Lesson 23: Newton's First Law (Inertia)

Newton's Laws of Motion, as written in his book the ***Principia***, are actually very difficult to read.

- At the time, Newton didn't care too much about the "readability" of his book. He just wanted to get the stuff put down on paper.
- As a result, the way we state his laws today, and the formulas we use, are in some ways different from the way he originally wrote them. They still mean the same thing.

He actually wrote the laws in a specific order for a specific reason.

- As we go through the laws, you should realize that he builds one on top of the other.

First Law ("The Law of Inertia")
What happens when there is **no** net force.
Uniform Motion

Second Law ("Law of Motion")
What happens when there **is** a net force.
Accelerated Motion

Third Law ("Law of Action-Reaction)
How forces interact between **two** objects.

} Newton's Three Laws of Motion

The First Law (The Law of Inertia)

"**Every body continues in a state of rest or uniform velocity in a straight line when no net force acts on it**."

"**Every body**…"
Means ***any*** physical object in the universe that has mass. It can be here on the Earth, on the moon, floating in space, wherever.

"…**continues in a state of rest or uniform velocity in a straight line**…"
If it is sitting still, it will stay that way. If it is moving, it will keep on moving forever at that velocity in a straight line.

"…**when no net force acts on it.**"
There can be forces, just no ***net*** force acting on it.

We will basically say that as long as the net force on the object is zero, we will not see a change in its velocity.

$$\text{If } F_{NET} = 0, \text{ then } \Delta v = 0$$

An object resisting a change in its "state of motion" (stopped or moving in a straight line) is something that Newton called **inertia**.

- That's why this law is sometimes called the **Law of Inertia**.
- Basically, the idea of inertia is that however an object is moving right now, it will keep on moving that way.
- In day to day experience you don't necessarily see this because of the effects of friction.

- If you roll a ball across the floor it will slow down and eventually stop.
- This is not because it is violating inertia, but because there is an external force acting on it... friction.

Example 1: **Describe** the motion of a book sitting on a desk.

A book sitting on a desk won't start to move all on its own. A force needs to be applied to it to accelerate it (change its motion). With no net force acting on it, it started in a state of rest and it will stay that way.

Example 2: Use Newton's First Law to **explain** why people are injured in car accidents when they do not wear seat belts. Assume the person was in a head on collision.

During the collision the car is rapidly brought to rest by a force acting against it. In the car the person still has inertia, so the person will continue to move forward at the same speed as the car was originally traveling at until a force acts against him. This force will be supplied by the steering wheel, dashboard, or windshield as they hit it. It is this force that causes injuries to his body.

Example 3: A car has an applied force and a force of friction acting on it that are equal but opposite in direction. Is it possible for the car to be moving?

Yes, the car can be moving. Having a net force of zero does NOT mean that you have a velocity of zero, it just means there is no CHANGE in velocity. If the car is already moving, it will stay moving at the same velocity.

Newton's First Law goes against what Aristotle said, but is basically what Galileo had said a few years earlier.

- Aristotle had said that if you stop pushing an object, it will come to rest.
  - He believed that "at rest" was the natural state for any object.
- Galileo told us to ignore friction and basically came up with Newton's First Law.
  - It is called Newton's First Law because he was the one that formally published it and had the mathematical proofs to back it up.

Homework

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