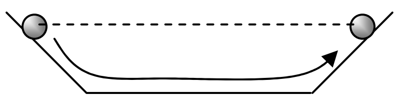
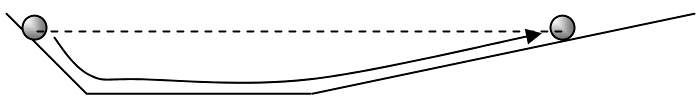
Until Newton's time, it was believed that constant force was required for constant motion. If fact, this belief had been held since the time of the ancient Greeks. The Greeks, and all those that followed, never conceptualized friction. Newton correctly conjectured that all objects maintain a state of rest or uniform motion unless acted upon by a unbalanced external force. Newton's meticulous experimental evidence as well the increasingly accepted planetary mechanical models of the universe supported this idea of his first law. Hence, something had to account for the omnipresent forces that impede motion. **Friction**.

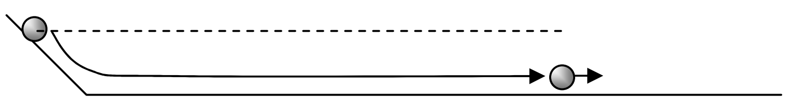
Q: How did he come up with this idea of his First law?
A: Using a logical argument. If you take a ball roll it down a double ended ramp, it should reach the same height on the other side.



Now consider if you lower the ramp on one side



The ball will travel further, until it reaches the same height.



In this case, the ball will never reach the same height, so theoretically, it should go on forever (Newton's first law: "every object maintains constant motion in a straight line unless acted upon by an unbalanced external force"). We know it doesn't go on forever; therefore a force must be stopping it. Newton called this force **friction**.

Friction can be broken into two categories. **Kinetic** and **Static**

Kinetic Friction: Is the resistive force that opposes the forward motion of all moving objects.

Static Friction: Is the resistive force that opposes any applied force that attempts to start an object in motion.

<u>Friction always opposes motion</u>. Friction always robs a moving object of it energy of motion (kinetic energy) or always attempts to prevent an object form starting to move.

<u>FACTS ABOUT FRICTION:</u>

- **Static** friction is always greater than **kinetic** friction. $\mu_s > \mu_k$ ←Greek symbol *meu*
- Force of friction **IS INDEPENDENT OF SURFACE AREA!** This implies that the maximum force of friction between two surfaces is only dependent on the properties of the two surfaces. The surface area is irrelevant.
- Force of friction is given by the formula

$$F_f = \mu F_N$$

Where F_f is the force of friction in Newtons, F_N is the normal force acting on the object and μ is the coefficient of friction. Note, there are two different coefficients, μ_s for static friction, μ_k for kinetic friction

Common Coefficients of Friction

Materials	μ_s	μ_k
Steel on steel	0.74	0.57
Aluminum on steel	0.61	0.47
Copper on steel	0.53	0.36
Rubber on concrete (dry)	1.0	0.8
Rubber on concrete (wet)	0.3	0.25
Wood on wood	0.25-0.5	0.2
Glass on glass	0.94	0.4
Teflon on Teflon	0.04	0.04
Teflon on steel	0.04	0.04
Waxed wood on wet snow	0.14	0.1
Waxed wood on dry snow	0.10	0.04
Metal on metal (lubricated)	0.15	0.06
Ice on ice	0.1	0.03
Synovial joints in humans	0.01	0.003
Very rough surfaces		1.5

Examples:

1. A 5kg block of wood is sliding along a tabletop with a force of 20N.
   a) What is the force of friction acting on the block?
   b) What is the net force acting on the block?
   c) What is the acceleration of the block?
   d) What would happen to the force of friction if the mass was doubled?
   e) What would happen to the acceleration?

2. Some hick in a pickup truck wants to push my Japanese import in to the Thames. If my car has a mass of 1000kg.
   a) How much force must the pickup apply to my car before it starts to move (assume a concrete road surface)?
   b) Once it starts to move, what happens to the force of friction?
   c) What is the force of friction as it's moving
   d) What will be its acceleration if the force in a) is still applied?