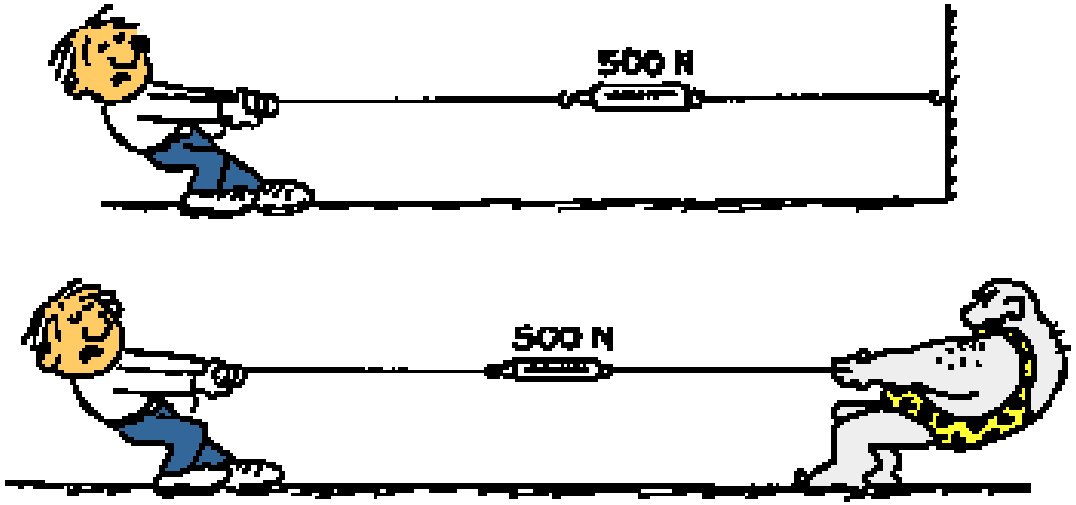
The parachute increases the skydiver's air resistance.

The skydiver will reach its terminal velocity as the force of air resistance will equal the force of gravity.

Check for Understanding

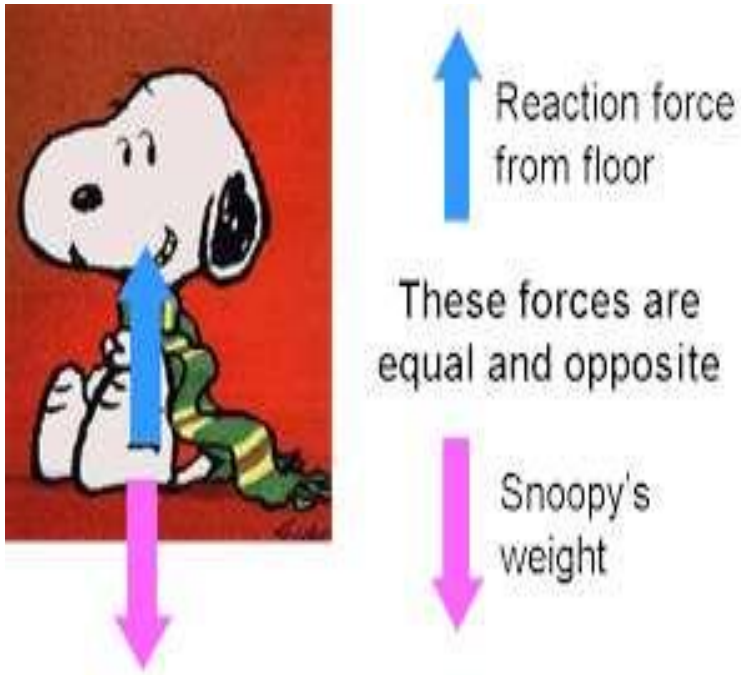
- You drop a feather and a rock off a building.
  - What causes each object to accelerate?
  - Which object will hit the ground hit the ground first?
  - Why?
  - How does this relate to the 1st and 2nd Laws of Motion?

Newton's Third Law of Motion



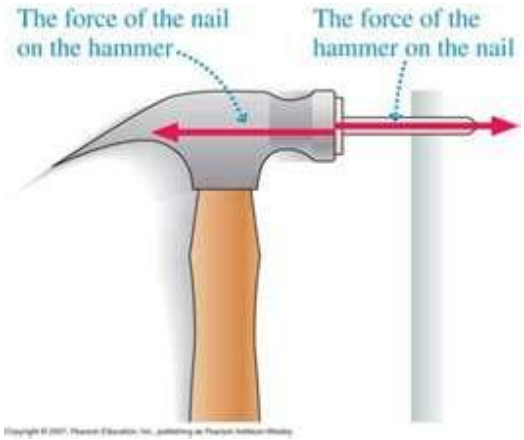
Newton's Third Law of Motion

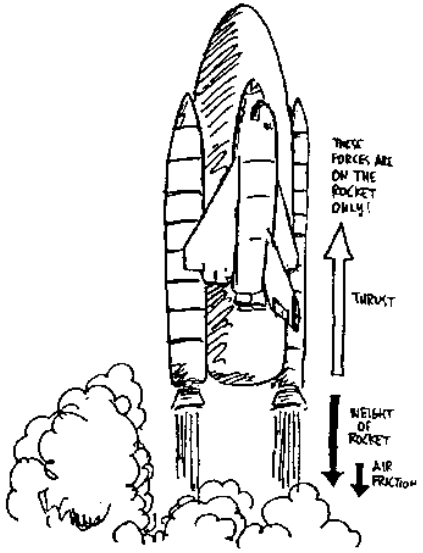
- *When one object exerts a force on a second object, the second one exerts a force on the first that is equal in magnitude and opposite in direction.*



- Law of Action and Reaction
  - For every action force, there is an equal and opposite reaction force
    - Equal in magnitude
    - Opposite in direction

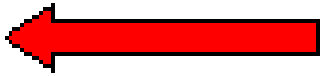
Newton's Third Law of Motion





Newton's Third Law

The boy accelerates to the left



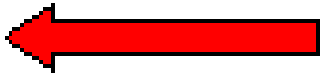
There is a force acting on HIM to the left.

The girl accerates to the right.

There is a force acting on HER to the right.

Newton's Third Law

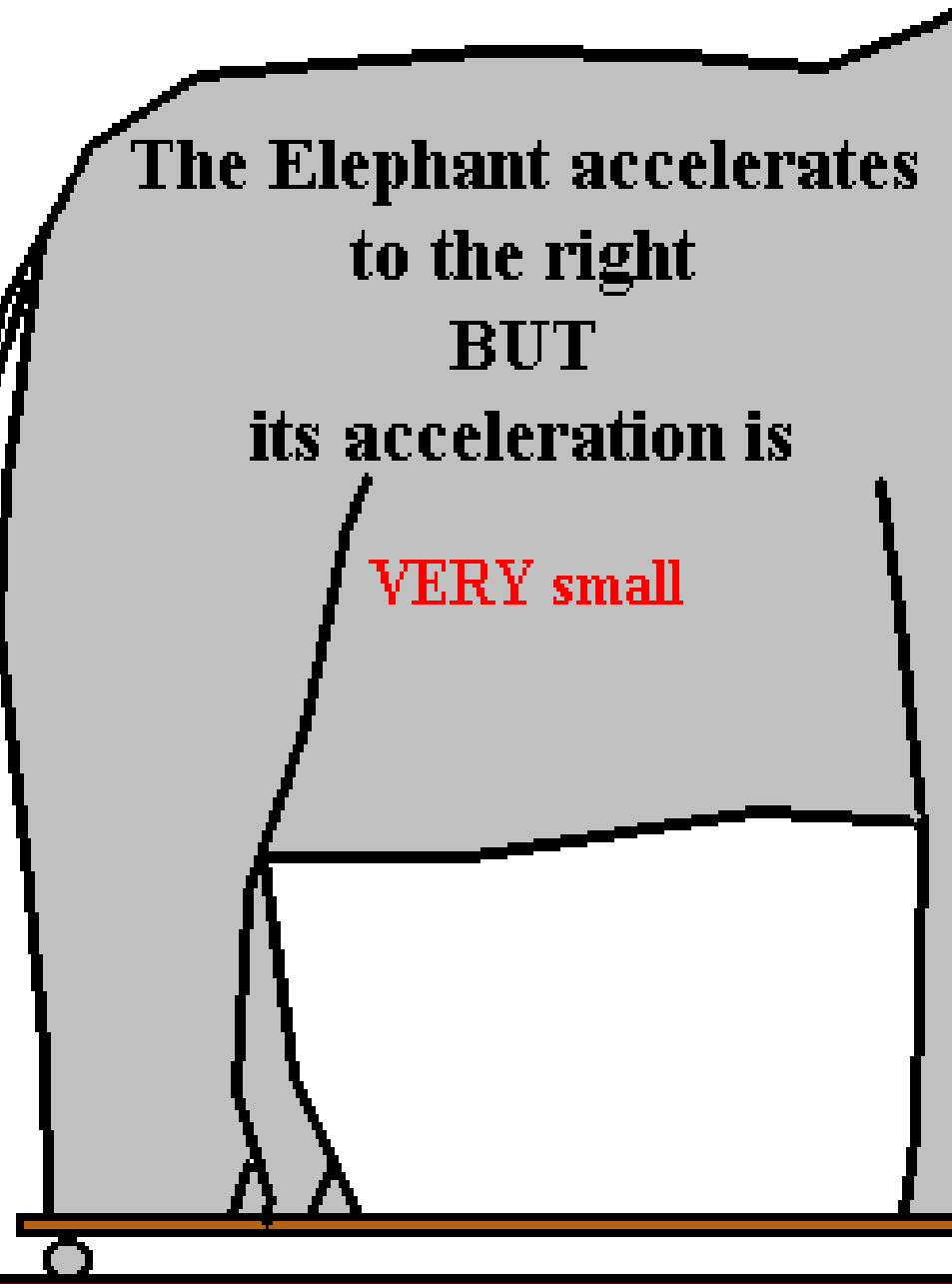
The boy accelerates to the left



There is a force acting on HIM to the left.

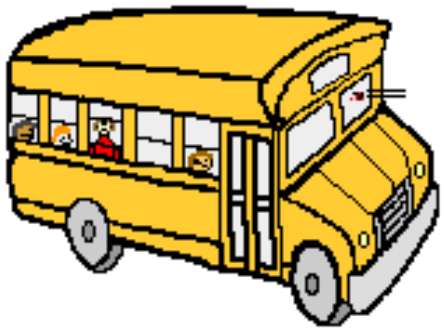
The Elephant accelerates to the right BUT its acceleration is

VERY small



Check for Understanding

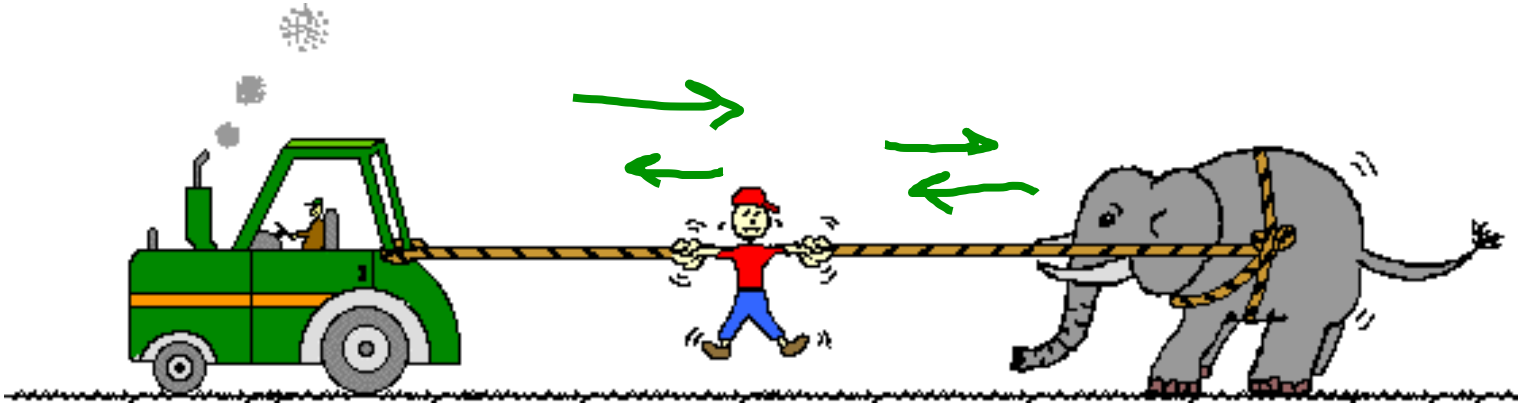
- Restate Newton's Third Law in your own words



- While driving down the road, a firefly strikes the windshield of a bus and makes a quite obvious mess in front of the face of the driver. This is a clear case of Newton's third law of motion. The firefly hit the bus and the bus hits the firefly. Which of the two forces is greater: the force on the firefly or the force on the bus?

Check for Understanding

- Look at the picture below and try to identify at least 4 pairs of action-reaction forces.



Closure
Which law is it???

Which of Newton's Three Laws Applies: Law 1, 2, or 3?
____ When you put a book on a table gravity pulls down on the book and the table pushes up on the book.
____ A person is pushed forward into their seatbelt when a car stops.
____ A larger car takes more force to move.
____ A person leans on a wall and the wall pushes back.
____ A brick sits on a table until you push on it.

Practice Using Newton's Laws

- Complete the worksheets for Newton's Laws of Motion according to the directions.

- These are due Thursday as a QUIZ GRADE!


PEANUTS
by
SCHULZ
I SURE LIKE CHARLIE BROWN'S LITTLE SISTER..
SOMEHOW I FEEL THAT SHE AND I HAVE SOMETHING IN COMMON..
I JUST CAN'T FIGURE OUT WHAT IT IS, THOUGH...
THAT'S IT!
SHE'S THE ONLY OTHER ONE AROUND HERE WHO KNOWS HOW TO WALK ON FOUR FEET!
SCHULZ

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