

# Motion 4 - Forces

The two most famous equations of physics are  $F = ma$  and  $E = mc^2$ . Today we learn about  $F = ma$ , also known as, Newton's 2nd Law of Motion.

Newton's 3 laws of motion describe how objects move.

**1st Law - Inertia** - says objects won't change their motion for no reason.

**2nd Law - Forces** - gives the equation when an object WILL change their motion.

**3rd Law - Equal and opposite** - states what happens when two objects run into each other.

**Vocabulary - Force:** A force is anything that causes something to move or change its current motion. The unit is a Newton (N), named for Issac Newton.

## Newton's 2nd Law

Newton's second law says that the **sum of all forces is equal to mass times acceleration**,

$$\sum F = ma$$

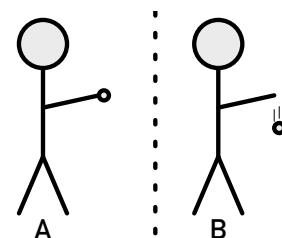
The symbol  $\sum$  (sigma, the capital greek letter 's') means *sum of all*, or, *add all together*. This means that ALL forces must be accounted for, not just one force.

There are only 3 parts to the equation; sum of all forces, mass, and acceleration. Mass is usually constant, so the only two parts that need examined are the sum of all forces and acceleration.

## Sum of all Forces

Sum of all forces can be explained with the two pictures at the right. In picture A, the ball is not moving because the sum of all the forces is zero. The hand is holding the ball with enough force to oppose gravity, canceling out the force of gravity.

In picture B, the ball is falling because the only force acting on the ball is gravity, and with no other force acting on it, it falls.



## Acceleration

Acceleration is a change in motion, and most easily understood comparing when something is accelerating, and when something is not.

### Something IS NOT Accelerating if:

- Moving at a constant speed
- Not moving at all

### Something IS Accelerating if:

- A change in speed
- Turning a corner

# Activity - Measuring the acceleration due to gravity

The most common force is gravity. It is so common that you cannot fathom (imagine) a world without gravity. Gravity pulls everything together, but since the earth is so much bigger than everything else around, we experience gravity as a downward pull. In fact, we define 'down' as the direction gravity pulls us!

As you have just learned, where there is a force, there is also an acceleration. You have also just learned that you can measure the acceleration by collecting time and distance data. Putting those together you will measure the acceleration of gravity!

## Step 1 - EACH group member drops and object

- EACH member of your group should pick a different object to drop. Note, they cannot be too heavy or you will break things or too light because air resistance will play a part.
- Record a video of each team member dropping their object.
  - Keep the camera still
  - Have a meter stick in the background for calibrating the video
- Each group member should process their own video using the *Tracker* application.
  - You only want to track the motion from the time you let go of the object to the time right before it hits the floor. If you track the bounces your data will be off.

## Step 2 - Sketch yours AND your partners plots in your labbook

Make sure you have correctly labeled axis on your sketches.

- Sketch the following plots for your dropped object:

X-axis	vs	Y-axis
t	vs	y
t	vs	vy (velocity-y)
t	vs	ay (acceleration-y)

(Note, if your video is sideways, call me over and I'll explain how to rotate it.)

- Sketch the plot of each group members time vs ay (acceleration-y) plot into your notebook.
- Compare your results for the acceleration due to gravity (the y-acceleration plots) with at least 3 other people.

## Step 3 - Complete the following in Schoology

- The lab report
- Upload an image of your T vs AY plot.