Lesson 20: Galileo's Force Theories

Over time questions started to be asked about why objects moved.

- Just describing the motion (**kinematics**) wasn't good enough.
- The study of **dynamics**, an analysis of the forces acting on an object, was born.
- By putting these two ideas together, you get a complete explanation of the motion of objects, a branch of physics known as **mechanics.**

kinematics + **dynamics** = **mechanics**

Greeks (like Aristotle) had noticed 2300 years ago that to keep something moving you had to keep pushing on it (a force). If you stopped pushing, it stopped moving.

- From this they came up with the idea that ***the natural state of any object is to be at rest*** (not moving).
- They believed ***a constant force results in a constant velocity.***
- From our everyday experience this seems to be true… but is it?

Galileo's Work

Galileo imagined a world where there was ***no friction***.

- He believed friction complicated his study of dynamics, and by ignoring it he could simplify his theories.
- He came up with two "thought experiments" (they could only be imagined, not done in real life). Remember… NO FRICTION!

Experiment One

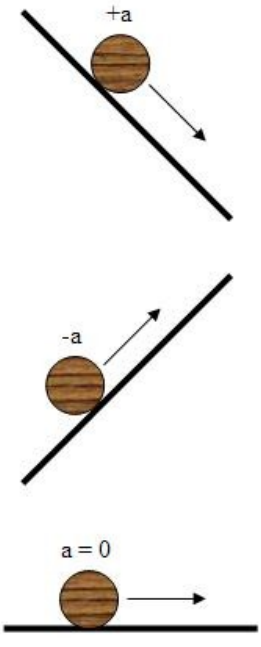

Illustration 1: Experiment One

Ignoring everything else, an object rolling down a slope will speed up. The only reason its velocity will increase (positive acceleration) is because it is going down a slope while gravity is pulling down on it.

Ignoring everything else, an object rolling up a slope will slow down. The only reason its velocity will decrease (acceleration) is because it is going up a slope while gravity is pulling down on it.

If the ball is moving on a level surface it has no reason to speed up or slow down! With no acceleration, it will move at a constant velocity forever.

This first thought experiment is Galileo's way of challenging Aristotle's idea that an object will naturally be at rest.

- Galileo shows that an object can naturally be moving... forever!
- The only special rule that Galileo wants us to follow is that there is no friction.
- The idea is that if we can understand this simple situation better, we can add friction back in later.

Experiment Two

In the first drawing, a ball rolls down a slope on one side, then rolls just as high up a similar slope on the other side.

Next, the ball now has to roll up a slope that is not as steep, but rolls to the same height. Notice the distance it must go along the slope is greater.

Finally, since it has no slope to go up in the last drawing, it should keep moving forever along the level surface at a constant velocity. Galileo said that this is the natural motion of the object.

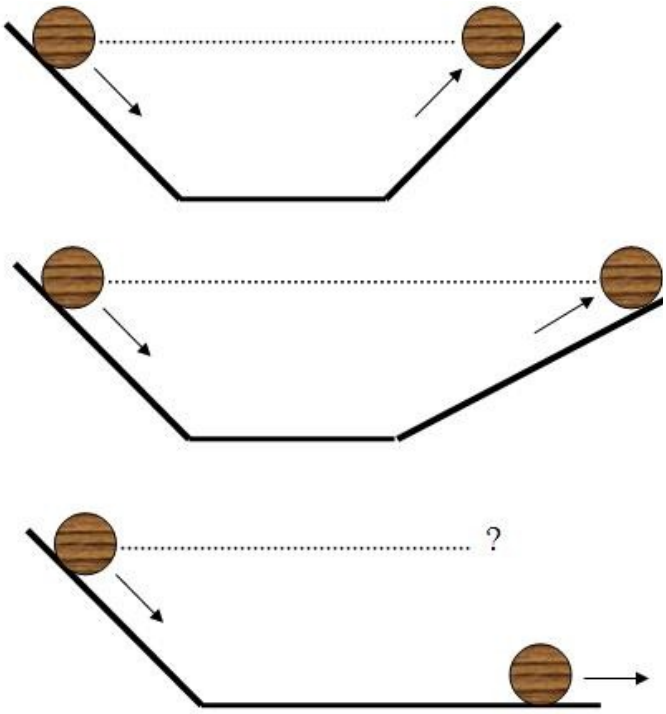

Illustration 2: Experiment Two

Here Galileo gives an even more detailed example of why an object in motion can be a perfectly normal thing.

- Since this was a challenge against Aristotle, it was not particularly popular.
- Galileo didn't take this research much further, partly because of the limitations he had doing the math.
    - We need someone else to come along and invent ***Calculus*** to be able to figure this stuff out in detail.
    - This is exactly what Sir Isaac Newton did, and we'll be looking at his work later lessons.

For now, here's one more way to look at Galileo's ideas without all the slopes…

- What do you have to do to keep the box moving at a constant velocity of 2.0 m/s in each of these situations?

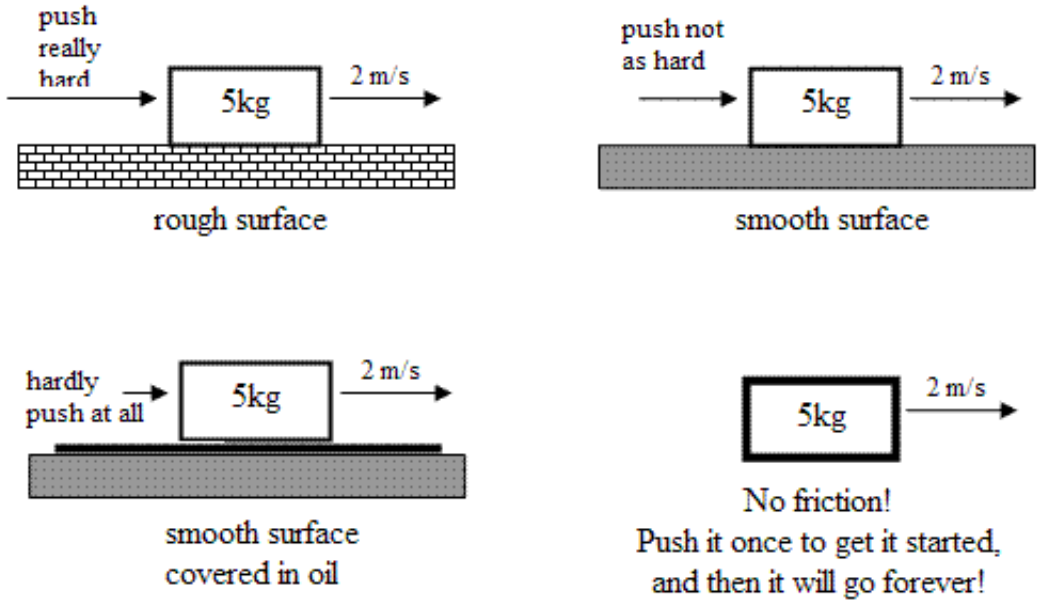

Illustration 3: Pushing objects on various surfaces.